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Effect of Irrigation Scheduling on Tomato (*Lycopersicon esculentum*) Yield and Water Use Efficiency under Drip Irrigation System

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ABSTRACT

The study was conducted to assess the effect of drip irrigation scheduling on growth and fruit quality of tomato and to determine the benefit-cost (B-C) ratio of tomato under different treatments. Five treatments *viz*., T1, T2, T3, T4 and T5 using drip irrigation method without using fertilizer and chemicals were tested to improve irrigation scheduling in tomato. The experimental setup consisted of screen filter, main, sub mains, laterals, drippers and other accessories required for drip irrigation and fitted in the experimental plot of 0.006 ha land. Total production of 2851.08 q/ ha tomato was obtained under various treatments and maximum production of 644.83 q/ ha was under treatment T3 (3 hr water applied in time interval of three day) whereas minimum achieved under treatment T5 (control) as 508.25 q/ha out of three treatments such as T1 (1 hr water applied in one day time interval), T2 (2 hr water applied in two day time interval) and T4 (4 hr water applied in four day interval). Highest fruit weight also recorded in T3 treatment as 10.40 kg/ plant and lowest 5.20 kg/ plant was obtained under T5 treatment. Highest water use efficiency (WUE) and benefit-cost ratio (BCR) were achieved under T3 as 3.15 q/ha-cm and 8.10, respectively. From the present study, it was concluded that modern irrigation system (drip) should be used as a benchmark for planning and management of available water resource by reducing water losses in large extent.

Key Words: Drip irrigation method, Fruit, Scheduling, Tomato, Water use efficiency, Yield.

INTRODUCTION

Drip irrigation is one such technology which can help to increase the irrigation potential by optimizing the use of available irrigation water. Hence, an attempt were made to generate the information on water requirement through drip method for one of the common commercial vegetable crops, tomato and water is a most limiting factor and main source of crop production in irrigation sector. Efficient management of available water resources is very essential to meet the increasing competition of water between agricultural and non-agricultural sectors both. Hence, proper utilization of water is prime requirement for ensuring the food security of the country. India has largest irrigation network but still now irrigation efficiency is estimated less than 60-70% due to improper utilization of available water resources (Imamsaheb *et al,* 2011). Therefore, judicious use of the available water resources through modern drip irrigation method becomes essential to enhance the water use efficiency and yield to get maximum crop production per unit of water application (Dunage *et al,* 2009). In India, most of the rainfall occurred during the monsoon season (June to October). Therefore, adoption of modern irrigation method such as pressurized irrigation method (drip and sprinkler) will be very helpful for fulfilling the food demands of growing

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population. Now a days, drip irrigation method can be used effectively for crop production under water stress situation. Hence, it is needed that the available water resources should be utilized effectively through adoption of advanced irrigation technology.

A lot of work related to application of drip irrigation method to show its impact on various parameters; growth, weight and height etc. responsible for high crop production of tomato crop by efficient and accurate application of water has been done by Firoj *et al* (2009), Singh *et al* (2009), Semiz *et al* (2010), Berihun *et al* (2011), Kahlaoui *et al* (2011), Mohammad *et al* (2013), Alaoui *et al* (2014), Reddy *et al* (2014), Khalel *et al* (2015), Sharma *et al* (2015) and Biswas *et al* (2016). They suggested that drip irrigation method has provided high yield and maximum water use efficiency and studied the relationship between irrigation amount, yield and quality. Crop diversification responsible resulted in increasing demands of fresh vegetables crops by which drip irrigation method become very popular among farmers and make a balance between demand and supply by growing of vegetable crops without reduction of agricultural land.

MATERIALS AND METHODS

Location of experimental site

The experiment was carried out at IFTM University, Moradabad (U.P.). The research farm is geographically situated at 28°21´ to 28°16´ N latitude and 78°4´ to 79° E longitudes at an altitude of 193.23 m above the mean sea level. The present research has been conducted for the year, 2016-2017 for the crop duration of tomato *i.e.* from October to April in Rabi season. This experiment has been conducted under five treatments *viz.,* T1, T2, T3, T4 and T5 using the drip irrigation method without using fertilizer and chemicals to improve irrigation scheduling of organic tomato. Land topography of the Moradabad district is almost flat.

Layout of drip irrigation system

The experimental setup consists of screen filter, main, sub mains, laterals, drippers and other accessories required for drip irrigation and fitted in the experimental plot of 0.006 ha land. The main and sub main pipelines used for drip irrigation were made of PVC pipes of 50 mm and 25 mm diameter respectively. Linear Low Density Poly Ethylene (LLDPE) pipes of 12 mm diameter were used for laterals in the treatment. Drippers having flow rate, 1.46 l/ hr (lph) were fitted on the laterals at a spacing of 70 cm and the end plug fixed on each lateral of the plot to control the flow rate of all taps. Switching was allowed through small valves placed in the beginning of each treatment. The experiment has been analyzed using the completely randomized block design (RBD).

Treatments

Five treatments were taken up for irrigation management of test plot according to soil type and weather condition of the present study area. These were T1- I hr at one day interval ; T2- 2 hr at two days interval; T3- 3 hr at three days interval;T4- 4 hr at four day interval and T5 –Control. In present study, treatments comprised of five drip irrigation levels at 50, 65, 80, 95 and 100 per cent with three replications. Harvesting was started 55-60 days after sowing (DAS). As practiced by commercial growers, curved or deformed fruits were removed from the plant during pruning operations and marketable immature fruits were harvested in 8–10 d and then weighed. The numbers of fruits were also counted. Statistical analysis of the data was performed using a completely RBD (Randomized box design) with three replications. The analysis of variance was also accounted for factors. The level of the significant difference (LSD at $P < 0.05$) was used in the ANOVA to test the effect of irrigation treatments on different response variables (Steel and Torrie, (1980). Field water use efficiency of each treatment was conducted.

Table 1. Experimental details of drip irrigation system in Tomato.

Sr. No.	Description	Unit	Details
1.	Net irrigation Area	ha	0.006
2.	Row to Row Spacing (spacing between laterals)	m	0.70
3.	Plant to Plant Spacing (spacing between emitters)	m	0.50
4.	Row Direction	-	East-West
5.	No. of emitters in each row		16
6.	Total Nunber of Plants	No	192
7.	Type of irrigation System	-	Typical Drip Irrigation System
8.	Emitter Type	-	online Emitter
9.	Emitter Per Plant	No	1 Emitter
10.	Emitter Discharge (l/hr)	LPH	1.46
11.	No. of Lateral Per Row	No	1 Lateral
12.	Water Source		Tube well
13.	Water Source Depth	m	30

Experimental details

The drip irrigation system in the present study for tomato crop different characteristics, which is crop water requirement the following steps were considered for designing purpose. The design Data of the drip irrigation system and the experimental details for the test plots are given in Table 4. 16 laterals of 12 mm diameter have been laid with spacing of 70 cm and 50 cm between row to row and plant to plant, respectively and one seeds were transplanted at a depth of 3 to 4 cm in each row.

Crop

Hybrid NS-524 variety of tomato (*Lycopersicon esculentum*) was planted in the month of January by following 70 X 50 cm spacing in the month of October and harvested in March. The soil samples were collected from the different location of the field by physical properties was judged as sandy soil. The detailed physical properties of the soils are given in Table 2.

Meteorological data

The average temp, humidity, sunshine duration, wind velocity, rainfall, and evaporation) of year 2016 were collected from the website (www.accuweather.com) which was used for the analysis. The average maximum temperature exceeds 32 ºC during hot summer in May and June and minimum temperature occasionally falls below 1ºC during winter in December and January were 16º C. The mean annual rainfall is 1024 mm. Weather parameters prevailed during the crop season were obtained from the meteorological observatory. The total rainfall during the crop season was 285 mm out of which the maximum was received in the month

Table 2. Soil physical characteristics of experiment .

Soil Depth (cm)	Size distribution of soil			Texture Class	Saturated Point (%)	F.C. (%)	W.P. %)	EC (dSm-1)
	Coarse Sand	Fine Sand	Clay Silt					
0-20	46.72	48.76	2.85	Sandy	23.0	10.5	5.6	0.35
20-40	57.73	39.55	3.60	Sandy	20.0	14.4	6.5	0.30
40-60	39.62	9.42	3.50	Sandy	22.0	12.8	4.2	0.50

of July. The relative humidity ranged from 87 to 80 per cent in July and December, respectively during the crop growing period.

Water Use Efficiency

Water use efficiency (WUE) is the yield that can be produced from a given quantity of water. It was worked out *by* using the following formula and expressed as (kg/ha/cm). Field water use efficiency of each treatment was computed using the following equation: WUE=Y/WR Where, Y = Weight of marketable produce of the crop (kg/ha) and WR=Depth of water used (cm)

Economic Analysis

The expenditure incurred from field preparation to harvest was worked out and expressed as Rs./ha. The green tomato yield was computed per hectare and the total income was worked out based on the prevailed minimum market rate of Rs. 5.0/kg. Net returns were obtained by subtracting the cost of cultivation from gross return. The cost of drip system for one hectare was worked out based on current market rates. The life of the drip system was assumed to be 5 yr.

Benefit-cost ratio (BCR)

The benefit cost ratio (BCR) was worked out by using the formula suggested by Palaniappan (1985).

Statistical Analysis

The data on various parameters studied during the course of investigation were statistically analysed, applying the technique of analysis of variance suggested by Panse and Sukhatme (1978). Wherever the treatment differences were found significant, (ANOVA test) critical difference was worked out at five per cent probability level.

RESULTS AND DISCUSSION

Effect of cropping system and water management practice

The physical characteristics of tomato crop recorded after every picking from the field and the average yield were expressed under various treatments (Table 3).

The data show that maximum average yield of tomato has been recorded under the treatment T3 when irrigation was done for three hour time interval in three days during whole crop period while least was recorded when irrigation applied every day for one hour interval (T1). Table indicated that the highest average fruit weight 10.40 kg/plant was obtained from drip irrigation and lowest 5.20 kg per plant of treatment T3. High values of uniformity coefficients indicated that drip irrigation system gave excellent performance in terms of uniformly supply of water throughout the lateral lines in the experiment. The data of growth related parameters like plant height, 17.467 cm, average fruit weight 5.0 g, Yield 644.8 q/ha, Net return 2, 49,113 Rs/

Table 3. Effect of different treatments on fruit weight, plant height , fruit yield , water use efficiency and net returns of tomato crop.

Treatment	Plant height (cm)	Fruit weight (g)	Yield (q/ha)	Water depth (cm)	Water use efficiency (q/ha-cm)	Net return (Rs./ha)	Benefit-Cost ratio
T1	16.158	5.5	561.4	20.44	2.75	199918	6.92
T2	16.367	5.0	597.8	20.44	2.92	217748	7.31
T3	17.467	5.0	644.8	20.44	3.15	249113	8.10
T4	17.125	5.0	538.8	20.44	2.64	187953	6.58
T5	16.175	4.5	508.3	20.44	2.48	173663	6.30

Table 4. Effect of irrigation scheduling on yield parameters of tomato.

Treatment	Av. plant height (cm)	Av. fruit weight (g)	Fruit weight (kg/plant)	Yield (q/ha)
T1	16.26	5.33	5.38	548.09
T2	16.54	4.83	5.96	580.50
T3	17.61	5.17	7.49	630.08
T4	17.29	5.33	4.96	526.83
T5	16.13	4.67	4.82	512.25
Mean	17.07	5.09	7.57	630.08
S.E.D	0.10	0.24	0.91	14.33
CD (0.01)	0.23**	0.13**	1.43**	33.56**
CD (0.05)	0.08*	0.16*	1.35*	7.43*

Note- * - significant at 5 % level, **- significant at 1 % level, NS – not significant

ha, Water use efficiency (WUE) 3.15 q/ha-cm, and Benefit- cost ratio (BCR) 8.10 give in table 5 indicated that drip irrigated treatments.

The data on fruit yield (t/ha) of tomato (Table 34) indicated that drip irrigation gave significantly higher yield over surface irrigation. Drip irrigation uniformity use of applied water with obtained average yield (T1) 561.4 (q/ha), (T2) 597.8 (q/ha), (T3) Yield 644.8 (q/ha), (T4) 538.8 (q/ha) and (T5) 508.3 (q/ha) indicated that drip irrigated treatments. The utmost yield obtained from the treatment of (T3) was 644.8 (q/ha). Hence, there was no significant effect of applied drip irrigation scheduling on fruit weight. It can be concluded that various yield parameters recorded under the treatment T3 ensured that more water was saved and will support the sustainable crop production and this water could be utilized for other purpose.

Benefit-cost (B:C) ratio of tomato

It can be concluded (Table 5) that treatment T3 in which irrigation water was supplied through drippers by a network of drip irrigation system in which three hour water was supplied to the root zone of the crop in every three days during whole crop grown period for achieving good quality of produce as well as maximum net return. From this study, more water was saved under treatment T3 and achieved best results such as maximum production, maximum net benefit by utilizing the less amount of irrigation water which was the main aim of conducting present trial and it will be benchmark in water deficit zones of the country to fulfill the food demands of rapidly growing population because of shrinkage of cultivation land and water resources.

The life of drip system varies from 5 to 10 yr based on quality and maintenance of drip system. Hence a normal life of drip system of 6 yr was considered for computation. Though the initial capital investment was high due to drip irrigation system, the cumulative benefit would be greater, considering the longer life of the system. The fixed cost towards installation of drip system was worked out to be Rs. 80,000/ ha taking into the prevailing rate. For maximum highest seasonal net income was recorded for the treatment with site drip irrigation and drip irrigation scheduling (Rs. 2,91,363/-) in treatment (T3). The lowest net seasonal income was recorded for the treatment with alternate day drip irrigation (Rs. 41,012/-) treatment (T3). The Benefit – Cost Ratio (BCR) values worked for various treatments show that highest BCR was recorded with the treatment site of drip irrigation and drip irrigation scheduling (8.10) treatment (T5). The

Table 5. Cost Economics from per hectare of land under various treatments.

Sr. No.	Description	T1	T2	T3	T4	T5
1	Fixed cost (Rs) Life (Years) Annual cost (Rs) Interest @ 8% (Rs) Repair and maintenance (Rs) Total Cost (Rs) (A)	80000 5 16000 6400 512 20812	80000 5 16000 6400 512 20812	80000 5 16000 6400 512 20812	80000 5 16000 6400 512 20812	80000 5 16000 6400 512 20812
2	Cost of cultivation, (Rs/ha) (B)	20050	20000	20200	20100	19500
3	Seasonal total cost (Rs) (C = A+B)	40562	40812	41012	40912	40312
4	Maximum production (q/ha)	561.417	597.33	644.750	538.83	508.250
5	Selling price (Rs/ha)	500	500	500	500	500
6	Income from produce (Rs) (D)	280780	298665	332375	269415	254125
7	Total Net seasonal benefit (Rs) E = (D – C)	240218	257852	291363	228503	213813
8	Benefit – Cost ratio F = (D/C)	6.92	7.318	8.10	6.58	6.30

lowest Benefit – Cost Ratio was recorded under the treatment with alternate day drip irrigation (6.30) treatment (T5).

CONCLUSION

It was concluded that modern irrigation system (drip) should be used as a benchmark for planning and management of available water resource by reducing water losses in large extent. For dry land area drip irrigation method will be very helpful for obtaining more food production by efficient use of water to fulfill the demand of growing population. Indian agriculture today faces the challenge of meeting demand for safe and quality food. Care has to be taken in protecting the natural resources and the environment in the race for food security. Water is a major input in agriculture. The water use efficiency of the crops has to be increased in order to reduce the water loss from the field. Drip irrigation system is considered as the most effective micro irrigation method, as water is applied directly into soil at the crop root zone.

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