



## Response of tomato (*Solanum lycopersicum* L.) to fertigation by irrigation scheduling in drip irrigation system

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**Abstract:** Drip irrigation technique has proved its superiority over other methods of irrigation due to direct application of water and nutrient in the vicinity of root zone. A field study was conducted to evaluate the effect of irrigation and fertigation scheduling through drip irrigation in tomato (*Solanum lycopersicum* L.) during Rabi season of 2015-16 at Rajasthan College of Agriculture, MPUAT, Udaipur. There were three irrigation levels and five fertilization levels in split-plot design with three replications. Nutrient content in plant and fruit was found higher under the application of drip irrigation at 100 % PE (I<sub>1</sub>) and at 100 % RDF through fertigation (F<sub>1</sub>). Maximum nutrient uptake by tomato i.e. nitrogen (166.83 kg ha<sup>-1</sup>), phosphorus (41.59 kg ha<sup>-1</sup>) and potassium (183.08 kg ha<sup>-1</sup>) was recorded with treatment combination of drip irrigation at 75 % PE (I<sub>2</sub>) + 75 % RDF through fertigation + 2 foliar spray of 1 % urea phosphate (F<sub>3</sub>). Similarly, significantly maximum yield and growth attributes i.e. fruit yield (201.25 q ha<sup>-1</sup>), plant height (67.43 cm) and number of branches (12.33) were registered with treatment combination of drip irrigation at 75 % PE and 75 % RDF through fertigation + 2 foliar spray of 1 % urea phosphate. Drip fertigation method has proved to be very significant in improving nutrient uptake which finally resulting in enhancement of growth and yield of tomato crop.

**Keywords:** Fertigation, Growth, Nutrient content and uptake, Tomato, Yield

### INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is an important and widely grown solanaceous vegetable crop around the world and belongs to the family Solanaceae. It is considered an important source of vitamin A, C and minerals (Hari, 1997). Apart from this, lycopene is valued for its anti-cancer property. Water supply is major constraint to crop production. Water is the source of life and has a special place in our planet. 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. With the drip irrigation systems, water and nutrients can be applied directly to the crop at the root level, having positive effects on nutrient uptake, yield and water saving and increasing the irrigation performance (Nagaz *et al.*, 2012). Drip irrigation is an advanced system through which water can be applied precisely, judiciously and uniformly with the help of regulatory system direct to the root of the crop. At the same time, adequate fertilization both in time and through method application to maintain optimum nutrient supply for optimum growth and development of the crop are also equally important towards the higher

productivity (Nijamodeen and Dharmasena, 2002). Drip irrigation include improves nutrient content and uptake, increase plant growth and development, higher yield in scheduling water application. Application of water soluble fertilizer through micro-irrigation system like drip (fertigation) is gaining importance in present day agriculture to boost the production and productivity of various crops. With this background, the present study was conducted on filed grown tomato with the objectives: i) To study the effect of various irrigation and fertigation scheduling on nutrient content and uptake of tomato crop ii) To study the effect of NPK drip fertigation on growth and yield of tomato crop.

### MATERIALS AND METHODS

The experiment was conducted at field no. C3, Department of Horticulture, Rajasthan College of Agriculture, Maharana Partap University of Agriculture and Technology (MPUAT), Udaipur. The region falls under agro-climatic zone IVA (Sub- Humid Southern Plain and Aravalli Hills) of Rajasthan. The soil of the experimental area belongs to clay loam in texture. The physic-chemical properties of soil are given in Table 1. The experiment was laid out in split plot design and replicated three times with fifteen fertigation treatment

**Table 1.** Physio-chemical properties of Udaipur soil (clay loam soils).

Physio-chemical properties	
pH (1:2, soil : water)	8.15
Bulk density (Mg m <sup>-3</sup> )	
Particle density (Mg m <sup>-3</sup> )	
Porosity (%)	1.52
Organic carbon (%)	0.71
DTPA-extractable copper (mg kg <sup>-1</sup> )	1.98
DTPA-extractable zinc (mg kg <sup>-1</sup> )	1.78
EC (dSm <sup>-1</sup> ) (1:2, soil: water)	0.67
Available nitrogen (kg N ha <sup>-1</sup> )	296.45
Available phosphorus (kg P <sub>2</sub> O <sub>5</sub> ha <sup>-1</sup> )	23.76
Available potassium (kg K <sub>2</sub> O ha <sup>-1</sup> )	318.65
DTPA-extractable iron (mg kg <sup>-1</sup> )	5.98
DTPA-extractable manganese (mg kg <sup>-1</sup> )	6.64

combinations. The treatments include three levels of irrigation water viz., 100 %, 75 % and 50 % PE through drip and five levels of fertilizations viz., 100 % RDF, 75 % RDF, 75 % RDF through fertigation + 2 foliar spray of 1 % urea phosphate, 50 % RDF and 50 % RDF through fertigation + 2 foliar spray of 1 % urea phosphate. Irrigation schedules were planned to provide the estimated water requirement of the crop. Irrigation was schedules based on the three days interval water requirement of the crop. In order to determine the optimum water requirement for crops, three irrigation levels were adopted with 100, 75 and 50 percent (PE) water requirement of the crop. The discharge rate of the emitter was 2.5 liters per hour at nominal pressure of 1.25 kg cm<sup>-2</sup>.

The quantity of irrigation water was calculated by using following formula (Vermerien and Jobling, 1980).

$$ET_c = E_{pan} \times K_{pan} \times K_c \quad \dots\dots(Eq. 1)$$

Where, ET<sub>c</sub> = Evapotranspiration of crop (mm), E<sub>pan</sub> = Pan evaporation (mm), K<sub>pan</sub> = Pan Coefficient (0.7), K<sub>c</sub> = Crop coefficient (as per growth stages)

$$\text{Volume of water} = E_p \times K_p \times K_c \times S_1 \times S_2 \times Wa/E \quad \dots\dots(Eq. 2)$$

Where, S<sub>1</sub> = Spacing between laterals (M), S<sub>2</sub> = Spac-

ing between emitters (M), Wa = Wetted Area (%), E = Efficiency of System (%). The operation time of the system (T) was calculated by using the following formula

$$T = V / Q \times N_e \quad \dots\dots(Eq. 3)$$

where, T = Operating time of system (hrs.), V = Total volume of water (lit.), q = Emitter discharge (Lph), Ne = Number of emitters plot<sup>-1</sup>. Scheduling of irrigation was done by using crop coefficient in drip irrigation (Doorenbos and Pruitt, 1977).

Fertigation with recommended fertilizer dose *i.e.* 180:120:80 kg NPK/ha was given according to the treatments in 6 split doses at 15 days interval beginning 10 days after transplanting. All other package of practices were adopted as recommended for the region. Observations on different growth and yield parameters were recorded from five randomly sampled plants from each treatment.

The method used for estimation of N was Microkjeldhal (Parkinson and Allen, 1975), for P Vanadomolybdate yellow colour method in nitric acid system (Jackson, 1973) and for K Flamephotometer (A.O.A.C., 2012). For this purpose the tomato plants were sundried first for a period of 10 days and then kept in hot air oven at 65 °C till constant weight was obtained. The dried plant samples were grinded in stainless still wiley mill to fine powder and used for chemical analysis of N, P and K content.

## RESULTS AND DISCUSSION

### Nutrient content

**Effect of irrigation:** The results in Table 2 revealed that nutrient content in plant *i.e.* nitrogen (1.88 %), phosphorus (0.42 %) and potassium (1.94 %) and in fruit *i.e.* nitrogen (2.55 %), phosphorus (0.61 %) and potassium (2.72 %) was significantly increased with the application of drip irrigation upto 100 % PE (I<sub>1</sub>) as compared to irrigation level I<sub>2</sub> and I<sub>3</sub>. The maximum improvement in nitrogen, phosphorus and potassium

**Table 2.** Effect of drip irrigation and fertigation on N, P and K content (%) in tomato plant and fruit at harvest.

Treatments	Tomato plant			Tomato fruit		
	Nitrogen	Phosphorus	Potassium	Nitrogen	Phosphorus	Potassium
Irrigation levels						
I <sub>1</sub>	1.88	0.42	1.94	2.55	0.61	2.72
I <sub>2</sub>	1.81	0.39	1.87	2.43	0.58	2.66
I <sub>3</sub>	1.76	0.34	1.81	2.39	0.54	2.59
C.D.5%	0.05	0.003	0.019	0.043	0.025	0.063
Fertilization levels						
F <sub>1</sub>	1.91	0.43	1.95	2.56	0.63	2.78
F <sub>2</sub>	1.80	0.38	1.88	2.44	0.57	2.68
F <sub>3</sub>	1.84	0.42	1.96	2.48	0.62	2.77
F <sub>4</sub>	1.75	0.34	1.77	2.35	0.52	2.51
F <sub>5</sub>	1.80	0.36	1.82	2.44	0.55	2.54
C.D.5%	0.045	0.002	0.015	0.03	0.022	0.058

I<sub>1</sub> = Drip irrigation at 100% PE; I<sub>2</sub> = Drip irrigation at 75 % PE; I<sub>3</sub> = Drip irrigation at 50% PE; F<sub>1</sub> = 100% RDF through fertigation; F<sub>2</sub> = 75% RDF through fertigation, F<sub>3</sub> = 75% RDF through fertigation + 2 foliar spray of 1% urea phosphate; F<sub>4</sub> = 50% RDF through fertigation; F<sub>5</sub> = 50% RDF through fertigation + 2 foliar spray of 1% urea phosphate

**Table 3.** Effect of drip irrigation and fertigation on N, P and K uptake ( $\text{kg ha}^{-1}$ ) by tomato plant and fruit after harvest.

Treatments	Tomato plant			Tomato fruit			Total		
	Nitrogen	Phosphorus	Potassium	Nitrogen	Phosphorus	Potassium	Nitrogen	Phosphorus	Potassium
Irrigation levels									
I <sub>1</sub>	53.19	12.06	55.04	82.58	20.12	88.34	135.77	32.21	143.38
I <sub>2</sub>	54.20	12.09	56.33	83.59	20.18	92.05	137.79	32.24	148.38
I <sub>3</sub>	49.21	9.79	50.52	76.64	17.54	83.09	125.86	27.33	133.61
C.D.5%	1.76	0.72	3.22	3.16	1.45	5.12	4.83	2.12	8.19
Fertilization levels									
F <sub>1</sub>	60.46	13.79	61.96	92.96	23.09	101.27	153.43	36.87	163.23
F <sub>2</sub>	52.04	11.07	54.23	80.90	18.93	89.13	132.94	30.00	143.37
F <sub>3</sub>	60.52	14.04	64.58	94.09	23.63	104.98	154.62	37.67	169.56
F <sub>4</sub>	42.00	8.34	42.42	64.93	14.55	69.17	106.93	22.88	111.60
F <sub>5</sub>	45.97	9.35	46.63	71.80	16.20	74.58	117.78	25.54	121.21
C.D.5%	2.08	0.51	2.53	4.15	1.08	4.04	5.93	1.52	6.39

I<sub>1</sub> = Drip irrigation at 100% PE; I<sub>2</sub> = Drip irrigation at 75 % PE; I<sub>3</sub> = Drip irrigation at 50% PE; F<sub>1</sub> = 100% RDF through fertigation; F<sub>2</sub> = 75% RDF through fertigation, F<sub>3</sub> = 75% RDF through fertigation + 2 foliar spray of 1% urea phosphate; F<sub>4</sub> = 50% RDF through fertigation; F<sub>5</sub> = 50% RDF through fertigation + 2 foliar spray of 1% urea phosphate.

**Table 4.** Combined effect of drip irrigation and fertigation levels on N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O uptake ( $\text{kg ha}^{-1}$ ) by tomato crop.

Treatment	Tomato plant			Tomato fruit			Total		
	Nitrogen	Phosphorus	Potassium	Nitrogen	Phosphorus	Potassium	Nitrogen	Phosphorus	Potassium
I <sub>1</sub> F <sub>1</sub>	62.36	14.80	63.84	95.14	23.91	101.20	157.50	38.71	165.04
I <sub>1</sub> F <sub>2</sub>	53.20	11.58	56.03	83.61	20.30	90.15	136.81	31.87	146.18
I <sub>1</sub> F <sub>3</sub>	57.18	14.08	63.03	89.69	23.19	99.24	146.87	37.26	162.27
I <sub>1</sub> F <sub>4</sub>	45.92	9.90	45.86	72.27	16.35	76.03	118.19	26.24	121.89
I <sub>1</sub> F <sub>5</sub>	47.28	10.11	46.43	72.19	16.84	75.10	119.47	26.95	121.53
I <sub>2</sub> F <sub>1</sub>	61.66	14.69	65.11	95.60	24.15	106.63	157.26	38.83	171.75
I <sub>2</sub> F <sub>2</sub>	53.53	11.82	56.41	80.99	19.11	92.84	134.52	30.93	149.25
I <sub>2</sub> F <sub>3</sub>	65.65	15.74	69.09	101.17	25.85	113.99	166.83	41.59	183.08
I <sub>2</sub> F <sub>4</sub>	42.09	8.14	42.28	65.11	14.40	68.49	107.19	22.54	110.77
I <sub>2</sub> F <sub>5</sub>	48.09	9.91	48.77	75.09	17.41	78.30	123.17	27.32	127.07
I <sub>3</sub> F <sub>1</sub>	57.37	11.87	56.91	88.15	21.20	95.98	145.52	33.07	152.90
I <sub>3</sub> F <sub>2</sub>	49.41	9.81	50.26	78.10	17.37	84.41	127.50	27.18	134.67
I <sub>3</sub> F <sub>3</sub>	58.73	12.29	61.61	91.42	21.87	101.72	150.16	34.16	163.33
I <sub>3</sub> F <sub>4</sub>	38.00	6.98	39.13	57.42	12.89	62.99	95.42	19.87	102.13
I <sub>3</sub> F <sub>5</sub>	42.55	8.01	44.70	68.13	14.35	70.33	110.69	22.36	115.02
C.D. 5%	3.63	0.91	4.46	7.19	1.91	7.17	10.21	2.69	11.34

I<sub>1</sub> = Drip irrigation at 100% PE; I<sub>2</sub> = Drip irrigation at 75 % PE; I<sub>3</sub> = Drip irrigation at 50% PE; F<sub>1</sub> = 100% RDF through fertigation; F<sub>2</sub> = 75% RDF through fertigation, F<sub>3</sub> = 75% RDF through fertigation + 2 foliar spray of 1% urea phosphate; F<sub>4</sub> = 50% RDF through fertigation; F<sub>5</sub> = 50% RDF through fertigation + 2 foliar spray of 1% urea phosphate.

**Table 5.** Effect of drip irrigation and fertigation on growth characters yield of tomato.

Treatments	Plant height (cm)	Number of branches	Average fruit weight (gm)	Average fruit yield per plant (kg)	Fruit yield (q ha <sup>-1</sup> )
Irrigation levels					
I <sub>1</sub>	51.97	8.27	88.91	2.75	159.51
I <sub>2</sub>	55.83	9.00	95.32	3.19	169.03
I <sub>3</sub>	51.10	7.67	87.59	2.60	157.0
C.D.5%	2.72	0.96	3.79	0.12	8.57
Fertilization Levels					
F <sub>1</sub>	55.74	9.78	91.01	2.98	179.25
F <sub>2</sub>	53.98	8.44	90.28	2.84	163.38
F <sub>3</sub>	59.53	10.67	96.59	3.25	186.38
F <sub>4</sub>	45.29	5.33	85.38	2.49	135.61
F <sub>5</sub>	50.29	7.33	89.77	2.67	144.61
C.D.5%	1.86	0.59	3.56	0.06	7.23

I<sub>1</sub> = Drip irrigation at 100% PE; I<sub>2</sub> = Drip irrigation at 75 % PE; I<sub>3</sub> = Drip irrigation at 50% PE; F<sub>1</sub> = 100% RDF through fertigation; F<sub>2</sub> = 75% RDF through fertigation, F<sub>3</sub> = 75% RDF through fertigation + 2 foliar spray of 1% urea phosphate; F<sub>4</sub> = 50% RDF through fertigation; F<sub>5</sub> = 50% RDF through fertigation + 2 foliar spray of 1% urea phosphate.

content of tomato fruit and plant was recorded with higher level of drip irrigation which could be ascribed to better and timely availability of water and nutrients. Due to this, the force exerted by the plants to extract water and nutrients would be less and this might have enabled the crop to put forth better nutrient content in fruit and plant. These results are in conformity with the findings of Al-Mohammadi and Al-Zu'bi (2011) in tomato crop with higher dose of fertigation at flowering and fruiting stage and Vazquez *et al.* (2011) in cauliflower with plastic mulching.

**Effect of fertigation:** The results in Table 2 revealed that nutrient content in plant *i.e.* nitrogen (1.91 %), phosphorus (0.43 %) and potassium (1.95 %) and in fruit *i.e.* nitrogen (2.56 %), phosphorus (0.63 %) and potassium (2.78 %) was significantly higher under (F<sub>1</sub>) 100 % RDF through fertigation. Higher nutrient content under the higher levels of fertigation as compared to other treatments might be due to frequent application of irrigation and fertilizer in drip with low concentration, for which the nutrients were effectively utilized as these were in direct contact with root system with negligible loss through leaching beyond the deeper depth of the soil profile. The findings are in the line of Badr *et al.* (2007) in chilli at higher N rate *i.e.* 300 kg ha<sup>-1</sup>. Kohire and Das (2015) also reported higher nutrient content in chilli crop with 100 % irrigation regime and 100 % RDF through fertigation.

#### Nutrient uptake

**Effect of irrigation:** The results in Table 3 resulted that nutrient uptake by plant *i.e.* nitrogen (54.20 kg ha<sup>-1</sup>), phosphorus (12.09 kg ha<sup>-1</sup>) and potassium (56.33 kg ha<sup>-1</sup>) and by fruit *i.e.* nitrogen (83.59 kg ha<sup>-1</sup>), phosphorus (20.18 kg ha<sup>-1</sup>) and potassium (92.05 kg ha<sup>-1</sup>) was higher under drip irrigation at 75 % PE (I<sub>2</sub>) as compared to irrigation level I<sub>1</sub> and I<sub>3</sub>. Total nutrient uptake *i.e.* nitrogen (137.79 kg ha<sup>-1</sup>), phosphorus (32.24 kg ha<sup>-1</sup>) and potassium (148.38 kg ha<sup>-1</sup>) was also significant higher with I<sub>2</sub> treatment. Drip irriga-

tion at 75 % PE increase the nutrient uptake which may be due to approaching towards meeting the daily evaporation demand through drip irrigation, increased the availability of moisture resulting in higher nutrient uptake through its influence on biomass production and on the availability of nutrients. Preferential uptake of water from the sufficiently moist soil promoted the movement of nutrient ions towards roots and their uptake (Sanchez *et al.*, 2001).

**Effect of fertigation:** The results in Table 3 revealed that nutrient uptake by plant *i.e.* nitrogen (60.52 kg ha<sup>-1</sup>), phosphorus (14.04 kg ha<sup>-1</sup>) and potassium (64.58 kg ha<sup>-1</sup>) and by fruit *i.e.* nitrogen (94.09 kg ha<sup>-1</sup>), phosphorus (23.63 kg ha<sup>-1</sup>) and potassium (104.98 kg ha<sup>-1</sup>) was higher under 75 % RDF through fertigation + 2 foliar spray of 1 % urea phosphate (F<sub>3</sub>). Total nutrient uptake by crop *i.e.* nitrogen (154.62 kg ha<sup>-1</sup>), phosphorus (37.67 kg ha<sup>-1</sup>) and potassium (169.56 kg ha<sup>-1</sup>) was also significant higher with F<sub>3</sub> treatment. However, fertigation with 75 % RDF + 2 foliar spray of 1 % urea phosphate and 100 % RDF was found at par. The highest uptake of nitrogen, phosphorus and potassium at 75 % RDF through fertigation + 2 foliar spray of urea phosphate might be due to the fact that nitrogen increases the cation exchange capacity of plant roots and these make them more efficient in absorbing other nutrient ions like phosphorus and potassium. Increase in nitrogen uptake was due to increased availability of nitrogen in soil with higher rate of application (Kumar and Sahu, 2013 in cabbage and Kohire and Das, 2015 in chilli crop). The higher nitrogen, phosphorus and potassium, uptake was noticed at 75% RDF through fertigation + 2 foliar spray of urea phosphate treatment which might be due to fact that the cyclic regulation and continuous wetting of soil through drip irrigation maintained optimum moisture in the crop root zone which also reduces the force exerted by the plant to extract water and nutrients would be less. Further, application of nutrients number of splits in drip fertiga-

**Table 6.** Combined effect of drip irrigation and fertigation levels on fruit yield, number of branches and plant height of tomato.

Treatment	Plant height (cm)	Number of branches	Av. fruit weight (g)	Av. fruit yield per plant (kg)	Fruit yield (q ha <sup>-1</sup> )
I <sub>1</sub> F <sub>1</sub>	54.56	9.67	89.39	2.94	177.07
I <sub>1</sub> F <sub>2</sub>	53.55	8.33	88.65	2.76	161.45
I <sub>1</sub> F <sub>3</sub>	55.98	10.33	92.08	3.07	172.78
I <sub>1</sub> F <sub>4</sub>	46.40	5.67	86.35	2.43	144.45
I <sub>1</sub> F <sub>5</sub>	49.38	7.33	88.08	2.54	141.80
I <sub>2</sub> F <sub>1</sub>	58.43	10.33	95.45	3.40	186.92
I <sub>2</sub> F <sub>2</sub>	56.82	9.33	95.22	3.20	169.92
I <sub>2</sub> F <sub>3</sub>	67.43	12.33	98.62	3.49	201.25
I <sub>2</sub> F <sub>4</sub>	43.43	5.33	92.62	2.85	134.50
I <sub>2</sub> F <sub>5</sub>	53.02	7.67	94.72	3.00	152.58
I <sub>3</sub> F <sub>1</sub>	54.23	9.33	88.18	2.61	173.77
I <sub>3</sub> F <sub>2</sub>	51.58	7.67	86.98	2.54	158.77
I <sub>3</sub> F <sub>3</sub>	55.16	9.33	99.08	3.20	185.11
I <sub>3</sub> F <sub>4</sub>	46.03	5.00	77.19	2.19	127.88
I <sub>3</sub> F <sub>5</sub>	48.48	7.00	86.51	2.46	139.44
C.D. 5%	3.21	1.02	6.16	0.12	12.552

I<sub>1</sub> = Drip irrigation at 100% PE; I<sub>2</sub> = Drip irrigation at 75 % PE; I<sub>3</sub> = Drip irrigation at 50% PE; F<sub>1</sub> = 100% RDF through fertigation; F<sub>2</sub> = 75% RDF through fertigation, F<sub>3</sub> = 75% RDF through fertigation + 2 foliar spray of 1% urea phosphate; F<sub>4</sub> = 50% RDF through fertigation; F<sub>5</sub> = 50% RDF through fertigation + 2 foliar spray of 1% urea phosphate.

tion resulted in minimum or no wastage of nutrients either through deep percolation or evaporation leading to higher uptake of nutrients as reported by Rajput and Patil (2006) in onion.

#### Combined effect of drip irrigation and fertigation:

The combined effect of drip irrigation and fertigation proved superior to their individual effects (**Table 4**). Among different treatment combinations, 75 % PE + 75 % RDF through fertigation + 2 foliar spray of 1 % urea phosphate through fertigation recorded maximum nutrient uptake by plant *i.e.* nitrogen (65.65 kg ha<sup>-1</sup>), phosphorus (15.74 kg ha<sup>-1</sup>) and potassium (69.09 kg ha<sup>-1</sup>) and by fruit *i.e.* nitrogen (101.17 kg ha<sup>-1</sup>), phosphorus (25.85 kg ha<sup>-1</sup>) and potassium (113.99 kg ha<sup>-1</sup>). Total nutrient uptake by tomato *i.e.* nitrogen (166.83 kg ha<sup>-1</sup>), phosphorus (41.59 kg ha<sup>-1</sup>) and potassium (183.08 kg ha<sup>-1</sup>) was also found significant higher under treatment combination I<sub>2</sub>F<sub>3</sub>. Similar results of increased uptake with fertigation have been reported earlier by Shedeed *et al.* (2009) in tomato with 100 % RDF through fertigation and Kohire and Das (2015) in tomato crop.

#### Growth characters, yield and yield attributes

**Effect of irrigation:** The results of the experiment presented in Table 5 resulted that the growth characters *viz.*, plant height (55.83 cm) and number of branches (9) and yield attributes *viz.*, average fruit weight (95.32 g) and average fruit yield per plant (3.19 kg) and fruit yield (169.03 q ha<sup>-1</sup>) were significantly higher under (I<sub>2</sub>) 75 % PE as compared to irrigation level I<sub>1</sub> and I<sub>3</sub>. The increase in yield might be due to better proportion of air and water in soil which maintained throughout the life period of crop in drip irrigation (Kadam and Karthikeyan, 2006 in tomato crop). The number of branches and plant height were significantly improved by the application of major nutrients through drip irri-

gation at these boost the overall vegetative growth and biological efficiency of plant. The increase in tomato growth under drip irrigation system may be due to the availability of water when needed around the root zone at very low moisture tension. These results are in agreement with the findings of Yadav and Chouhan (2016) in brinjal at 1.2 ET<sub>c</sub> (drip). Gupta *et al.* (2015) also recorded higher average fruit weight (49.7 g) and fruit yield (893.4 q ha<sup>-1</sup>) in tomato crop with 80 % ET through drip fertigation.

**Effect of fertigation:** Results depicted in Table 5 revealed that the response of various fertigation levels in tomato revealed that among the various fertigation levels, 75 % RDF through fertigation + 2 spray of 1 % urea phosphate produced maximum growth characters *viz.*, plant height (59.53 cm) and number of branches (10.67) and yield attributes *viz.*, average fruit weight (96.59 g) and average fruit yield per plant (3.25 kg) and fruit yield (186.38 q ha<sup>-1</sup>) were significantly higher under F<sub>3</sub> treatment. The application of 75 % RDF through fertigation + 2 spray of 1 % urea phosphate increased fruit weight and fruit yield by 5.01 and 3.97 per cent over 100 % RDF through fertigation. The highest fruit yield at higher level of nutrients may be due to favorable growth and higher nutrients uptake. Increased nitrogen would have resulted in higher growth while phosphorous would have higher root growth which might have helped in increased uptake of nutrients (Singh and Maurya, 1992). The another reason is that, increased level of fertigation leads to increased photosynthetic activities, protein synthesis and assimilate translocation due to suitable environmental condition that activates enzyme activities resulted in more growth attributes. These results are in agreement with the findings of Kavitha *et al.* (2007) in tomato crop and Yadav and Chouhan (2016) in brinjal

with 75 % RDF with six splits.

#### Combined effect of drip irrigation and fertigation:

In case of interaction (Table 6), results revealed that the combined effect of drip irrigation and fertigation proved superior to their individual effects. The combined effect of drip irrigation and fertigation proved superior to their individual effects. Among different treatment combinations of 75 % PE + 75 % RDF through fertigation + 2 foliar spray of 1 % urea phosphate through fertigation recorded maximum plant height (67.43 cm), number of branches (12.33), average fruit weight (98.62 g), average fruit yield per plant (3.49 kg) and fruit yield (201.25 q ha<sup>-1</sup>). Similar findings are also reported by Riazeian and Mahdavi (2005) in tomato crop and Vijayakumar et al. (2010) in brinjal crop with 75 % ET and 75 % RDF through drip fertigation.

#### Conclusion

From the present investigation it could be concluded that drip irrigation system found to be very promising in saving water and fertilizers, also controlling weed growth thereafter allowing plant to gain more water and nutrients which further tends to increase nutrient content and uptake in fruit and plant of tomato. Hence, growth, yield and nutrient uptake by tomato was found to be very significant with drip at 75 % PE and at 75 % RDF through fertigation + 2 foliar spray of 1 % urea phosphate.

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