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Response of NPK fertilization on yield and quality of cherry tomato

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Abstract
Field study was conducted to assess the effect of levels of N, P and K on yield and quality of cherry tomato (*Solanum lycopersicum* var. *cerasiforme*) at the research farm of the department of Soil Science and Water Management, Nauni, Solan-Himachal Pradesh during kharif seasons of 2014 and 2015. Results revealed that maximum yield of fruit (22.41q ha^{-1}), shoot (15.22q ha^{-1}) and root dry matter (4.16 q ha^{-1}) were recorded under T_6 (125% recommended dose of NPK) treatment and minimum yield of fruit (16.54 q ha^{-1}), shoot (13.59 q ha^{-1}) and root dry matter (3.72 q ha^{-1}) were recorded under T_1 (without NPK fertilizers) treatment. Maximum fruit size (3.36 cm^2), fruit weight (9.29 g) and TSS (8.69^0 Brix) were recorded under T_6 treatment and the minimum fruit size (2.73 cm^2), fruit weight (8.26 g) and TSS (7.53^o Brix) were recorded under T_1 treatment.Maximum number of fruits per cluster (18.94), number of cluster per plant (8.27) and number of fruits per plant (156.55) were also recorded under T_6 treatment and minimum number of fruits per cluster (18.08), number of cluster per plant (7.33) and number of fruits per plant (132.63) were recorded under T_1 treatment.

Keywords: cherry tomato, yield, quality, fruit weight

Introduction
Accurately assays of nutrients, consumed by plants for yield formation determine reasonable fertilizer recommendations. The application of optimum levels of fertilizers is necessary to achieve the maximum yield of the crop.

The quality of fresh vegetable produce depends on several factors. Among these factors, fertilizer forms and rates play an important role in ensuring an optimal nutritional regime for successful plant development and in influencing the yield and quality of vegetables. In order to obtain fresh vegetable production with optimal yields and quality, it is necessary to apply fertilizer sources that appropriately meet crop nutrient requirements.

The objective of our study was to estimate the most appropriate fertilizers levels for maximal yields of cherry tomato crop and to recommend the amounts of nutrients for the optimal yield formation. Cherry tomato (*Solanum lycopersicum* var. *cerasiforme*) is a botanical and small sized garden variety of cultivated tomato (Lenucci *et al*., 2006) [9]. It is also known as probable ancestor of tomato. Cherry tomatoes are more closely related to wild tomato and may contain more beta-carotene than lycopene (Potaczek and Michalak, 1994) [12]. Cherry tomato is grown for its edible fruits, which can be consumed either fresh, (its small size makes it very appetizing in salad) as a salad and as a garnish for numerous dishes or after cooking as snacks, which is much appreciated in international markets. It is becoming a miniature product consumed on a daily basis in many countries. The solanaceous group of vegetables (tomato, eggplant, chili and bell peppers) generally take up large amounts of nutrients. The amount of nutrients they take up depends on the quantity of fruit and dry matter they produce, which in turn is influenced by a number of genetic and environmental variables (Shukla and Naik 1993) [19].

Materials and Methods
The investigation entitled "Nutrient uptake and yield of cherry tomato under NPK fertilization" was conducted at the research farm of the department of Soil Science and Water Management, Nauni, Solan during kharif seasons of 2014 and 2015 with six treatments comprising of T_1 – without NPK fertilizers – (Control), T_2 – 25% recommended dose of NPK, T_3 – 50% recommended dose of NPK, T_4 – 75% recommended dose of NPK, T_5 – 100% recommended dose of NPK and T_6 – 125% recommended dose of NPK with four replications in a randomized block design.

The recommended dose of NPK applied in cherry tomato cv Solan red round was- nitrogen (N)-100 kg ha^{-1}, phosphorus (P_2O_5)-75 kg ha^{-1} and potassium (K_2O)-55 kg ha^{-1}. The experiments were laid out in randomised block design with four replications during kharif seasons of 2014 and 2015.Source of N, P and K fertilizers were Urea (46% N), single super phosphate (16% P_2O_5) and muriate of potash (60% K_2O), respectively.During Rabi seasons of 2014 and 2015, no crops were grown in the experimental plots and were kept fallow. The full dose of P and ½ dose of K and 1/3 dose of N was applied at the time of field preparation as a basal dose. The rest ½ dose of K and 1/3 dose of N was applied after one month of transplanting and rest of N was applied after two months of transplanting.

During both the years of study composite soil samples from 0-20 cm soil depth were collected before start of experiment. Collected soil samples were air dried in shade and ground with the help of pestle and mortar, passed through 2mm sieve and stored in polythene bags for available N, P, K and Cu, Fe, Zn, Mn analysis following standard procedures. The experimental site is situated at 30° 52′ N latitude and 77° 11′ E longitude at an elevation of 1260 m above mean sea level having average slope of 7-8 per cent and represent the mid hill zone of Himachal Pradesh. The study area falls in sub-temperate, sub-humid agro-climatic zone of Himachal Pradesh (Zone-2). The average annual rainfall of the area is about 1115 mm and about 75 per cent of it is received during the monsoon period (mid-June -mid September). Winter rains are meager and received during the month of January and February. May – June are the hottest and December – January are the coldest months. The soils of study area fall in the order Inceptisol and sub-group Eutrochrept according to soils taxonomy of USDA. These soils owe their origin to ferromagnesian shales and dolomitic limestones. The soils are non-saline near neutral in reaction medium in available N and high in organic carbon, available P, K, Zn, Cu, and Fe & Mn. Before the execution of experiment, the field was well ploughed by tractor followed by planking 15 days prior to actual date of transplanting of seedling. Weeds, stones, pebbles etc. were removed from the field. Twenty four raised plots of dimension 3 m x 1.5 m were made and FYM was applied at rate of 20 t ha^{-1} in each plot. One month old seedlings were transplanted at a spacing of 90 cm x 30 cm. Each plot had 2 rows accommodating 16 plants and total 384 seedlings were transplanted in 24 plots. The seedlings were raised with all precautions and healthy seedlings were transplanted on April 28, 2014 and 8th April 2015. During both the years, plant samples (fruit, shoot and root) collected at harvest were washed, air dried in shade, subsequently in an oven at 65±5°C till constant weight.The total fruit yield was obtained by adding yields of all the pickings of each plot upto 5th September, 2014 during first year and upto 10th August, 2015 during second year and expressed in q ha^{-1}. After weighing fruits for fresh weight, a known weight of fruit samples were cut into slices and dried in dry air first and then samples were kept in oven at 65±5°C for further drying till they attain constant weight and then their weights were recorded and expressed in grams. Plants were removed from the soil and washed thoroughly with distilled water to remove the adhering soil. The plants were then divided into two parts by cutting from the collar end and taken as root and shoot portions. The samples were then kept in oven at 65±5°C for drying till constant weight and their weights recorded and expressed in grams.

The randomly selected fruits were crushed and juice passed Through a double layer of fine mesh cloth and total soluble solids (TSS) determined with the help of Erma hand refract meter and expressed as percentage of fruit weight. Data on number of fruits per cluster, number of clusters per plant and number of fruits per plant was also recorded.

Days were counted between first picking to final harvest of marketable fruits in each entry to record the data on harvest duration. Data on the days to first harvest was recorded from the date of transplanting to the date of first marketable harvest of fruits at fruit maturity stage.

The data generated from present investigation were subjected to statistically analysis using the statistical package SPSS (16.0) and Microsoft Excel. Critical difference (CD) at 5 per cent level was used for testing the significant difference among the treatment means. An outline of analysis of variance based on randomized block design (RBD) with‘t’ treatment and ‘r’ replication was prepared.

Results and Discussion

Dry Matter Yield

The perusal of data presented in the Table1 reveals that fruit dry matter yield increased with increasing levels of N, P and K in all the treatments. The effect of levels of N, P and K in treatments found to exert a significant effect over the control treatment T_1. The maximum value (22.40 q ha^{-1}) of fruit dry matter was recorded under treatment T_6, whereas the minimum value for fruit dry matter yield (16.54 q ha^{-1}) was recorded under treatment T_1.

Table 1: Effect of levels of N, P and K on dry matter (q ha^{-1}) yield of fruit, shoot and root of cherry tomato

Treatment	Fruit			Shoot			Root		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
T_1	16.05	17.03	16.54	13.37	13.82	13.59	3.65	3.78	3.72
T_2	17.69	19.22	18.45	13.79	14.24	14.01	3.82	3.95	3.88
T_3	18.80	20.60	19.69	14.15	14.60	14.37	3.94	4.07	4.00
T_4	19.82	21.95	20.87	14.46	14.91	14.68	4.04	4.16	4.10
T_5	20.69	22.79	21.73	14.75	15.19	14.97	4.10	4.23	4.16
T_6	21.35	23.48	22.41	15.00	15.45	15.22	4.16	4.28	4.22
C.D. (0.05)	0.85	1.00	0.90	0.48	0.31	0.37	0.08	0.10	0.09

The data presented in Table1 indicates that shoot dry matter yield increased with increasing levels of N, P and K in all the treatments and found to exert a significant influence. The maximum shoot dry matter yield of 15.22 q ha^{-1} was recorded under treatment T_6, however, the minimum shoot dry matter yield of 13.59 q ha^{-1} under T_1.

An inquisition of data in Table 1 indicates that root dry matter of 4.22 q ha^{-1} found to be the maximum, under treatment T_6. The effect of levels of N, P and K in all the treatments exerted a significant effect on root dry matter. The minimum root dry matter yield of 3.72 q ha^{-1} recorded under treatment T_1.

The increase in levels of application of N, P and K were found to affect dry matter yield (fruit, shoot and root) of tomato. The total dry matter increased with the increasing levels of NPK inputs (Table1). A comparison of nutrient application contributing to the overall fruit, shoot and root biomass reveals that in this case N is playing a major role. P and K application also increased the biomass but the increase was more due to their interactive effect with N rather than their individual effects. N is known to play an important role in accelerating the plant growth, which, ultimately helps in increasing the photosynthetic activity, which leads to the accumulation of higher amount of biomass. Similarly, increased dry matter production by the soil fertility management treatments have also been reported by Pandey *et al*. (1996) [11]. Similar results have, also, been reported by earlier workers (Gupta and Shukla, 1977 [3], Sharma, 1995 [18] and Singh and Kohli, 1999 [20]). Gupta *et al.* (1978) [4] attributed the response in yield of tomato to increased N applications. The results obtained in the present studies are further supported by the works of Khan and Misra (1976) [7] and Sangeeta *et al.* (1997) [17].

Quality

An inquisition of data in Table 2 indicates that fruit size increased with increasing levels of N, P and K in all the treatments and found to exert a significant effect. The maximum fruit size of 3.36 cm^2 was recorded under treatment T_6 where maximum level of N, P and K fertilizer was applied; however, the minimum fruit size of 2.73 cm^2 was recorded under treatment T_1.

Table 2: Effect of levels of N, P and K on quality of cherry tomato

Treatment	Fruit size (cm^2)			Fruit weight (g)			Total Soluble Solid (°Brix)		
	2014	2015	2014	2014	2015	Pooled	2014	2015	Pooled
T_1	2.70	2.77	2.73	8.15	8.36	8.26	7.66	7.53	7.53
T_2	3.03	3.06	3.04	8.49	8.71	8.60	7.88	7.58	7.58
T_3	3.09	3.13	3.11	8.71	8.90	8.80	8.05	8.01	8.01
T_4	3.13	3.21	3.17	8.90	9.17	9.03	8.34	8.28	8.28
T_5	3.26	3.32	3.29	9.06	9.29	9.18	8.70	8.57	8.57
T_6	3.34	3.37	3.36	9.17	9.41	9.29	8.78	8.69	8.69
C.D. (0.05)	0.14	0.19	0.15	0.18	0.20	0.17	0.34	0.53	0.32

The increase in levels of application of N, P and K were found to affect the fruit size significantly. Since the size of fruit depend upon the vegetative growth of a plant, it was noticed that higher nutrient doses led to increase in vegetative growth and metabolism, which in turn was probably responsible for increase in size of the fruits. These findings are in agreement with those of Khan and Misra (1976) [7] and Prema *et al*. (2011) [14].

The data pertaining to fruit weight (Table 2) shows that fruit weight increased with increasing levels of N, P and K. The effect of levels of N, P and K in all the treatments exerted a significant effect. The maximum (9.29 g) and minimum fruit weight (8.26 g) were recorded under treatments T_6 and T_1, respectively.

Fruit weight is directly related to fruit yield of the tomato crop. The results of present investigations shows that the fruit weight increased with increasing levels of N, P and K fertilizer doses. These results are in line with those reported by Randhawa *et al.* (1977) [16], Bhatnagar and Pandita (1979) [2], Gupta (1989) [5], Singh and Verma (1991) [21] and Mehraj *et al.* (2014) [10].

The data presented in Table 2 indicates that levels of N, P and K in all the treatments found to exert a significant influence. The maximum value for total soluble solids (8.69 °Brix) was recorded under treatment T_6 whereas the minimum value of TSS (7.53 °Brix) was recorded under treatment T_1.

The increasing levels of N, P and K show significant effect on TSS. The increase in TSS with an increase in fertilizer level may be due to the fact that K is involved in sugar/carbohydrate metabolism by the plant**.** The present results confirm the findings of Gupta *et al.* (1978) [4], Kumar *et al.* (1998) [8] and Arora *et al.* (1993) [1].

An evinced from the Table 3 shows levels of N, P and K in all the treatments exerted a significant effect. The maximum (18.94) number of fruits per cluster was recorded in treatment T_6 whereas minimum (18.08) number of fruits per cluster was recorded in treatment T_1.

Number of Fruits per cluster directly affects the yield of cherry tomato. The different levels of NPK exerted significant effect on number of fruits per cluster. The present result confirms the findings of Poudel and Lee (2009) [13] under tomato crop.

A perusal of data presented in Table 3 indicates that maximum number of clusters per plant was recorded in treatment T_6 (8.27) whereas minimum number of fruits per cluster was recorded in treatment T_1 (7.33).

Like number of fruits per cluster, number of clusters per plant significantly affects the yield of cherry tomato crop. The present results confirms the findings of Prema *et al*., (2011) [14] under cherry tomato cultivation.

The data presented in Table 3 reveals that levels of N, P and K in all the treatments exerted a significant effect. The maximum number of fruits per plant was recorded in treatment T_6 (156.55) whereas minimum number of fruits per plant was recorded in treatment T_1 (132.63).

Table 3: Effect of levels of N, P and K on number of fruits per cluster, number of clusters per plant and number of fruits per plant of cherry tomato

Treatment	Number of fruits per cluster			Number of clusters per plant			Number of fruits per plant		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
T_1	17.99	18.18	18.08	7.24	7.42	7.33	130.35	134.91	132.63
T_2	18.23	18.45	18.34	7.42	7.77	7.59	135.25	143.28	139.26
T_3	18.46	18.68	18.57	7.59	8.04	7.81	140.07	150.14	145.11
T_4	18.64	18.87	18.75	7.75	8.24	7.99	144.44	155.35	149.90
T_5	18.76	18.99	18.87	7.90	8.38	8.14	148.12	159.06	153.59

T_6	18.81	19.06	18.94	8.04	8.50	8.27	151.12	161.98	156.55
C.D. (0.05)	0.31	0.31	0.29	0.15	0.20	0.16	4.50	5.76	4.89

The multiplication of number of fruits per cluster and number of clusters per plant results into total yield per plant. The increase in levels of application of N, P and K exerted the significant effect on number of fruits per plant. The present results are in line with findings of Hebbar *et al*., (2004) [6] and Vidyadhar *et al*., (2015) [23].

An inquisition of data in Table 4 indicates that days to first harvest ranged from 51.94 to 54.25 days. The maximum days to first picking was recorded under T_1 whereas minimum days to first picking was recorded under T_6.

Earliness is important to fetch premium prices in a market. Therefore, days to first harvest are primary indicator to predict earliness in a crop like tomato. The findings of Rana and Vidyasagar (2005) [15] are in line with the present results.

Table 4: Effect of levels of N, P and K on days to first picking and harvest duration of cherry tomato

Treatment	Days to first picking			Harvest duration (days)		
	2014	2015	Pooled	2014	2015	Pooled
T_1	54.13	54.38	54.25	51.00	51.75	51.38
T_2	53.50	53.75	53.63	51.13	52.13	51.63
T_3	53.13	53.13	53.13	52.13	52.50	52.31
T_4	52.50	53.00	52.75	53.25	53.50	53.38
T_5	52.25	52.88	52.56	53.38	53.75	53.56
T_6	51.50	52.38	51.94	54.25	54.75	54.50
C.D. (0.05)	0.97	1.02	0.81	1.94	1.60	1.75

A perusal of data presented in the Table 4 reveals that harvest duration days ranged from 51.38 to 54.50 days. The maximum harvest duration days were recorded under treatment T_6 (54.50) whereas minimum harvest duration days was recorded under treatment T_1 (51.38).

Longer harvest duration ensures the continuous supply of produce and good price of tomato for over a longer period. It also keeps a balance between the demand and supply, thereby in avoiding glut in the market and fall in prices. These results are in line with the findings of Thakur *et al.* (2004) [22].

Conclusion

The studies revealed that maximum yield of fruit, shoot & root dry matter, fruit size, fruit weight, TSS, number of fruits per cluster, number of cluster per plant and number of fruits per plant were recorded under T_6 (125% recommended dose of NPK) treatment and minimum yield of fruit, shoot & root dry matter, fruit size, fruit weight, TSS, number of fruits per cluster, number of cluster per plant and number of fruits per plant were recorded under T_1 (without NPK fertilizers)) treatment.

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