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Fertigation schedules and NPK doses influence growth and yield of tomato under polyhouse conditions

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Abstract

An experiment was conducted to develop a fertigation schedule and assess the effect of different levels of NPK on the growth, yield and quality attributes of tomato grown under polyhouse conditions. There were nine different treatments of 75, 100 and 125 per cent RDF at three intervals (two, three and four days) of fertigation. The experiment was laid out in a completely randomized design with three replications. Most of the traits under study were significantly influenced by various levels of fertigation except specific gravity. Results revealed that maximum plant height (241.70 cm), number of branches (18.24), leaf area (328.70 sq cm), number of fruits per plant (83.42), weight of fruits (88.53 g), volume of fruits (90.88 cc), length of fruit (5.88 cm), yield per plant (7385.04 g) and yield per square meter (17.72 kg) were reported under 125 % RDF at three days interval followed by 125 % RDF at two days interval. In contrast, treatment 125 % RDF at four days interval took minimum days to first harvest (84.97) and was earliest among the treatments studied. Thus, tomato crops grown under polyhouse conditions should be supplemented with 125 percent of RDF *i.e.* 225 kg N, 125 kg each of P and K per ha, at three days interval of fertigation for higher yield.

Key words: Protected cultivation, tomato, RDF, fertigation, irrigation, polyhouse

Introduction

Tomato (*Solanum lycopersicon* L.) is an important and widely grown solanaceous vegetable crop around the world. It is one of the most important protective foods due to its special nutritive value and is a major vegetable crop that has achieved tremendous popularity in the greenhouse over the last century. Polyhouse cultivation is becoming popular due to advantage of off season vegetable cultivation as in main growing season prices of vegetables remain literally on the ground, where even cost of production cannot be recovered, while in off season, prices of vegetables are used to range on very high side, even 8-10 times more as compare to normal growing season (Ameta *et al.,* 2019) and four to six times more production can be taken from polyhouse as compared to open field condition as in polyhouse, microclimate surrounding the plant is controlled partially or fully, as per the requirement of the plant species (Mishra *et al.,* 2010).

Tomato is heavy feeder of NPK and responds well to additional fertilizer applied (Amala and Syriac, 2016), hence, fertigation is the most important aspect in tomato cultivation and fertilizers should be applied in a form that becomes available in synchrony with crop demand for maximum utilization of nutrients from fertilizers (Boyhan *et al.*, 2001). Therefore, uniform application of such chemicals is necessary to insure considerable increase in vegetable production and real decrease in production costs. The use of drip-fertigation in the polyhouse, not only saves water and fertilizers, but also gives better yield and quality by precise application of inputs in the root zone (Phuntsho *et al.*, 2011). In drip fertigation systems, which combine drip irrigation with fertilizer application, the fruit yield of tomato was 20-30 % higher in drip fertigation than in furrow irrigation (Hebber *et al.*, 2004). The application of deficit irrigation at the seedling stage may not significantly influence the total yield of greenhouse tomato (Chen *et al.*, 2013). Incroci *et al.* (2017) stated that the combination of fertigation and micro-irrigation provides a technical solution whereby nutrients and water can be supplied to the crop with high precision in terms of time and space. Further the excessive use of irrigation water leads to low water productivity and deterioration (Zheng *et al.*, 2013). In this context, high frequency water and fertilizers management through drip irrigation improve WUE and decrease salinization and thereby maximizing net returns to the farmer. In green house tomato due to indeterminate nature of the crop, plants need nutrients even up to fruit ripening stage for better growth and yield so, application method such as fertigation at various interval may be very effective in green house tomato.

Since very limited work has been carried out on fertigation scheduling at various interval and different levels of NPK and there is burning need to provide exact information regarding fertigation technology, hence, the present investigation was conducted to ascertain optimum doses of NPK through drip irrigation for tomato grown under polyhouse conditions.

Materials and methods

The experiment was conducted under naturally ventilated polyhouse (NVP) at Hi-tech Horticulture Unit, Rajasthan College of Agriculture, Udaipur (Rajasthan), India during two consecutive years *i.e.,* 2015 and 2016. Udaipur is situated at 24º 34' N latitude and 73º 42' E longitude at an elevation of 582.17 m above mean sea level. The experiment was laid out in Completely Randomized Design with three replications. The size of the polyhouse was 28 × 32 m (896 sq. m) covered with aluminate sheet and ultra violet stabilized low density polyethylene sheet having 200 micron thickness with provision of foggers installed over head. There were nine treatments *viz.* T_1: 75 % RDF at 2 days interval (RDF was 180 kg N, 100 kg P, 100 kg K), T_2 : 75 % RDF at 3 days interval, T_3 :75 % RDF at 4 days interval, T_4 : 100 % RDF at 2 days interval, T_5 : 100 % RDF at 3 days interval, T_6 : 100 % RDF at 4 days interval, T_7 : 125 % RDF at 2 days interval, T_8 : 125 % RDF at 3 days interval and T_9 : 125 % RDF at 4 days interval. The seeds of tomato were sown in plastic pro-trays having cells of 1.5 inch size containing growth medium (coco peat, vermiculite and perlite mixture in the ratio of 3:1:1), respectively. The beds were prepared 30 cm above from ground level and 1 meter width along the length of polyhouse. A row to row and plant to plant spacing of 45 x 30 cm, respectively was adopted during investigation. All the agricultural operations were followed as per recommended package and practices. Spraying for pests and diseases were applied whenever it appeared necessary throughout the growing season. Plants were vertically trained with plastic twin.

Observations regarding plant height (cm), number of branches per plant, leaf area (cm^2), days to first harvesting, number of fruits per plant, weight of fruit (g), volume of fruit (cc), specific gravity (g/cc), length of fruit (cm), total yield per plant and yield per square meter (kg) on five randomly selected plants were recorded and data were analyzed statistically as suggested by Panse and Sukhatme (1985).

The plant height was measured from the ground level to the tip of the main plant at the time of final harvest. Total number of branches of the individual plants was counted at the time of final harvest. Fruits were harvested when they attained horticulture maturity. Number of marketable fruits were counted at each picking and summed for all the pickings for each plot. Average number of fruits per plant was calculated after dividing total number of fruit by five. Five marketable fruit were randomly selected from each plot from each replication during the picking and length of each fruit was measured in centimeter from head end and up to blossom scar with the help of Vernier calipers. Total fruit weight of plot was divided by total number of fruits of the plot to get the average weight of fruit. Specific gravity of the fruit was worked out by water displacement method and expressed as g/cm^3. Total fruit yield over all the pickings were recorded for each plot and yield per plant was obtained after dividing total yield by number of plants of a plot.

Result and discussion

Results showed that different levels of RDF at different days significantly affected growth parameters during both the year of experimentation. The maximum pooled plant height (241.70 cm), number of branches per plant (18.24), leaf area (328.70 cm^2), number of fruits per plant (83.42) were recorded in treatment T_8 (125 per cent RDF at 3 days interval) followed by T_7 (125 per cent RDF at 2 days interval). This might be due to the combined effect of fertigation scheduling at various interval of different levels of NPK which provide timely and uniformly availability of all the macro nutrients through fertigation during initial crop growth period which resulted in better crop growth of tomato plant. The present findings are in accordance with the findings of Arora *et al.* (2006) in greenhouse tomato and Amala and Syriac (2016) while working with tomato.

The perusal of data in Table 2 revealed that different level of RDF at different days significantly affected yield and yield attributing characteristics except specific gravity. The maximum fruit weight (88.54 g), volume of fruit (90.88 cc) and length of fruit (5.88 cm) were recorded in treatment T_8 (125 per cent RDF at 3 days interval) in pooled analysis. This might be due to more uptake and utilization of macro nutrients when added through fertigation at different intervals. The similar findings of increase in average fruit weight was reported by Bahadur and Singh (2005) in tomato, Pandey *et al.* (2005) reported significant differences for fruit length of glass house grown capsicum and Mane *et al.* (2015) in tomato. Whereas maximum specific gravity (0.978 g/cc) was recorded in T_1 (75 per cent RDF at 2 days interval) and minimum days to first fruit harvest (84.97) was observed in T_9 (125 per cent RDF at 4 days interval). The pooled maximum total yield per plant (7385.04 g) and yield per square meter (17.72 kg) were recorded in T_8 (125 per cent RDF at 3 days interval), whereas total yield of 8.48 kg per plant have been observed by Yadav *et al.* (2017) while working with tomato. The increased yield in treatment T_8 might have resulted due to higher uptake of macro nutrients and better utilization under fertigation system. Tanaskovik *et al.* (2011) also reported that in tomato drip fertigation system shows greater yield as compared with conventional fertilizer application. These

Table 1. Effect of fertigation schedule and NPK doses at different interval on plant height, number of branches and leaf area.

Treatments	Plant height (cm)			No. of branches			Leaf area (sq. cm)		
	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
T_1	193.03	194.90	193.97	11.90	11.83	11.87	273.20	269.33	271.27
T_2	195.87	196.20	196.03	11.93	11.60	11.77	274.17	272.47	273.32
T_3	202.43	201.97	202.20	12.83	13.13	12.98	285.60	283.50	284.55
T_4	221.00	223.27	222.13	16.23	17.40	16.82	316.77	317.20	316.98
T_5	233.47	233.83	233.65	17.43	17.97	17.70	315.43	318.70	317.07
T_6	218.60	223.37	220.98	15.07	16.17	15.62	309.80	311.53	310.67
T_7	237.67	240.63	239.15	16.43	17.30	16.87	324.13	327.27	325.70
T_8	241.23	242.17	241.70	18.10	18.37	18.23	329.00	328.40	328.70
T_9	221.60	225.63	223.62	16.70	17.60	17.15	315.00	315.97	315.48
SEm±	3.17	3.53	3.36	0.45	0.49	0.47	3.76	3.86	3.81
CD at 5 %	9.43	10.50	9.63	1.36	1.46	1.36	11.20	11.49	10.95

results are in accordance of with the findings of Mahajan and Singh (2006) in green house tomato, Amala and Syriac (2016) while working with tomato and Xiukang and Yingying (2016) in green house tomato.

On the basis of present study it can be recommended that tomato crop grown under polyhouse conditions should be supplemented with 125 per cent of RDF *i.e.* 225 kg N, 125 kg each of P and K per ha with three days interval of fertigation for maximum fruit yield.

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Table 2. Effect of fertigation schedule and NPK doses at different interval on days to first harvest number of fruits and fruit weight

Treatment	Days to first harvest			Number of fruits per plant			Weight of fruits (g)		
	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
T_1	90.20	89.33	89.77	55.40	54.07	54.73	81.18	80.74	80.96
T_2	88.63	89.13	88.88	55.13	54.43	54.78	81.30	80.48	80.89
T_3	88.27	88.77	88.52	56.73	56.23	56.48	82.04	81.45	81.75
T_4	87.63	88.13	87.88	62.07	61.33	61.70	85.32	83.90	84.61
T_5	86.57	87.17	86.87	68.33	68.07	68.20	85.11	84.75	84.93
T_6	86.67	86.80	86.73	68.50	68.73	68.62	84.39	85.11	84.75
T_7	86.43	86.00	86.22	83.77	82.83	83.30	88.07	87.24	87.66
T_8	85.63	85.23	85.43	83.77	83.07	83.42	89.08	88.00	88.54
T_9	85.07	84.87	84.97	71.87	70.47	71.17	83.90	83.71	83.81
SEm±	0.39	0.42	0.40	0.881	0.491	0.713	1.072	0.480	0.831
CD at 5 %	1.17	1.24	1.17	2.618	1.459	2.046	3.186	1.427	2.383

Table 3. Effect of fertigation schedule and NPK doses at different interval on volume of fruit and specific gravity

Treatment	Volume of fruit (cc)			Specific gravity (g/cc)		
	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
T_1	82.76	82.81	82.79	0.981	0.975	0.978
T_2	83.38	82.26	82.82	0.975	0.978	0.977
T_3	84.18	83.61	83.90	0.975	0.974	0.974
T_4	87.33	86.02	86.68	0.977	0.975	0.976
T_5	87.17	86.95	87.06	0.976	0.975	0.976
T_6	86.30	87.47	86.89	0.978	0.973	0.975
T_7	89.88	89.61	89.75	0.980	0.974	0.977
T_8	91.22	90.55	90.88	0.977	0.972	0.974
T_9	85.72	86.10	85.91	0.979	0.972	0.976
SEm±	1.272	0.506	0.968	0.004	0.002	0.003
CD at 5 %	3.778	1.504	2.776	NS	NS	NS

Table 4. Effect of fertigation schedule and NPK doses at different interval on length of fruit, yield per plant and per square meter

Treatment	Length of fruit (cm)			Yield per plant (g)			Yield per square meter (kg)		
	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
T_1	5.50	5.49	5.50	4496.57	4365.29	4430.93	10.79	10.48	10.63
T_2	5.55	5.49	5.52	4479.86	4380.24	4430.05	10.75	10.51	10.63
T_3	5.51	5.51	5.51	4654.44	4580.04	4617.24	11.17	10.99	11.08
T_4	5.71	5.60	5.66	5296.36	5145.08	5220.72	12.71	12.35	12.53
T_5	5.71	5.64	5.67	5814.88	5769.13	5792.00	13.96	13.85	13.90
T_6	5.67	5.65	5.66	5779.39	5849.64	5814.51	13.87	14.04	13.95
T_7	5.80	5.74	5.77	7376.67	7226.30	7301.48	17.70	17.34	17.52
T_8	5.94	5.82	5.88	7460.04	7310.05	7385.04	17.90	17.54	17.72
T_9	5.60	5.64	5.62	6026.63	5899.24	5962.94	14.46	14.16	14.31
SEm±	0.054	0.033	0.044	66.623	45.142	56.905	0.160	0.108	0.137
CD at 5 %	0.159	0.097	0.127	197.946	134.124	163.213	0.475	0.322	0.392

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