International Journal of Agriculture Sciences
ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 10, Issue 12, 2018, pp.-6361-6365.
Available online at https://www.bioinfopublication.org/jouarchive.php?opt=&jouid=BPJ0000217

Research Article

STUDIES ON NUTRIENT AND WATER USE EFFICIENCY THROUGH DRIP IRRIGATION ON PLANT GROWTH AND YIELD ATTRIBUTES OF TOMATO

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Received: June 09, 2018; Revised: June 17, 2018; Accepted: June 18, 2018; Published: June 30, 2018

Abstract: The experiments were carried out during the period from September to January in consecutive years 2013, 2014 and 2015 at JVR, Horticulture Research Station, Malyal, Mahaboobabad (Dist). The primary objective is to determine optimum dosage of nutrients and irrigation through drip method in tomato for higher yields. Nine treatments with combination of different irrigation and fertigation levels were studied. The results of this study revealed that during three years of research the level 90 % RDF of N and K along with 10000 lit/acre/day (T_8) gave significantly higher yields in comparison with other treatments. So, it can be concluded that the drip irrigation with 10000 lit/acre/day with fertigation 90% RDF of N and k (T_8) increase yield of tomato by enhancing the water and fertilizer use efficiency.

Keywords: *Tomato, Drip irrigation, Fertigation, WUE,FUE*

Citation: Cheena J., *et al*., (2018) Studies on Nutrient and Water use Efficiency Through Drip irrigation on Plant growth and yield attributes of Tomato. International Journal of Agriculture Sciences, ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 10, Issue 12, pp.- 6361-6365.

Introduction

Tomato (*Lycopersicon esculentum* Mill, 2n=24), a popular vegetable crop, belongs to solanaceous family and cultivated throughout the world after potato. It is used as processed vegetable as well as consumed in salad as well as curry. In India, tomato is grown throughout the country. The leading tomato growing states are Karnataka, Andhra Pradesh, Telanaga, Orissa, Bihar and West Bengal. In India, tomatoes are grown in an area of 808.54 thousand hectares with annual production of 19696.92thousand MT with a productivity of 15.9 t ha^{-1}. Telangana stands in fourth place for area with 53.64 thousand hactare and production of 1364.93thousand MT[1]. The geographical location and the related climatic condition in the Telangana state are suitable for the quality agricultural production in general and particular to tomato cultivation. However, the major limiting factor for higher yields and more profitable production are deficit or excess application of fertilizers which often aggregated by the uneven seasonal distribution of rainfall and the inefficient irrigation water and fertilizer. Prolonged dry periods and sudden heavy rains are common phenomenon, in the regular calendar year of their region. In addition to the errectic rainfall, depletion of ground water in semi-arid areas of the state is a threatening problem which is to be addressed with improved method of irrigation and fertigation systems. Over the past decade due to the encouragement given by government the vegetable growers in Telangana state have widely adopted the micro irrigation technique. However, they are still facing problem related to optimal irrigation scheduling, for different crops. The appropriate scheduling of irrigation to Tomato along with fertigation is need of the hour to tackle the wastage of water and fertilizers. Combination of micro irrigation techniques with application of fertilizer through the irrigation systems in a common practice in modern agriculture. many authors in their drip irrigation and fertigation research reports emphasize the advantages of this practice over the conventional methods of application of water and fertilizers. Through fertigation the supply of nutrients can be more carefully regulated and monitored [2,3] minimal losses of water and plant nutrients [4], decrease in leaching and volatilization losses and minimize the chances for ground water pollution [5,2,4], improved fertilizer use efficiency – FUE [4-8], improved yield and water use efficiency [9-12]. Therefore, in view of the above facts the present work has been designed with the primary objective of determining the optimum water and fertilizer dosages through fertigation practice for higher yield potential in tomato crop. Simultaneously, this study also aimed to evaluate the impact of this practice on the water and fertilizer use efficiency in tomato production.

Material and methods

The field experiment was conducted during September to January for consecutive three years 2013,2014, and 2015 at JVR Horticultural Research Station Malyal, Sri Konda Laxman Telangana State Horticulture University, Mahabubabad(Dist). The variety chosen for the experiment is US608, the soil type of experiment site is black soil and the pH is 6.5-7.0 and EC is 6.2 dS/m. The experiment was laid out in two factors and nine treatment combinations consists of three fertigation treatments and three irrigation treatments. The experiment was laid in factorial randomized block design in three replications the plot size of each treatment is 3 x2.50 m and spacing was 60 x 50 cm

Irrigation treatments	fertigation treatments
I_1-8000 lit /acre/day	F_1-70% RDF of N&K
I_2-10000 lit /acre/day	F_2-80% RDF of N&K
I_3-12000 lit /acre/day	F_3-90% RDF of N&K

Irrigation scheduling

Irrigation were scheduled on the basis of climatological approach. Life saving irrigation was given immediately after transplanting and field was regularly irrigated continuously for ten days after 10th day subsequent irrigation was

Table-1 Studies on nutrient and water use efficiency through Drip irrigation on plant height of Tomato

Treatment	Plant height (cm)															
	2013-14				2014-15				2015-16				Pooled			
	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean
F_1	44.15	48.02	45.96	46.04	44.92	47.01	46.58	46.17	48.01	49.41	49.05	48.82	45.69	48.15	47.20	47.01
F_2	49.36	52.10	51.64	51.03	48.68	54.52	54.05	52.42	51.40	54.24	52.12	52.59	49.82	53.62	52.61	52.02
F_3	52.18	65.32	57.48	58.33	55.22	66.93	55.75	59.30	55.11	68.80	57.48	60.46	54.17	67.02	56.90	59.36
Mean	48.56	55.15	51.69		49.61	56.15	52.13		51.51	57.48	52.88		49.89	56.26	52.24	
	SEM±		CD(P=0.05)		SEM±		CD(P=0.05)		SEM±		CD(P=0.05)		SEM±		CD(P=0.05)	
F	0.14		0.42		0.12		0.36		0.31		0.92		0.37		1.11	
I	0.14		0.42		0.12		0.36		0.31		0.92		0.37		1.11	
FxI	0.26		0.79		0.20		0.61		0.53		1.58		0.64		1.93	

Table-2 Studies on nutrient and water use efficiency through Drip irrigation on Number of branches of Tomato

Treatment	No of Branches															
	2013-14				2014-15				2015-16				Pooled			
	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean
F_1	3.93	4.38	4.11	4.14	6.77	7.51	7.09	7.12	7.75	8.68	8.19	8.21	6.15	6.86	6.46	6.49
F_2	4.90	6.08	5.60	5.53	7.94	8.93	8.04	8.30	8.72	9.04	8.95	8.90	7.19	8.02	7.53	7.58
F_3	6.14	6.42	6.19	6.25	8.99	9.03	9.01	9.01	9.08	9.60	9.47	9.38	8.07	8.35	8.22	8.21
Mean	4.99	5.63	5.30		7.90	8.49	8.05		8.52	9.11	8.87		7.14	7.74	7.40	
	SEM±		CD(P=0.05)		SEM±		CD(P=0.05)		SEM±		CD(P=0.05)		SEM±		CD(P=0.05)	
F	0.12		0.35		0.13		0.38		0.13		0.40		0.09		0.27	
I	0.12		0.35		0.13		0.38		0.13		0.40		0.09		0.27	
FxI	0.21		0.62		0.22		0.65		0.24		0.71		0.16		0.48	

Table-3 Studies on nutrient and water use efficiency through Drip irrigation on No of fruits of Tomato

Treatment	No of Fruits															
	2013-14				2014-15				2015-16				Pooled			
	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean
F_1	31.63	35.91	32.08	33.21	35.32	37.76	36.32	36.47	35.49	39.60	36.64	37.24	34.15	37.76	35.01	35.64
F_2	36.65	39.42	37.90	37.99	37.82	39.29	38.43	38.51	40.01	42.17	41.28	41.15	38.16	40.29	39.20	39.22
F_3	42.09	52.09	48.39	47.52	40.25	42.32	41.36	41.31	42.83	44.96	43.43	43.74	41.72	46.45	44.39	44.19
Mean	36.79	42.47	39.46		37.80	39.79	38.70		39.44	42.24	40.45		38.01	41.50	39.53	
	SEM±		CD(P=0.05)		SEM±		CD(P=0.05)		SEM±		CD(P=0.05)		SEM±		CD(P=0.05)	
F	0.03		0.10		0.34		1.02		0.03		0.10		0.88		2.63	
I	0.03		0.10		0.34		1.02		0.03		0.10		0.88		2.63	
FxI	0.06		0.19		0.59		1.77		0.05		0.16		1.51		4.54	

Table-4 Studies on nutrient and water use efficiency through Drip irrigation on fresh fruit weight of Tomato

Treatment	Fresh Fruits weight (g)															
	2013-14				2014-15				2015-16				Pooled			
	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean
F_1	39.33	50.07	42.67	44.02	49.00	54.00	63.47	55.49	40.00	58.82	44.67	47.83	42.78	54.30	50.27	49.12
F_2	51.59	56.56	53.25	53.80	61.54	68.49	66.18	65.40	60.36	68.65	64.28	64.43	57.83	64.57	61.23	61.21
F_3	58.25	64.27	60.43	60.98	69.39	74.51	70.35	71.42	68.99	74.15	69.33	70.82	65.54	70.98	66.70	67.74
Mean	49.72	56.97	52.12		59.98	65.67	66.67		56.45	67.21	59.43		55.38	63.28	59.40	
	SEM±		CD(P=0.05)		SEM±		CD(P=0.05)		SEM±		CD(P=0.05)		SEM±		CD(P=0.05)	
F	0.47		1.42		0.35		1.05		0.29		0.88		1.24		3.72	
I	0.47		1.42		0.35		1.05		0.29		0.88		1.24		3.72	
FxI	0.82		2.48		0.61		1.83		0.52		1.55		2.14		6.43	

Table-5 Studies on nutrient and water use efficiency through Drip irrigation on yield per plant of Tomato

Treatment	Yield/plot (kg)															
	2013-14				2014-15				2015-16				Pooled			
	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean
F_1	1.24	1.80	1.37	1.47	1.42	2.33	1.64	1.80	1.42	2.33	1.64	1.80	1.36	2.15	1.55	1.69
F_2	1.89	2.23	2.02	2.05	2.42	2.90	2.65	2.66	2.42	2.90	2.65	2.66	2.24	2.67	2.44	2.45
F_3	2.45	3.35	2.92	2.91	2.96	3.33	3.01	3.10	2.96	3.33	3.01	3.10	2.79	3.34	2.98	3.04
Mean	1.86	2.46	2.10		2.27	2.85	2.43		2.27	2.85	2.43		2.13	2.72	2.32	
	SEM±		CD(P=0.05)		SEM±		CD(P=0.05)		SEM±		CD(P=0.05)		SEM±		CD(P=0.05)	
F	0.02		0.06		0.03		0.09		0.01		0.04		0.05		0.15	
I	0.02		0.06		0.03		0.09		0.01		0.04		0.05		0.15	
FxI	0.03		0.09		0.05		0.14		0.02		0.06		0.09		0.26	

Table-6 Studies on nutrient and water use efficiency through Drip irrigation on yield per ha of Tomato

Treatment	Yield (t/ha)															
	2013-14				2014-15				2015-16				Pooled			
	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean
F_1	24.89	35.97	27.39	29.42	34.62	40.85	46.09	40.52	28.39	46.59	32.74	35.91	29.30	41.14	35.41	35.28
F_2	37.81	44.59	40.36	40.92	46.55	53.81	50.86	50.41	48.31	57.90	53.07	53.09	44.22	52.10	48.10	48.14
F_3	49.03	66.96	58.49	58.16	55.86	63.07	58.19	59.04	59.10	66.68	60.22	62.00	54.66	65.57	58.97	59.73
Mean	37.24	49.17	42.08		45.68	52.58	51.71		45.27	57.06	48.68		42.73	52.94	47.49	
	SEM±		CD(P=0.05)		SEM±		CD(P=0.05)		SEM±		CD(P=0.05)		SEM±		CD(P=0.05)	
F	0.38		1.13		0.57		1.71		0.25		0.76		1.39		4.18	
I	0.38		1.13		0.57		1.71		0.25		0.76		1.39		4.18	
FxI	0.65		1.95		0.99		2.97		0.44		1.31		2.52		7.57	

scheduled once in three days based on the following formula and applied each time as per the treatment schedule. The discharge ratio of single dipper is 4 lph at anominal operating pressure

$$WRc=CPE \times Kp \times Kc \times Wp \times A$$

Where
WRc : computed water requirement (litre plant^{-1})
CPE : Cumulative pan evaporation
for three days
Kp : Pan Factor (0.8)
Kc : Crop Factor
Wp : Wetted fraction
A : area per plant. m^2

$$Time\ of\ operation = \frac{Volume\ of\ water\ required \times irrigation\ interval}{Emitter\ discharge}$$

Fertigation Scheduling

Drip laterals were laid along the length of each raised bed at the centre with spacing kept at 1.20m between two adjacent laterals. Fertigation to individual plant in each replication was controlled by a manual regulating value fixed to the lateral lines to ensure precise delivery of the required inputs thus enabling full control of experimental setup. A dosage of 100:375:150 NPK Kg ha^{-1} was taken as 100 percent recommended dose entire dose of Phosphorous was applied as basal dose and 70%, 80% and 90% of RDF of N and K were applied through fertigation at four stages of crop growth *i.e.*,

1. Transplanting to plant establishment stage (0-10 days)
2. Flower initiation to flowering stage (10-40 days)
3. Flowering to fruit set (40-70 days)
4. Alternate day from picking (70-120 days)

Results and Discussion

Plant height (cm)

A perusal of data on plant height is presented in [Table-1]. Indicates a significant effect of drip irrigation and fertigation levels on plant height at final harvest. The maximum plant height (67.02 cm) was recorded under treatment T_8 (10000 lit/acre/day irrigation + 90% RDF of N&K) and the minimum Plant height (45.69 cm) was recorded in T_1 (8000 lit/acre/day irrigation + 70 % RDF of N&K). These results are in agreement with the findings of (13) recorded the average plant height (95.9 cm) with fertigation of 80 percent of RDF. (14) calculated that drip fertigation was equally efficient in improving yield and growth parameters with 30% saving in fertilizers compared with the conventional system of fertilizer application

Number of branches

The data presented in [Table-2]. Represents a significant effect of drip irrigation and fertigation levels on Number of branches at 90 days after transplanting. The maximum number of branches (8.35) was recorded under treatment T_8 (10000 lit/acre/day irrigation + 90 % RDF of N&K) and the minimum Number of branches (6.14) was recorded in T_1 (8000 lit/acre/day irrigation + 70% RDF of N&K). Similar findings were found with (15), (16) where no. of branches were found maximum (8.20) for the treatment T_6 (100 % evaporation through drip irrigation+ polythene mulch) and they concluded that the sufficient soil moisture and nutrients maintained by drip irrigation and fertigation leads to better development of photosynthetic area and full fills the nutritional requirements of the plant. This can be explained by the fact that with drip fertigation the root zone is simultaneously supplied with water and readily available nutrients. [17] reported that in a fertigation system, the timing, amounts, concentrations and ratios of the nutrients are easily controlled. Due to this improved control crop yields are higher than those produced by a conventional fertilizer application and irrigation.

Number of fruits

The data presented in the [Table-3]. Indicates significant effect of drip irrigation and fertigation levels on number of fruits at final harvest. The maximum number of fruits (46.45) was recorded under treatment T_8 (10000 lit/acre/day irrigation + 90 % RDF of N&K) and the minimum number of fruits (34.15) was recorded in T_1 (8000 lit/acre/day irrigation + 70 % RDF of N&K).

Fresh fruit weight (g)

The data presented in the [Table-4]. Indicates significant effect of drip irrigation and fertigation levels on fresh fruit weight at final harvest. The maximum fresh fruit weight (70.98 g) was recorded under treatment T_8 (10000 lit/acre/day irrigation + 90% RDF of N&K) and the minimum fresh fruit weight (42.78 g) was recorded in T1 (8000 lit/acre/day irrigation + 70 %RDF of N&K).

Yield per plot (kg/plot)

The data presented in the [Table-5]. Indicates significant effect of drip irrigation and fertigation levels on Yield per plant (kg/plot) at final harvest. The maximum Yield per plant (kg/plant) (3.34 kg/plot) was recorded under treatment T_8 (10000 lit/acre/day irrigation + 90 % RDF of N&K) and the minimum Yield per plot (kg/plot) (1.36 kg/plant) was recorded in T_1 (8000 lit/acre/day irrigation + 70 % RDF of N&K).

Yield per hectare(t/ha)

The data presented in the [Table-6]. Indicates significant effect of drip irrigation and fertigation levels on Yield per hectare(t/ha) at final harvest. The maximum Yield per hectare(t/ha)(65.57 t/ha) was recorded under treatment T_8 (10000 lit/acre/day irrigation + 90 % RDF of N&K) and the minimum Yield per hectare(t/ha)(29.30 t/ha) was recorded in T_1 (8000 lit/acre/day irrigation + 70 % RDF of N&K). The better yield components in different crops especially when drip irrigation was used in comparison with other irrigation techniques as well as when the drip fertigation was applied in comparison with conventional fertilizer application [18-21]. This can also be explained by the fact that the drip irrigation the plants are permanently provided with readily available water i.e., their crop water requirements are met in a timely manner. Increased yields using drip irrigation can be attributed to several factors: higher water use efficiency because of precise application of directly to the root zone and lower losses due to reduced evaporation, runoff and deep percolation, reduced fluctuations in the soil water content resulting with avoidance of water stress and *etc* [22].

Conclusion

The treatment 1000 lit/acre/day of irrigation in combination with 90 percent RDF of N&K(T_8) resulted in was higher Tomato yield when compared with other dosage of fertilizers and various levels of irrigation. Generally, the benefit of combining drip irrigation with fertigation in tomato improved yield and yield components by increasing water use efficiency. In addition to drip, improved fertigation is an effective method to protect the environment because applied nutrients are not leached beyond the root zone during the irrigation as well as because of the reduced volatilization losses. Finally, from our research we can conclude that the optimal frequency for irrigation and fertigation of tomato crop is 2-4 days.

Application of research: Proposed for the State level technical programme for the year 2013 for the director of research and Director of research has approved the programme

Research Category: Drip fertigation studies on Horticulture crop (Tomato)

Abbreviations:

FUE= Fertilizer Use Efficiency
WUE= Water Use Efficiency
RDF= Recommended Dose of Fertilizer

Acknowledgement / Funding: Author thankful to Sri Konda Laxman Telangana State Horticulture University, Rajendranagar, Hyderabad-30, Telangana, India

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Research project name or number: Studies on nutrient and water use efficiency through Drip irrigation on plant growth and yield attributes of Tomato under SLTP

Author Contributions: All author equally contributed
Author statement: All authors read, reviewed, agree and approved the final manuscript

Conflict of Interest: There is no conflicts regarding the research.

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.

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