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Effect of different levels of fertigation on yield and quality of tomato grown under soil-less media

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Abstract
The present investigation was conducted during 2018 at the Polyhouse, Department of Agriculture, Mata Gujri College, Fatehgarh Sahib, Punjab, India. The experiment was laid out in a completely randomized design having six treatments with five replications. The treatments consisted of T_1: 120% Nitrogen Phosphorus Potassium, T_2: 110% Nitrogen Phosphorus Potassium, T_3:100% Nitrogen Phosphorus Potassium, T_4: 90% Nitrogen Phosphorus Potassium, T_5: 80% Nitrogen Phosphorus Potassium and T_6: Control. Application of different levels of Nitrogen Phosphorus Potassium fertilizers increased the growth and yield of tomato. The maximum number of fruits plant^{-1} (74.34), crop duration (188.44), average fruit weight (79.99 g), fruit length (8.05 cm), fruit diameter (8.38 cm), fruit yield plant^{-1} (4.44 kg), fruit yield (123.39 t ha^{-1}), fruit firmness (0.79 kg/cm^2), ascorbic acid (19.08 mg/100g), lycopene content (3.74 mg/100g), titratable acidity (0.33%), TSS (4.00 ºbrix), fruit pH (4.26), shelf life (11.04 days), physiological loss in weight (17.18%) were recorded maximum with the application of 100 per cent NPK Fertilizers. The same treatment also produced the highest net returns of Rs. 2362519.739 along with benefit: cost ratio (4.2: 1).

Keywords: NPK, fertigation, yield and quality

Introduction
Tomato (*Solanum lycopersicum* L.) is one of the most important fruit vegetable crops grown in the world. Tomato belongs to the family Solanaceae, which thrives well in temperature 10 to 30 ºC with optimum range of temperature of 21 to 24 ºC (Patel *et al.* 2015) [12]. Tomato is a rich source of vitamins A and C is referred to as poor man's orange (Dhaliwal, 2017) [2]. Besides, the fruits of tomato are very useful for our health as they also rich in minerals like Ca, P and Fe etc. Tomato is recognized globally for its nutraceutical values. It is a good source of minerals, vitamins and organic acids, essential amino acids and dietary fibres. Tomato fruits are rich in lycopene which turns tomato fruits to red is a very powerful antioxidant that prevents the development of many forms of cancer (Kalanjiyam *et al.* 2015) [3]. Lycopene has been found as the most powerful antioxidant that helps to keep cholesterol down and bolster resistance to cancer (Watznman, 2000) [14]. World Wide tomato ranks third in area and production after potato and sweet potato but rank first among processed in various vegetables. India ranks second in the world next to China in both area and production. In India it is grown in an area of 0.79 million hectares with an annual production of 20.7 million tonnes (NHB, 2017) [1]. Fertilizers play a major role in crop production for achieving better yield and quality of vegetables. In order to increase the fertilizers, use efficiency, there are several systems of fertilizer application methods. Among all the systems, application of fertilizers along with drip irrigation is gaining popularity.

This system has proved its superiority over other conventional methods of irrigation especially for vegetable and fruit cultivation owing to its precise and direct application of water with soluble fertilizers at the root zone with a considerable saving in fertilizer and irrigation water (Kumar *et al.* 2015) [6]. Soil-less culture is an artificial means of providing plants with support and reservoir for nutrients and water. Coconut coir is an inexpensive soil-less media with suitable water and air retension capacity. Replacing soils by soil-less growing media is to overcome plant protection problems, soil borne pathogens and environmental regulations against groundwater pollution with nitrate pesticides (Kaur *et al*. 2017) [4].

Material and Methods

F_1 hybrid of tomato KSP-1115 was used for present study. All the recommended cultural practices were adopted during the course of planting. Soil-less media composed of cocopeat, vermicompost and neem cake. The bag size was 35 cm × 20 cm and a spacing of 60 cm × 60 cm. The experiment was carried out in completely randomized design (CRD) with six treatments with T_1 (120% RDF of NPK), T_2 (110% RDF of NPK), T_3 (100% RDF of NPK), T_4 (90% RDF of NPK), T_5 (80% RDF of NPK), T_6 (Control). Each treatment was replicated five times. The treatments consisted of T_1: 120% NPK, T_2: 110%NPK, T_3: 100% NPK, T_4: 90% NPK, T_5: 80% NPK and T_6: Control. Observations were recorded on randomly selected plants with different characters *i.e.* plant height (m), first days to flowering (days) days to 50 per cent flowering (days), number of flower cluster plant^{-1}, days to first picking (days), harvest duration (days), number of branches plant^{-1}, number of fruits plant^{-1}, crop duration (days), average fruit weight (g), fruit length (cm), fruit diameter (cm), fruit yield plant^{-1} (kg), fruit yield (t ha^{-1}), net return (Rs./ha) and benefit cost ratio.

Result and Discussion

Yield and yield contributing attributes

The data recorded on yield parameters of tomato have been presented in table 1. The maximum number of fruit plant^{-1} (74.34) was recorded in T_3. Minimum number of fruit plant^{-1} (54.28) was observed in treatment T_6. The increase in fruits per plant might be due to supply of nutrients at critical growth stage (Narayan *et al.* 2011) [9]. Minimum days to first picking (76.44) were recorded in T_3 and maximum days to first picking 86.22 days were recorded in treatment T_6. Earliness in fruiting might to be due to early accumulation of photosynthates which resulted accelerated photosynthesis and rapid translocation of photosynthesis towards initiating flower buds in early flowering ultimately early fruiting (Kaur *et al.* 2017) [4]. The findings for maximum days of crop duration (188.44 days) was recorded in T_3 and minimum days of crop duration (183.12 days) was observed in treatment T_6. Maximum fruit diameter (8.38 cm) was recorded in treatment T_3 and minimum fruit diameter (6.28 cm) was recorded in T_6. The mean performance of different treatments showed that maximum fruit length (8.05 cm) was recorded in treatment T_3. Minimum fruit length (6.33 cm) was recorded in control T_6. The increase in fruit length might be due to higher rate of photosynthates translocation from vegetative to productive organs, which might be increased the fruit size (Ughade *et al.* 2015) in tomato. The findings regarding maximum average fruit weight (79.99 g) was recorded in treatment T_3. Minimum (69.95 g) average fruit weight was observed T_6. The increase in fruit weight of tomato might be attributable to positive action of potassium fertilizer application through drip and plant relationship as well as physiological and metabolic activities. The increase in fruit weight might also be due to better partitioning of photosynthates for fruit development. These findings are in conformity with the results of Nantha Kumar and Veeraragavathatham (2003) [10] and Narayanamma *et al.* (2002) [8]. Highest fruit yield plant^{-1} (4.44 kg) was obtained in treatment T_3 and lowest fruit yield plant^{-1} (2.28 kg) was recorded in T_6. The fruit yield per plant by application of a recommended dose of fertilizer increases the fruit yield per plant. The best results obtained in respect of the growth parameters like plant height and number of lateral per plant could be attributed to the highest fruit yield. The yield under open condition was per plant could be attributed to the highest fruit yield. The under open condition was less because of the fact that mobilization an translocation of nutrients and photosynthates to the developing parts was much more reduced at high temperature experienced in open condition than under skill (Kavitha *et al.* 2007) [5]. Maximum fruit yield ha^{-1} (123.39 ha^{-1} t) was obtained in T_3 and minimum (63.44 t ha^{-1}) fruit yield ha^{-1} was observed in T_6. The fruit yield hectare^{-1} might be increase because of enhanced supply of nitrogen, phosphorous and potassium in the root. The rhizosphere increase the uptake of nutrients and favourable microclimatic conditions were optimized inside polyhouse with maintaining optimum temperature. $C0_2$ concentration and higher relative humidity that enhanced luxurious growth of crop which helps to absorbed more photosynthetically active radiation accompanied with increased enzyme actions aids in higher rate of photosynthesis and dry matter accumulation reflected in efficient translocation of sugar and starches towards reproductive parts reflected increase in yield attributes in tomato (Ughade *et al.* 2016).

Quality attributes

Maximum pericarp thickness (6.64 mm) data was recorded in T_3. However, Minimum pericarp thickness (4.98 mm) was obtained in T_6. Maximum pH (4.26) was recorded in T_6. However, minimum pH (3.34) was recorded in T_3. An examination of the data showed that TSS was affected by all the treatments as values obtained were significant. Maximum TSS (4.10 °Brix) was obtained in T_3. Higher fertility level increases uptake and utilize more nutrients by which increases total soluble solids content of fruit. Higher TSS content might be due to when water applied in lesser amount through drip system sugar imported by fruits become concentrated which help in increasing TSS content of fruits (Kalanjiyam and Manickam 2015) [3]. Minimum titratable acidity (0.33%) was recorded in T_3. Maximum Titratable acidity (0.71%) was obtained in T_6. The increase in titratable acidity might be due to optimum quantity of nutrient supply by means of fertigation throughout the crop growth period enhanced the metabolic activities and photosynthetic rate which translocated the maximum photosynthates towards reproductive part resulted in increasing the titratable acidity of tomato fruit Ughade *et al.* 2016 in tomato. The maximum performance of different treatments showed that maximum ascorbic acid content (19.08 mg/100g) was recorded in T_3. It may observed that the increase in ascorbic acid content might be because of optimum quantity of nutrient supply by means of fertigation throughout the crop growth period enhanced the metabolic activities and photosynthetic rate which translocated the maximum photosynthates towards reproductive part resulted in creasing the ascorbic acid of tomato fruit Ughade *et al.* 2016. A perusal of the data revealed that there was significant effect of various treatments

on lycopene content. Maximum lycopene content (3.74 mg/100g) data was recorded in of T_3. Lycopene was synthesized by isoprenoid pathway, nitrogen fertilizer enhanced the enzymes in this pathway therefore increasing in lycopene concentration in fruit occurs. Maximum fruit firmness (0.79 kg/cm^2) was obtained in T_3 which was statistically at par with T_2 having value of 0.77 kg/cm^{2}fruit firmness. Minimum fruit firmness (0.58 kg/ cm^2) was recorded in T_6 (control). Maximum fruit firmness (0.79 kg/cm^2) was obtained in T_3 which was statistically at par with T_2 having value of 0.77 kg/cm^{2}fruit firmness. Minimum fruit firmness (0.58 kg/ cm^2) was recorded in T_6. Maximum shelf life (11.04 days) was recorded in T_3. The possible reason for better shelf life may be due to low respiration and transpiration rates, resulting in a reduced level of shrinkage and reduced ethylene metabolism. Minimum physiological loss in weight (11.02%) was recorded in T_3. However, maximum physiological loss in weight (17.18%) was recorded in T_6 (control). The higher physiological loss at ambient condition can be associated with the increase cell wall degradation leading to exposure of cell water for easy evaporation combined with higher permeability due to faster metabolism and ripening rate at high temperature storage. Similar results were also in consonance with Lal and Kanaujia (2013) [7] in capsicum.

Examination of the data revealed that maximum net return (Rs 23, 62,519.739) was obtained in treatment T_3 (100% RDF of NPK) whereas, minimum net returns (10, 93,096.938) were obtained in treatment T_6 (control). On the same lines, maximum benefits: cost ratio of 4.2:1 was calculated in T_3 and minimum 2.2: 1 was calculated in T_6. The reason for increased profit and benefits: cost ration is due to maximum marketable yield due to healthy and better fruit size, maximum number of fruits per plant, higher net return as compared to the other treatments. Hence, the application of 100% fertigation of NPK is rated as the most economical treatment for quality production of tomato. Whereas, lowest benefits: cost ratio was calculated in control.

Table 1: Effect of different levels fertigation on yield and yield contributing attributes

Treatments	Number of fruits plant^{-1}	Days to first picking	Crop duration (days)	Fruit diameter (cm)	Fruit length (cm)	Average fruit weight (g)	Fruit yield plant $^{-1}$ (kg)	Fruit yield ha^{-1} (t)	Net return (₹/ha)	B:C ratio
T_1(120% RDF of NPK)	65.26	83.78	186.70	7.88	7.79	75.96	3.45	95.89	1624608.114	3.102741
T_2(110% RDF of NPK)	70.30	79.42	187.40	8.24	7.98	77.35	3.93	109.22	1983971.294	3.657397
T_3(100% RDF of NPK)	74.34	76.44	188.44	8.38	8.05	79.99	4.44	123.39	2362519.739	4.271269
T_4(90% RDF of NPK)	61.12	84.02	185.34	7.38	7.57	73.56	2.99	83.00	1377179.186	2.973542
T_5(80% RDF of NPK)	56.52	82.98	184.56	6.96	7.29	70.36	2.47	68.61	1217962.335	2.449073
T_6(Control)	54.28	86.22	183.12	6.28	6.33	69.95	2.28	63.44	1093096.938	2.217171
S.Em±	3.00	1.47	185.93	0.25	0.32	1.00	0.21	5.84		
$CD_{(0.05)}$	8.76	4.30	2.09	0.73	0.91	2.90	0.61	17.06		

Table 2: Effect of different levels fertigation on quality parameters of tomato

Treatments	Titratable acidity (%)	Ascorbic acid (mg/100g)	Lycopene content (mg/100g)	Fruit firmness (kg/cm^2)	Shelf life (days)	Physiological loss in weight (%)	Fruit pH	TSS (ºBrix)
T_1 (120% RDF of NPK)	0.44	17.90	3.67	0.71	10.00	12.96	3.88	3.72
T_2 (110% RDF of NPK)	0.42	18.76	3.71	0.77	10.78	11.61	3.62	4.00
T_3 (100% RDF of NPK)	0.33	19.08	3.74	0.79	11.04	11.02	3.34	4.10
T_4 (90% RDF of NPK)	0.46	16.52	3.06	0.66	9.74	14.00	3.96	3.40
T_5 (80% RDF of NPK)	0.56	15.52	2.70	0.62	9.12	15.03	4.16	3.16
T_6 (Control)	0.71	12.00	2.57	0.58	8.86	17.18	4.26	3.06
S.Em±	0.05	0.22	0.21	0.02	0.32	0.80	0.10	0.20
$CD_{(0.05)}$	0.14	0.64	0.62	0.06	0.92	2.34	0.28	0.58

Conclusion

Integrated approach of 100 per cent recommended dose of NPK performed better respect to yield and yield contributing characters (number of fruits per plant, days to first picking, fruit, crop duration, average fruit weight, fruit yield plant^{-1}, fruit yield hectare^{-1}) and quality characters *viz*; fruit firmness, ascorbic acid, lycopene content, titratable acidity, TSS, fruit pH, shelf life, physiological loss in weight. Therefore, application of 100 per cent recommended dose of NPK may be suggested after on farm testing in trail for commercial cultivation of tomato for getting fruit yield and high quality per unit area. Nitrogen, Phosphorus and Potassium should be applied as optimum nutrition is the key to achieve maximum crop production.

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