Current Journal of Applied Science and Technology

Volume 41, Issue 48, Page 14-22, 2022; Article no.CJAST.95404
ISSN: 2457-1024
(Past name: British Journal of Applied Science & Technology, Past ISSN: 2231-0843, NLM ID: 101664541)

Crop Water Requirement of Tomato under Different Transplanting Dates in Poly-house Environments

Jagtap Priyanka [a*], Sonawane Shital [b] and Upadhyay Harsh [a]

[a] *Department of Soil and Water Engineering, CTAE, MPUAT, Udaipur, Rajasthan, India.*
[b] *Department of Farm Machinery and Power Engineering, CTAE, MPUAT, Udaipur, Rajasthan, India.*

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/CJAST/2022/v41i484030

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/95404

Original Research Article

Received: 20/10/2022
Accepted: 27/12/2022
Published: 27/12/2022

ABSTRACT

Tomato (*Lycopersicon esculentum* Mill) belongs to the *Solanaceae* family. It is one of the most popular, cash earning and versatile vegetable crops for small farmers of India. A field experiment was conducted to investigate the Crop Water Requirement of Tomato Crop Transplanting under Different Dates under Poly-house Conditions at the Plasticulture Farm of CTAE, MPUAT Udaipur, Rajasthan, during the period of July, 2018 to May, 2019. There were total six treatments for different dates of transplanting of tomato i.e., 5th July (T1), 5th August (T2), 5th September (T3), 5th October (T4), 5th November (T5), 5th December (T6). The experiment was laid out in randomized block design with six treatments and four replications each to find out the optimum water requirement of Tomato crop where the ETc was calculated by Penman–Monteith (PM). The results reveal that for T3 (5th September) treatment the minimum water requirement (418.40 mm) and for T6 (5th December) it was maximum (486.64 mm). Therefore, considering the results finding, the 5th September date of transplanting is the best for tomato transplanting.

**Corresponding author: E-mail: priyankajagtap9196@gmail.com;*

Keywords: *Tomato; drip irrigation; crop water requirement; naturally ventilated polyhouse; transplanting dates.*

1. INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill) is most important and remunerative vegetable crop in India and able to fetch very good rates from market due to its high demand in hotels and restaurants. Therefore, farmers can able to produce vegetables in off season and can sell them at higher price in the market. As the farmer can produce vegetables in off season, so the farmer can sell the product in higher price to the retail stores, restaurants and big hotels. The main objectives of cultivation of vegetables in a polyhouse condition are, to protect the crop against biotic (pests, diseases and weeds) and abiotic (temperature, humidity and light,) stresses and to ensure round the year production of high-value quality vegetables like tomato especially, during the off-season [1]. Protected farming methods, such as poluhouse house technology, offer the best environmental conditions for improved crop growth in order to achieve the highest yield and the highest-quality food. These allow for crop production throughout the year and need relatively little space for agricultural production, increasing land productivity [2].

The adoption of strategies for saving irrigation water and maintaining acceptable yields like drip irrigation may contribute to the preservation of this ever more restricted resource [3]. A paramount approach consists in closing the gaps between water application and crop water requirements. These gaps refer to various irrigation issues such as improved irrigation methods and related irrigation and delivery scheduling, use of information and communication technologies, more precise cropping and water management practices, and farmers training and self-governance. On the base of related developments is knowledge and, particularly, knowledge on crop water requirements, thus on crop evapotranspiration processes and determination methods [4].

Crop water requirement was calculated by the FAO 56 paper and this FAO56 responded to various objectives: to provide a consolidated tool to ease the calculation of crop water requirements and therefore providing an information for users that help them to optimize water use and management, to improve crop yields through a more appropriate application of water to the crops, to gain information usable by managers of collective irrigation systems in satisfying the needs of irrigation farmers, and to support adopting measures that control impacts of irrigation on environment and better responding to climate change challenges, and water demand in particular [5].

The use of drip irrigation method in the polyhouse, not only saves water but also gives better yield and quality with reduced humidity build up due to precise application of water to the root zone and improving irrigation efficiency [6]. The optimal use of water for agriculture and enhancing irrigation efficiency is becoming more and more vital, and alternate water application methods like drip may significantly contribute to these goals. Drip irrigation has enhanced WUE in locations with dry and hot temperatures primarily by lowering runoff and evapotranspiration losses [7-9]. Direct application of water and nutrients to the crop's roots via drip irrigation systems has a favourable impact on output, reduces water use, and improves irrigation efficacy [10].

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. That means the date of transplanting has majorly affects the daily crop water requirement of Tomato crop. Optimum time of planting is one of the major inputs for increasing the productivity of the crop [11].

Thus, the present investigation aimed with the determination of the optimum crop water requirement for tomatoes grown under a poly-house in an arid region like Rajasthan based on the different transplanting dates.

2. MATERIALS AND METHODS

The 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 July, 2018 to May 2019. 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. Udaipur comes under sub-humid agro-climatic region. It receives an average annual rainfall of 654.3 mm, most of the received during the period of July to

September. May is the hottest and December is the coolest month of the year. The maximum temperature goes as high as 46°C during summer and minimum as low as 5°C during winter months. The atmospheric humidity is high from June to October.

The meteorological data of significant weather parameters were collected on a daily basis from the meteorological observatory of Department of Soil and Water Engineering, CTAE, Udaipur. The meteorological data for a period of 5 years (2013-2017) were collected in this study. The meteorological data inside the polyhouse include daily parameters (i.e. maximum temperature (Tmax) and minimum temperature (Tmin), maximum relative humidity (RHmax), minimum relative humidity (RHmin), wind speed at the height of 3 m, pan evaporation, and sunshine hours) were recorded with the help of automatic weather station already installed inside the polyhouse. Dry and wet bulb thermometers located inside the polyhouse was used to determine relative humidity values inside the polyhouse.

The size of structure is 32 m × 24 m i.e. 768 m^2 and it have south side face opening gate. Curtains are having roll up provision and insect net firm. 200 micron transparent plastic film is used as curtain provided up to 3 m height on all sides and provision for manual opening and closing of curtain provided 40 mesh nylon insect proof nets of equivalent size fixed inside the curtains. The experiment was laid out in randomized block design with six treatments and four replications. There were total six treatments for different dates of transplanting of tomato i.e., 5^{th} July (T1), 5^{th} August (T2), 5^{th} September (T3), 5^{th} October (T4), 5^{th} November (T5), and 5^{th} December (T6).

Raised nursery beds were first prepared and drenched with captain before transplanting the seeds in nursery beds. One month old seedlings were transplanted in plots that measured 16 × 1.0 m at spacing of 50x50 cm. The first irrigation was applied immediately after transplanting. The crop was irrigated as required depending on the moisture status of the soil and requirement of plants. Other intercultural operations and plant protection measures were taken as and when necessary.

2.1 Estimation of Reference Crop Evapotranspiration (ET_0)

For pre scheduling of crop water requirement the daily reference evapotranspiration was estimated by using standard method i.e. Penman-Monteinth [12] for the present study and is given by,

$$ET_0 = \frac{0.408\Delta(R_n - G) + \gamma\left(\frac{900}{T+273}\right)u_2(e_s - e_a)}{\Delta + \gamma(1 + 0.34u_2)^{*}E0} \quad (1)$$

Where,

ET_0 = 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, (^{0}C)
Γ = Psychometric constant, (kPa/^{0}C)
Δ = Slope of saturation vapour pressure function, (kPa/^{0}C)
e_s = Saturated 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)

The standard reference ET (ET_o) calculations of FAO56 and ASCE assume that the surfaces underlying collected weather data are well-watered so that near-surface meteorological measurements reflect the cooling and humidifying effects of an evaporating surface [13].

2.2 Crop Evapotranspiration

Crop evapotranspiration obtained as:

$$\boldsymbol{ET_C = K_C \times ET_O} \quad (2)$$

Where,

ET_c = Crop evapotranspiration, (mm/day)
K_c = Crop coefficient
ET_0 = Reference Crop Evapotranspiration, (mm/day)

2.3 Water Requirement

The water requirement of plants varies with time and depends on the season and growth of plants. It is essential to irrigate optimally during the stage of flowering to fruit maturity. Water requirement of the plant was calculated from following equation.

$$W_r = \frac{Crop\ area \times ET_0 \times K_c \times W_a}{E_u} \quad (3)$$

Where,

W_r = Peak water requirement, (lit/day/plant)
Crop area = Row to row spacing (m) × plant to plant spacing (m) of the crop
ET_c = Crop evaporation rate, (mm/day)
K_c = Crop Coefficient
W_a = Wetted area, (%)
E_u = Emission Uniformity of drip system, decimal

3. RESULTS AND DISCUSSION

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

The daily climatic data for the growth period were used to determine crop water requirement for entire crop period and after that it converted into weekly reference and crop evapotranspiration. The relationship between crop evapotranspiration (ET_c) and reference evapotranspiration (ET_0) was determined by using equation (1)**.** It was referred from FAO-56. The growing season of tomato crop divided into four stages viz., (i) initial stage, (ii) crop development stage, (iii) mid-season stage, and (iv) late season stage. The crop coefficient (Kc) for initial stage, mid-season stage and late season stage was taken 0.6, 1.15, and 0.75 respectively.

The detail information about the tomato crop *i.e.* date of planting and harvesting, crop duration, growth stages, is depicted in Table 1.

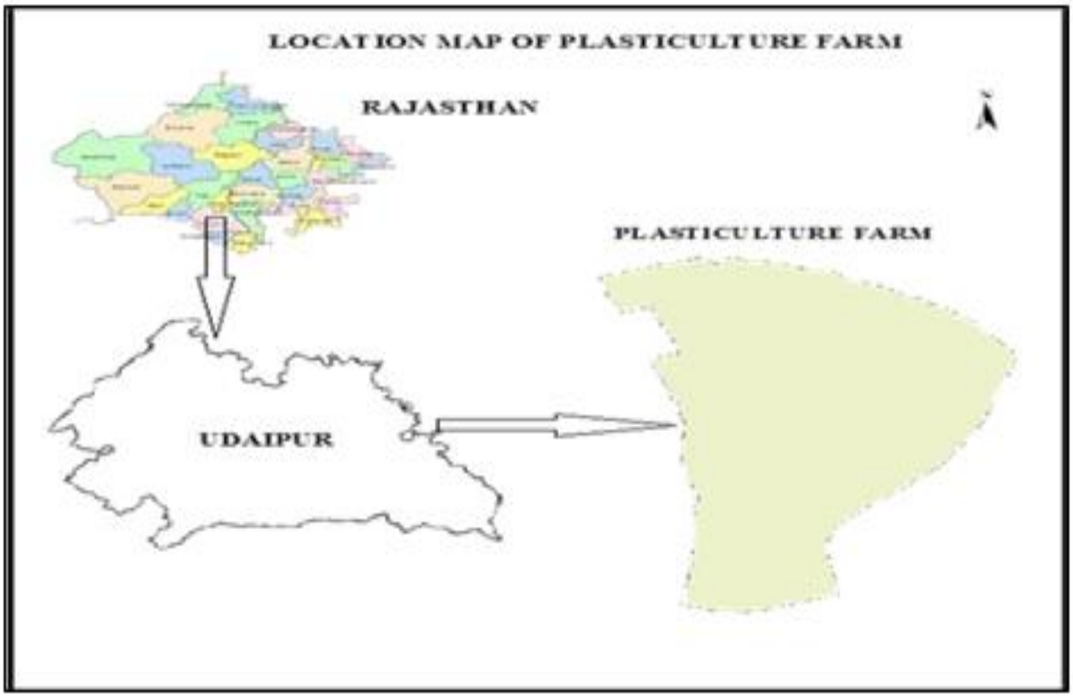

Fig. 1. Location map of the study area plasticulture farm, CTAE, MPUAT, Udaipur

Table 1. Detail of crop duration, growth stages and irrigation days pertaining to the crop grown in the field

Crop	Dates of transplanting	Date of Harvesting	Duration(Days)	Growth Stages 1.	2.	3.	4.
Tomato	5.07.2018	11.01.2019	186	35	45	74	30
	5.08.2018	5.03.2019	210	35	45	100	30
	5.09.2018	1.04.2019	207	35	45	97	30
	5.10.2018	3.05.2019	209	35	45	99	30
	5.11.2018	10.05.2018	185	35	45	75	30
	5.12.2018	25.05.2018	160	35	45	60	30

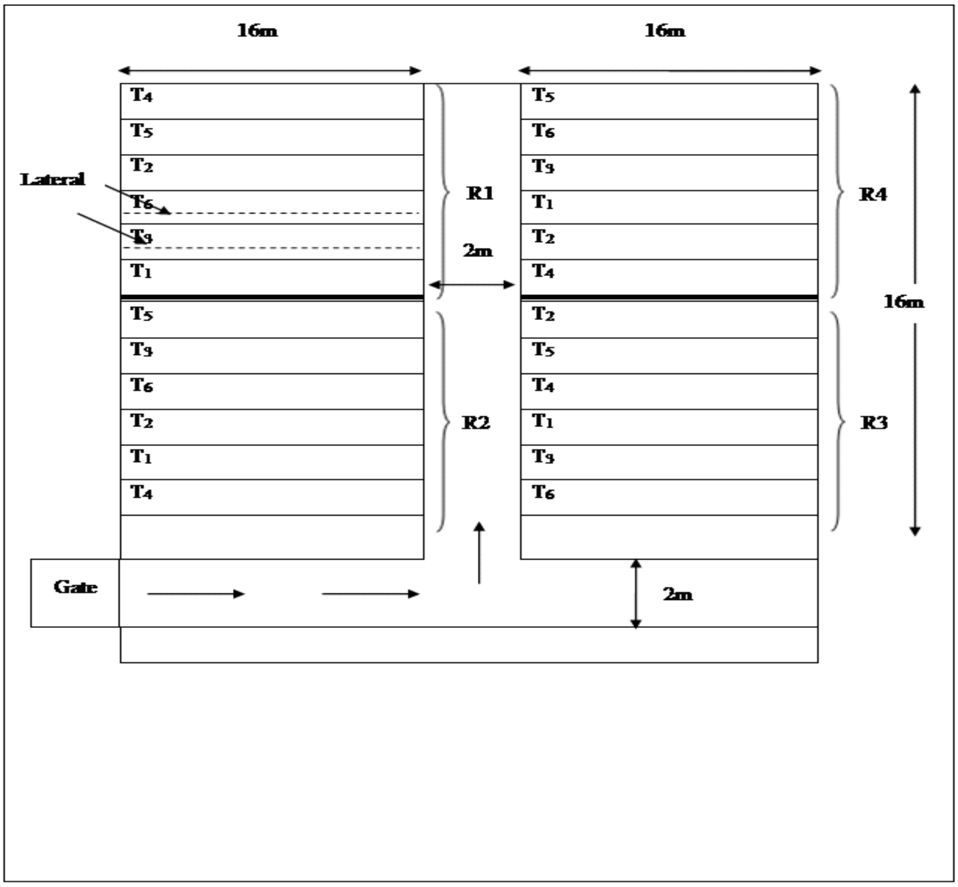

Fig. 2. Experimental layout inside polyhouse

Bed Width = 80cm, Gallery between beds = 20 cm, Path = 2 m

The weekly reference evapotranspiration (ET_0) requirement for all dates of transplanting inside the polyhouse is indicated in Table 2.

Table 2. Estimated weekly ET_0 (mm/day) from climatologically data for the year 2018-2019 inside naturally ventilated polyhuose

Week No.	Treatment wise ET_0 (mm/day)					
	T1	T2	T3	T4	T5	T6
27	4.37	-	-	-	-	-
28	3.33	-	-	-	-	-
29	2.65	-	-	-	-	-
30	3.22	-	-	-	-	-
31	4.18	-	-	-	-	-
32	4.61	4.61	-	-	-	-
33	4.20	4.20	-	-	-	-
34	2.96	2.96	-	-	-	-
35	3.76	3.76	-	-	-	-
36	4.11	4.11	4.11	-	-	-
37	3.97	3.97	3.97	-	-	-
38	3.48	3.48	3.48	-	-	-
39	3.40	3.40	3.40	-	-	-
40	3.11	3.11	3.11	3.11	-	-
41	2.72	2.72	2.72	2.72	-	-

Week No.	Treatment wise ET_0 (mm/day)					
	T1	**T2**	**T3**	**T4**	**T5**	**T6**
42	2.00	2.00	2.00	2.00	-	-
43	2.21	2.21	2.21	2.21	-	-
44	2.05	2.05	2.05	2.05	2.05	-
45	1.77	1.77	1.77	1.77	1.77	-
46	1.73	1.73	1.73	1.73	1.73	-
47	1.65	1.65	1.65	1.65	1.65	-
48	1.45	1.45	1.45	1.45	1.45	-
49	1.45	1.45	1.45	1.45	1.45	1.45
50	1.31	1.31	1.31	1.31	1.31	1.31
51	1.19	1.19	1.19	1.19	1.19	1.19
52	1.27	1.27	1.27	1.27	1.27	1.27
1	1.24	1.24	1.24	1.24	1.24	1.24
2	-	1.30	1.30	1.30	1.30	1.30
3	-	1.38	1.38	1.38	1.38	1.38
4	-	1.47	1.47	1.47	1.47	1.47
5	-	1.80	1.80	1.80	1.80	1.80
6	-	1.87	1.87	1.87	1.87	1.87
7	-	2.04	2.04	2.04	2.04	2.04
8	-	2.49	2.49	2.49	2.49	2.49
9	-	2.71	2.71	2.71	2.71	2.71
10	-	-	3.05	3.05	3.05	3.05
11	-	-	3.05	3.05	3.05	3.05
12	-	-	3.52	3.52	3.52	3.52
13	-	-	3.78	3.78	3.78	3.78
14	-	-	-	3.94	3.94	3.94
15	-	-	-	4.04	4.04	4.04
16	-	-	-	4.09	4.09	4.09
17	-	-	-	4.28	4.28	4.28
18	-	-	-	-	4.56	4.56
19	-	-	-	-	4.43	4.43
20	-	-	-	-	-	4.48
21	-	-	-	-	-	4.40
ET_0 (mm)	**512.16**	**495.17**	**465.07**	**487.09**	**467.01**	**470.78**

The weekly crop water requirement for all dates of transplanting inside the polyhouse is indicated in Table 3.

Table 3. Estimated weekly ET_C (mm/day) from climatologically data for the year 2018-2019 inside naturally ventilated polyhuose

Week No.	Treatment wise ET_c (mm/day)					
	T1	**T2**	**T3**	**T4**	**T5**	**T6**
27	2.62	-	-	-	-	-
28	2.00	-	-	-	-	-
29	1.59	-	-	-	-	-
30	1.93	-	-	-	-	-
31	2.51	-	-	-	-	-
32	2.85	2.77	-	-	-	-
33	2.92	2.52	-	-	-	-
34	2.32	1.78	-	-	-	-
35	3.27	2.25	-	-	-	-
36	3.92	2.47	2.44	-	-	-
37	4.12	2.61	2.38	-	-	-
38	3.91	2.56	2.09	-	-	-
39	3.91	2.78	2.04	-	-	-

Week No.	**Treatment wise ET_c (mm/day)**					
	T1	**T2**	**T3**	**T4**	**T5**	**T6**
40	3.58	2.79	1.87	1.84	-	-
41	3.12	2.66	1.70	1.68	-	-
42	2.30	2.12	1.42	1.21	-	-
43	2.54	2.51	1.76	1.36	-	-
44	2.35	2.35	1.80	1.24	-	-
45	2.03	2.03	1.71	1.07	1.07	-
46	1.99	1.99	1.82	1.11	1.04	-
47	1.89	1.89	1.86	1.19	1.01	-
48	1.67	1.67	1.67	1.16	0.88	-
49	1.67	1.67	1.67	1.26	0.88	0.88
50	1.50	1.50	1.50	1.25	0.85	0.81
51	1.30	1.36	1.36	1.20	0.85	0.71
52	1.26	1.46	1.46	1.28	0.95	0.71
1	1.11	1.42	1.42	1.53	1.19	0.80
2	-	1.49	1.49	1.44	1.22	0.80
3	-	1.59	1.59	1.55	1.42	0.97
4	-	1.69	1.69	1.71	1.69	1.19
5	-	2.03	2.07	1.99	1.99	1.54
6	-	1.95	2.15	2.15	2.15	1.81
7	-	1.93	2.34	2.31	2.31	2.11
8	-	2.13	2.87	2.81	2.81	2.77
9	-	2.08	3.02	3.09	3.09	3.09
10	-	-	3.12	3.44	3.44	3.44
11	-	-	2.86	3.49	3.49	3.49
12	-	-	2.93	3.96	3.96	3.96
13	-	-	3.01	4.37	4.37	4.37
14	-	-	-	4.26	4.47	4.47
15	-	-	-	4.08	4.68	4.68
16	-	-	-	3.66	4.49	4.63
17	-	-	-	3.47	4.30	4.89
18	-	-	-	-	4.15	5.27
19	-	-	-	-	3.55	4.96
20	-	-	-	-	-	4.48
21	-	-	-	-	-	3.96
ET_c (mm)	**465.01**	**434.57**	**418.40**	**464.68**	**465.08**	**486.64**

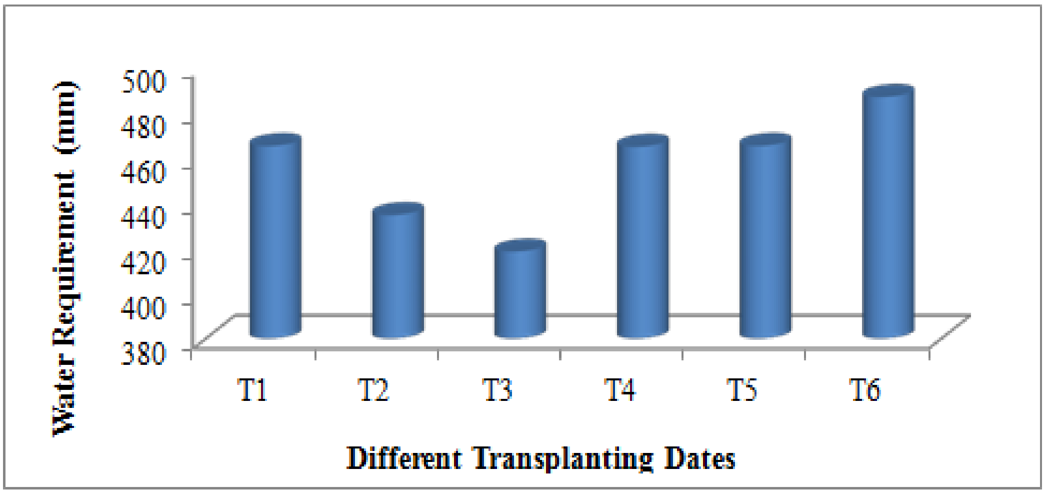

Fig. 3. Total crop water requirement inside naturally ventilated polyhouse

From Tables 1 and 2 it was found that the crop evapotranspiration under NVPH at different transplanting dates like 5th July, 5th August, 5th September, 5th October, 5th November and 5th December were observed as 465.01 mm, 434.57 mm, 418.40 mm, 464.68 mm, 465.08 and 486.64 mm, respectively. The water requirement of tomato crop was estimated on daily basis for all months consider under study and application of water to the tomato crop in alternate days only. Daily time to operate drip irrigation system was worked out taking the application rate per plant. The results reveal that for 5th September transplanting date the minimum water requirement and for 5th December it is maximum.

4. CONCLUSION

On the basis of present investigation it is concluded that the appropriate date of transplanting of tomato in naturally ventilated polyhouse is in month of September. The result indicated that the transplanting in 5th September with 100% ET_c showed the minimum water requirement for tomato crop in order to save the water in water scarcity areas like Rajasthan and observed as most promising treatment under poly house condition for tomato.

ACKNOWLEDGEMENT

I acknowledge the, ICAR for providing fund under AICRP on PET, MPUAT and Udaipur. It is my proud privilege to express my devout gratitude and indebtedness to Department of SWE, CTAE, Udaipur for their thoughtful guidance, constant fomenting and impeccable advices throughout out the research work in time.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Murthy DS, Prabhakar BS, Hebbar SS, Srinivas V, Prabhakar M. Economic feasibility of vegetable production under polyhouse: A case study of capsicum and tomato. J Hortic Sci. 2016;4:148-52.
2. Dunage V, Balakrishnan P, Patil M. Water use efficiency and economics of tomato using drip irrigation under net-house conditions. Karnataka J Agric Sci. 2010;22(1):133-6.
3. Mahmoud AW, Abdulrasoul MA. Effect of water quality and deficit irrigation on tomato growth, yield and water use efficiency at different developmental stages. J Agric Environ Sci. Dam. Univ., Egypt 11; 2012.
4. Moncada A, Miceli A, Vetrano F. Use of plant growth-promoting rhizobacteria (PGPR) and organic fertilization for soilless cultivation of basil. Sci Hortic. 2021; 275:109733.
5. Pereira LS, Paredes P, Hunsaker DJ, López-Urrea R, Jovanovic N. Updates and advances to the FAO56 crop water requirements method. Agric Water Manag. 2021;248.
6. Ramanjaneya B. Greenhouse grown tomato (*Lycopersicon esculentum* L.) to drip irrigation and n-fertigation in semiarid tropics [masters thesis] submitted to Water Technology Centre. Rajendranagar, Hyderabad: College of Agriculture Telangana State Agricultural University; 2015.
7. Cheena J, Saidaiah P, Geetha A, Tejaswini N. Effect of sowing dates on yield and growth of indeterminate tomato varieties under poly house conditions. J Pharmacogn Phytochem. 2018;7:880-2.
8. Harmanto, Salokhe VM, Babel MS, Tantau HJ. Water requirement of drip irrigated tomatoes grown in greenhouse in tropical environment. Agric Water Manag. 2005; 71(3):225-42.
9. Pereira LS, Paredes P, Melton F, Johnson L, Wang T, López-Urrea R et al. Prediction of crop coefficients from fraction of ground cover and height. Background and validation using ground and remote sensing data. Agric Water Manag. 2020; 241:106197.
10. Nagaz K, Masmoudi MM, Mechlia NB. 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 Int Develop. – JAEID. 2012;14(2):85-103.
11. Madhumathi C, Sadarunnisa S. Effect of different transplanting dates and varieties on fruit quality and seed yield of tomato. The Asian J Hortic. 2013;8:8-11.
12. Allen RG, Pereira LS, Raes D, Smith M. Crop evapotranspiration: guidelines for computing crop water requirements. Irrig Drain. 1998;56:300.

13. Allen RG, Dhungel R, Dhungana B, Huntington J, Kilic A, Morton C. Conditioning point and gridded weather data under aridity conditions for calculation of reference evapotranspiration. Agric Water Manag. 2021;245:106531.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/95404