

## Relevance of fertigation on tomato (*Solanum lycopersicum*) under polyhouse

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### ABSTRACT

A field experiment was conducted at Rahuri, Maharashtra during the summer seasons of 2013 and 2014, to study the effect of fertigation levels and schedules on yield and monetary returns of tomato (*Solanum lycopersicum* L.) under naturally ventilated polyhouse. The treatments included 3 fertigation levels [60% of recommended dose of fertilizer (RDF), 80% of RDF and 100% of RDF] and 3 fertigation schedules (6 equal splits of NPK at every 18 days interval, 9 equal splits of RD of NPK at every 12 days interval, 12 equal splits of RD of NPK at every 9 days interval). Yield attributes like number of fruits/plant and fruit weight/plant significantly increased 20.63 and 27.54% owing to fertigation of 80% RDF over 60% RDF. Similarly, fertigation schedule comprising application in 12 equal splits at 9 days interval resulted in significantly more yield attributes over the other schedules. Results of 2 years of investigation indicated that fertigation of 80% of RDF (240 : 120 : 120 N : P : K kg/ha) in 12 equal splits at every 9 days interval up to 120 days after transplanting proved most suitable to achieve the maximum tomato fruit yield (14.34 t), net monetary returns (₹148,300)/unit of polyhouse (784 m<sup>2</sup>) during summer season under naturally ventilated polyhouse condition.

**Key words:** Economics, Fertigation, Polyhouse, Scheduling, Tomato, Yield

Tomato 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 (Bose *et al.*, 2002). It acts as an antioxidant and scavenger of free radicals, which is often associated with carcinogenesis. Thus, lycopene has got great beneficial effects on human health. It may also interfere with oxidative damage to DNA and lipoproteins and inhibits the oxidation of low density lipoprotein (LDL) cholesterol.

Protected cultivation is a most contemporary approach to produce high-value vegetables like tomato and has shown tremendous potential quantitatively and qualitatively, extend the growing season of crop and fetches good market price during off season. These technologies are not only create avenues at higher level, but also keep the growers with the smaller landholdings at the higher productivity levels and retain economic relevance to agriculture. By adopting protected cultivation technology, the growers can look forward to a better and additional remuneration for high-quality produce.

Controlled environment agriculture (CEA) is highly productive, conservative of water, fertilizers and land and also protective of the environment like the temperature, humidity, light (Jensen, 2002). Polyhouse is a framed or inflated structure covered with transparent or translucent polythene papers, large enough to grow crops under partial or fully controlled environmental conditions to get optimum growth and productivity. Flowering and fruit setting in polyhouse were advanced by 3 to 4 days as compared to field condition. Similarly, tomato plants grown under polyhouse showed the best performance in terms of reproductive development and total yield. The fruit yield obtained from the polyhouse was about 29% higher than open space owing to optimum temperature and low relative humidity suitable for tomato production in polyhouse (Rasel Parvej, 2012).

Fertilizer is the most critical input which seriously affects the both yield of crop and cost of cultivation. Fertigation is an excellent method of optimizing the utilization of water and nutrients to improve the sustainability of polyhouse tomato. It allows frequent, uniform and precise application of nutrients through drip directly into the zone of maximum root activity as per need of crop that results in higher fruit yield. In addition, it saves the fertilizers, time and labour. In fertigation, nutrient-use efficiency could be as high as 90% as compared to 40% in

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conventional methods (Solaimalai *et al.*, 2005). Despite these improvements in the fertilizer-use efficiency, time of application and rate of fertilizers through drip for greenhouse tomato is far from optimal. As tomato is heavy feeder crop, it responds well to increased NPK application through drip. However, it is very necessary to determine the time and frequency of fertilizer application at appropriate stage of crop. Looking at the changing climatic scenario of protected cultivation, the awareness among the farming community is increasing day by day because in open field condition fruit yield and returns/unit land are poor due to frequent aberrant weather situation. In this direction, polyhouse is the best alternative for higher production of tomato and ultimately maximum monetary returns/unit of polyhouse during off season. Since not much information is available on this issue, this study was conducted to examine the frequency and rate of fertilizer application for maximizing tomato fruit yield and obtaining better returns under controlled environment.

## MATERIALS AND METHODS

The present investigation was carried out during the summer season of 2013 and 2014 at Post Graduate Research Farm, Department of Agronomy, Mahatma Phule Krishi Vidyapeeth, Rahuri (19°47' and 19°57' N, 74°19' and 74°32' E, 511 m above the mean sea-level), Maharashtra. The soils of the experimental site was sandy clay in texture, having pH 7.70, organic carbon 0.53% with low in available nitrogen (254.7 kg/ha), medium in available phosphorus (19.73 kg/ha) and very high in available potassium (369.5 kg/ha). It was low in iron (4.44 mg/kg) and zinc (0.49 mg/kg) and moderate in manganese (2.35 mg/kg) and copper (1.49 mg/kg). The field capacity, permanent wilting point and bulk density were 22.74%, 11.37% and 1.39 g/cm<sup>3</sup> respectively. The method used for estimation of available N in soil was modified alkaline permanganate, for available P in soil 0.5 M NaHCO<sub>3</sub> (pH 8.5) and for available K in soil N,N-Dimethylamino NH<sub>4</sub>OAc. The micronutrients, viz. DTPA Cu, Mn, Cu and Fe were estimated using atomic absorption spectrophotometer. The pH of soil was determined by potentiometric method and organic carbon by wet oxidation method. The field capacity (%) and permanent wilting point (%) were estimated by using pressure-plate apparatus. The core-sampler method was used for determination of bulk density. Fruit quality parameters, viz. pH, TSS, titrable acidity, ascorbic acid, lycopene and carotene content were analyzed with the help NIR-spectrophotometer.

The experiment was laid out in split-plot design and replicated thrice with 9 treatment combinations. The gross and net size of experimental plot was 8 m × 3 m. The treatments includes 3 fertigation levels [F<sub>1</sub>, 60% of recom-

mended dose of fertilizer (RDF : 180 : 90 : 90 kg N : P : K/ha); F<sub>2</sub>, 80% of RDF (240 : 120 : 120 kg N : P : K/ha); and F<sub>3</sub>, 100% of RDF (300 : 150 : 150 kg N : P : K/ha)] and 3 fertigation schedules (S<sub>1</sub>, 6 equal splits of RD of NPK at every 18 days interval up to 120 days after transplanting; S<sub>2</sub>, 9 equal splits of RD of NPK at every 12 days interval up to 120 days after transplanting; S<sub>3</sub>, 12 equal splits of RD of NPK at every 9 days interval up to 120 days after transplanting). The naturally ventilated polyhouse (784 m<sup>2</sup>) was oriented in north-south direction and covered with UV-stabilized LDPE film of 200 micron thickness as cladding material. The mean maximum temperature ranged from 26.8 to 40.8°C. The mean relative humidity ranged from 36 to 90% in morning and 14 to 85% in evening. Maximum evaporation was 11.74 mm/day, while the minimum 2.14 mm/day during the investigation period. To create a favourable environment for plant growth, side ventilation was provided. Whenever the temperature increases in the polyhouse, the rollable polyethylene flap (side ventilation) was opened. But under low temperature conditions, the side ventilations was closed with the rollable polyethylene flap to conserve the heat inside the polyhouse. The polyhouse was provided with fogger system erected beneath the roof of polyhouse that protects the crop from prevailing high temperature during noon time. An indeterminate type tomato hybrid 'NS 501' capable of high yield potential and round the year performance was used. This is an ideal hybrid having vigorous nature and tolerance to bacterial wilt and TLCV. Four weeks old healthy and uniform tomato seedlings were transplanted at the spacing of 60 cm × 50 cm on the raised beds. Fertigation was started 12 days after transplanting through automatic fertigation unit as per treatment. The fertigation was done by using water-soluble fertilizer (19 : 19 : 19 N : P : K grade) and urea (46.6% N). All the agronomic practices and plant-protection measures were adopted as per recommendation. Observations on different growth and yield parameters were recorded from 5 randomly sampled plants from each treatment.

## RESULTS AND DISCUSSION

### Fertigation levels

Fertigation of NPK with different levels significantly influenced the yield-attributing parameters of polyhouse tomato. The fertigation of 100% RDF recorded significantly higher number of fruits/plant, polar circumference, equatorial circumference, average fruit weight and fruit weight/plant than rest of the fertigation levels; however, it was at par with fertigation of 80% RDF (Table 1). The lowest yield attributes were noticed under the fertigation of 60% RDF. This might be due to enhanced supply of nitrogen, phosphorus and potassium in the root rhizosphere

which increases the uptake of nutrients that enhanced luxurious growth of crop which helps to absorb more photosynthetically active radiation (PAR) accompanied with increased yield attributes. These results are in the line of Hasan *et al.* (2014) and Singh *et al.* (2015).

Significant effect of fertigation was observed on fruit yield of tomato inside polyhouse (Table 1). Pooled data averaged over the 2 years revealed that the fruit yield of tomato increased significantly with increasing level of fertigation. The maximum fruit yield/unit of polyhouse was registered under fertigation of 100% RDF. However, it was at par with 80% RDF indicating 20% saving of fertilizers. While fertigation of 60% RDF resulted in significantly minimum fruit yield/unit of polyhouse. An increase of 30.40% fruit yield/unit of polyhouse was recorded under the fertigation of 100% RDF over 60% RDF. The 100% RDF applied through fertigation directly in the active root zone of the plant increased the nutrient-use efficiency, as evident from enhanced nutrient uptake by crop. As the crop was grown on raised beds under polyhouse condition, this helped in maintaining the proper proportion of air : soil : water and nutrient throughout the crop growth period. The microclimate in the polyhouse was more favourable to increase the growth and yield attributes of tomato crop. The higher rate of photosynthate translocation from vegetative part (source) to reproductive organs (sink) might have increased the fruit size and weight which resulted in higher fruit yield of tomato. Similar findings were reported by Nagre (2013), Patel *et al.* (2013) and Kuscu *et al.* (2014).

The economic evaluation of tomato crop, assessed in terms of gross monetary returns, net monetary returns and

benefit: cost (B:C) ratio, is presented in Table 2. The gross monetary returns/unit of polyhouse was influenced significantly due to the different fertigation levels. Fertigation of 100% RDF resulted in significantly maximum gross monetary returns/unit of polyhouse as compared to 60% RDF. However, it was at par with 80% RDF. The net monetary returns/unit of polyhouse was influenced significantly due to the different fertigation levels. Fertigation of 100% RDF recorded significantly maximum net monetary returns/unit of polyhouse than 60% RDF; however, it was on a par with 80% RDF. Fertigation of 100% RDF resulted in the maximum B:C ratio/unit of polyhouse as compared to 60% and 80% RDF. This might be because of fertigation of 100% RDF through increased nutrient uptake exhibited higher fruit production with top-quality fruit assessment having more demand in market that fetches good economical price resulted in increased the gross, net returns/unit of polyhouse. These results are in accordance with those reported by Kavitha *et al.* (2007), Prabhakara *et al.* (2010), Vasu and Reddy (2013) and Brahma *et al.* (2014).

#### Fertigation schedules

Different fertigation schedules significantly influenced the yield-contributing characters (Table 1). Among the fertigation schedules, fertigation of 12 equal splits of NPK at every 9 days interval up to 120 days after transplanting (DAT) exhibited significantly maximum number of fruits/plant, polar circumference, equatorial circumference, average fruit weight and fruit weight/plant. While the lowest values of these parameters were noticed under the fertigation of 6 equal splits of NPK at every 18 days interval up to 120 DAT. Fruits/plant and fruit weight/plant were

**Table 1.** Effect of fertigation treatments on yield attributes and yield of tomato (pooled data of 2 years)

Treatment	Fruits/plant	Polar circumference (cm)	Equatorial circumference (cm)	Average fruit weight (g)	Fruit weight/plant (kg)	Fruit yield/unit of polyhouse (784 m <sup>2</sup> ) (t)
<i>Fertigation levels</i>						
F <sub>1</sub> , 60% of RDF	54.51	4.72	4.23	61.07	3.21	10.37
F <sub>2</sub> , 80% of RDF	68.68	4.80	4.34	65.89	4.43	14.19
F <sub>3</sub> , 100% of RDF	70.82	5.02	4.44	67.00	4.64	14.90
SEm±	0.54	0.01	0.01	0.28	0.04	0.18
CD (P=0.05)	2.16	0.05	0.04	1.14	0.16	0.74
<i>Fertigation schedules</i>						
S <sub>1</sub> , 6 equal splits (18 days interval)	59.55	4.74	4.24	63.02	3.67	11.82
S <sub>2</sub> , 9 equal splits (12 days interval)	65.03	4.84	4.35	64.44	4.09	13.15
S <sub>3</sub> , 12 equal splits (9 days interval)	69.44	4.96	4.42	66.50	4.52	14.49
SEm±	0.39	0.01	0.008	0.17	0.03	0.10
CD (P=0.05)	1.21	0.03	0.03	0.69	0.09	0.30

RDF, Recommended dose of fertilizer

increased to tune of 14.24 and 18.81% under fertigation of 12 equal splits of NPK at every 9 days interval up to 120 DAT over the fertigation of 6 equal splits of NPK at every 18 days interval up to 120 DAT. This might be owing to continuous split application of nutrients throughout the crop growth period enhanced growth attributes accompanied with more physiological activities and absorbed PAR reflected in higher photosynthetic rate and translocation of assimilates towards reproductive parts resulted an increase in yield attributes. Similar kinds of results were reported by Tumbare and Nikam (2004) and Bahadur *et al.* (2006).

The fruit yield of tomato (Table 1) was significantly influenced by different fertigation schedules. The fertigation of 12 equal splits of NPK at every 9 days interval up to 120 DAT resulted in significantly higher fruit yield/unit of polyhouse. While fertigation of 6 equal splits of NPK at every 18 days interval up to 120 DAT exhibited significantly minimum fruit yield/unit of polyhouse. The extent of increase in fruit yield/unit of polyhouse under the fertigation of 12 equal splits of NPK at 9 days interval up

to 120 DAT was 18.43% over the fertigation of 6 equal splits of RD of NPK at every 18 days interval up to 120 DAT. Frequent application of required quantity of nutrients directly in vicinity of the root zone throughout crop growth period increased the nutrient-use efficiency which enhanced growth and yield attributes and improved the tomato fruit yield. Similarly, the favourable microclimatic conditions maintained inside polyhouse helps to change the phase of plant from juvenile to reproductive and significantly contributed to higher fruit yield of tomato. These results are in the line of Tumbare *et al.* (2004) and Singh *et al.* (2013).

The gross monetary returns/unit of polyhouse was influenced significantly due to the different fertigation schedules. Fertigation of RD of NPK in 12 equal splits at every 9 days interval up to 120 DAT recorded significantly higher gross monetary returns/unit of polyhouse than 6 equal splits at every 18 days interval and 9 equal splits at every 12 days interval. The net monetary returns/unit of polyhouse was influenced significantly due to different

**Table 2.** Economics of tomato/unit of polyhouse (784 m<sup>2</sup>) as influenced by fertigation treatments (pooled data of 2 years)

Treatment	Gross monetary returns (× 10 <sup>3</sup> ₹/unit of polyhouse)	Cost of cultivation (× 10 <sup>3</sup> ₹/unit of polyhouse)	Netmonetary returns (× 10 <sup>3</sup> ₹/unit of polyhouse)	Benefit: cost ratio
<i>Fertigation levels</i>				
F <sub>1</sub> , 60% of RDF	149.95	57.90	92.05	2.59
F <sub>2</sub> , 80% of RDF	205.37	59.17	146.20	3.47
F <sub>3</sub> , 100% of RDF	215.57	60.43	155.14	3.57
SEm±	1.78	-	1.78	-
CD (P=0.05)	7.02	-	7.02	-
<i>Fertigation schedules</i>				
S <sub>1</sub> , 6 equal splits (18 days interval)	171.04	59.17	111.87	2.88
S <sub>2</sub> , 9 equal splits (12 days interval)	190.29	59.17	131.12	3.21
S <sub>3</sub> , 12 equal splits (9 days interval)	209.56	59.17	150.39	3.54
SEm±	1.39	-	1.39	-
CD (P=0.05)	4.31	-	4.31	-

Price of fruit, ₹14/kg (2013), ₹15/kg (2014)

**Table 3.** Economics in terms of investment on polyhouse (784 m<sup>2</sup>)

Particular	Depreciation cost (× 10 <sup>3</sup> ₹/season)		
Non-recurring contingency (NRC)			
Construction of polyhouse @ ₹700/m <sup>2</sup> (For life span of 20 years)	13.72		
Top : UV stabilized plastic sheets @ ₹65/m <sup>2</sup> (For life span of 5 years)	5.096		
Drip system including automatic fertigation unit and centrifugal pump	6.593		
Total NRC	25.41		
<i>Recurring contingency (RC) (for a season)</i>			
	<i>Treatment</i>		
	F <sub>1</sub>	F <sub>2</sub>	F <sub>3</sub>
Total RC	35.02	33.76	32.49
Grand total (NRC + RC)	60.43	59.17	57.90

fertigation schedules. Fertigation of RD of NPK in 12 equal splits at every 9 days interval up to 120 DAT obtained significantly higher net monetary returns/unit than 6 equal splits at every 18 days interval and 9 equal splits at every 12 days interval. Fertigation of RD of NPK in 12 equal splits at every 9 days interval up to 120 DAT recorded higher benefit: cost ratio/unit of polyhouse than 6 equal splits at every 18 days intervals and 9 equal splits at every 12 days interval. This might be owing to continuous split application of nutrients throughout the crop-growth period increases the fruit yield/unit of polyhouse with reasonable good economical price during summer season resulted in increased the gross, net returns/unit of polyhouse. These results are in accordance with those reported by Gupta *et al.* (2009), Prabhakara *et al.* (2010), Imamsaheb *et al.* (2011), Vasu and Reddy (2013) and Brahma *et al.* (2014).

Based on 2 years results, it is concluded that to achieve the maximum tomato fruit yield and net monetary returns under polyhouse during the summer season, the suitable management options include fertigation of 80% RDF (240 : 120 : 120 kg N : P : K/ha) in 12 equal splits at every 9 days interval up to 120 days after transplanting.

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