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Nutrient uptake and yield of cherry tomato under NPK fertilization

NS Gill and ML Verma

Abstract
The investigation was conducted to assess the effect of levels of N, P and K on nutrient uptake and yield 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. The results revealed that the maximum fruit yield and nutrient contents in the fruit, shoot and root were found in the treatment-T_6 comprising of 125% recommended dose of NPK(RDF) followed by 100% RDF (T_5) and minimum levels were found in the treatment without fertilizer (T_{1}- control). The maximum uptake of N (90.06 kg ha^{-1}), P (13.19 kg ha^{-1}) and K (74.50 kg ha^{-1}) by cherry tomato was recorded under treatment T_6, whereas, the minimum uptake of N (69.66 kg ha^{-1}), P (7.51 kg ha^{-1}) and K (54.20 kg ha^{-1}) by cherry tomato was recorded under T_1 (control) treatment. The maximum uptake of Cu (316.09 g ha^{-1}), Fe (585.51g ha^{-1}), Zn (85.68 g ha^{-1}) and Mn (145.61 g ha^{-1}) by cherry tomato was recorded under treatment $T_{6,}$ whereas, the minimum uptake of Cu (253.73 g ha^{-1}), Fe (462.40 g ha^{-1}), Zn (67.97 g ha^{-1}) and Mn (115.95 g ha^{-1}) by cherry tomato was recorded under T_1 (control) treatment.

Keywords: nutrient uptake, cherry tomato, yield, nutrient content

1. Introduction
The application of optimum levels of fertilizers is necessary to achieve the maximum yield of the crop. The uptake of nutrients – nitrogen, phosphorus, potassium, copper, iron, zinc and manganese is one of main parameters that indicate nutrient plant requirements. Accurately assays of nutrients, consumed by plants for yield formation determine reasonable fertilizer recommendations. 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 is necessary to apply fertilizer sources that appropriately meet crop nutrient requirements.
The objective of our study is 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 on the base of its biological uptake. Cherry tomato (*Solanum lycopersicum* var. *cerasiforme*) is a botanical and small sized garden variety of cultivated tomato (Lenucci *et al*., 2006) [6]. 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) [10]. Cherry tomato is grown for its edible fruits, which can be consumed either fresh, (its small size makes it very appetising 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) [11]. According to Yawalkar *et al*. (1961) [16] a tomato crop yielding about 38 mt/ha of fruit removes 104 kg N, 9.5 kg P and 116 kg K from the soil. In the absence of any other production constraints, nutrient uptake and yield are very closely related. The studies were conducted to investigate the influence of NPK fertilization on nutrient uptake and yield of cherry tomato.

2. Materials and Methods
The investigation 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 randomized 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, 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, ground in an electric grinder and stored in paper bags for chemical analysis. The plant samples were analyzed for total nitrogen, phosphorus, potash, copper, zinc, iron and manganese following standard procedures. Fruits were harvested from each plot and weighed separately at every picking. 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. Nutrient uptake by root, shoot and fruit was calculated by the following formula:

$$\text{Nutrient uptake (kg /ha)} = \frac{\text{Nutrient content (\%)} \times \text{Dry matter yield (kg ha}^{-1}\text{)}}{100}$$

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.

3. Results and Discussion

3.1 Macronutrient in fruit

3.1.1 Nitrogen

Nitrogen uptake in cherry tomato fruit has been presented in table 1. An examination of data revealed that the maximum amount of uptake of N (42.74 kg ha^{-1}) by cherry tomato fruits was recorded under treatment T_6. Application of all the treatments were found to exert a significant effect on the N removal by cherry tomato fruit over the control treatment T_1, under which the minimum amount of N removal (29.86 kg ha^{-1}) was recorded.

Table 1: Effect of levels of N, P and K on macronutrient uptake (kg ha^{-1}) by fruit in cherry tomato

Treatment	N			P			K		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
T_1	28.82	30.91	29.86	3.61	3.92	3.76	24.38	26.08	25.22
T_2	32.11	35.24	33.66	4.29	4.80	4.54	28.45	30.91	29.67
T_3	34.47	38.17	36.30	4.84	5.56	5.19	31.19	34.58	32.86
T_4	36.73	41.09	38.88	5.35	6.31	5.82	33.27	37.72	35.45
T_5	38.75	43.15	40.92	5.84	6.84	6.33	35.07	39.95	37.46
T_6	40.49	45.05	42.74	6.24	7.34	6.78	36.70	41.78	39.19
C.D. (0.05)	1.55	1.88	1.67	0.22	0.37	0.26	1.35	1.57	1.42

The uptake of nitrogen by the fruit went on increasing with the successive increase in the levels of NPK. The effects are quite convincing since the uptake is a resultant of concentration and biological yield. Mamonova (1978) [7], Belicheki *et al.* (1982) [2] and Subbiah and Perumal (1986) [12] have also reported increased uptake of N with the increasing levels of applied N fertilizer doses.

3.1.2 Phosphorus

A perusal of data reveals that phosphorus uptake in cherry tomato fruit (Table 1) reveals that the P removal of 6.78 kg ha^{-1}, was found to be the maximum under treatment T_6. Imposition of all the treatments exerted a significant influence on the P removal by cherry tomato fruit, over the control. The lowest amount of P removal by cherry tomato fruit was recorded under T_1 (3.76 kg ha^{-1}).

Phosphorus uptake also went on increasing with increasing NPK levels; this may be due to improved absorption and utilization of P at higher rates of application. These findings are in line with those of Cannel *et al.* (1960) [3] and Anand and Muthukrishnan (1974) [1].

3.1.3 Potassium

Potassium uptake in cherry tomato fruit presented in table 1 revealed that K removal by cherry tomato fruit showed significant influence of all the treatments over the control. An inquisition of data indicates that maximum removal of K by tomato fruit (39.19 kg ha^{-1}) was under treatment T_6, whereas the minimum amount of K (25.22 kg ha^{-1}) was removed under treatment T_1 (control).

N and P, K uptakes also increased with the increasing fertilizer doses and this may be due to improved absorption and utilization of K at higher rates of application. These findings are in line with those of Cannel *et al.* (1960) [3] and Anand and Muthukrishnan (1974) [1].

3.2 Micronutrient in fruit

3.2.1 Copper

The perusal of data presented in the table 2 reveals that the maximum amount of uptake of copper (174.23 g ha^{-1}) by cherry tomato fruits was recorded under treatment T_6. The effect of levels of N, P and K in treatments found to exert a significant effect on the Cu removal by cherry tomato fruit over the control treatment T_1, under which the minimum amount of Cu removal (128.31 g ha^{-1}) was recorded.

3.2.2 Iron

An inquisition of data in table 2 indicates that iron removal of 309.54 g 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 influence on the Fe removal by cherry tomato fruit, over the control. The lowest amount of P removal by tomato fruit was obtained under T_1 (227.29 g ha^{-1}).

Table 2: Effect of levels of N, P and K on micronutrient uptake (g ha^{-1}) by fruit in cherry tomato.

Treatment	Cu			Fe			Zn			Mn		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
T_1	124.48	132.20	128.31	220.54	234.14	227.29	28.93	31.02	29.96	56.18	59.71	57.93
T_2	137.30	149.22	143.20	243.30	264.44	253.78	32.01	35.12	33.55	62.04	67.51	64.75
T_3	145.98	160.04	152.95	258.76	283.77	271.16	34.39	37.82	36.09	66.16	72.53	69.32
T_4	154.01	170.56	162.19	273.15	302.90	287.86	36.59	40.54	38.55	69.82	77.49	73.61
T_5	160.79	177.11	168.87	285.45	314.62	299.89	38.35	42.30	40.31	72.96	80.53	76.71
T_6	166.00	182.62	174.23	294.85	324.51	309.54	39.71	43.86	41.76	75.48	83.19	79.29
C.D. (0.05)	7.83	8.83	7.70	11.90	13.86	12.45	2.82	2.56	1.80	3.12	4.46	3.25

3.2.3 Zinc

An evinced from the table 2 shows the maximum amount of uptake of zinc (41.76 g ha^{-1}) by cherry tomato fruits was recorded under treatment T_6. The levels of N, P and K in all the treatments were found to exert a significant effect on the Zn removal by cherry tomato fruit over the control treatment T_1, under which the minimum amount of Zn removal (29.96 g ha^{-1}) was recorded.

3.2.4 Manganese

The data presented in the table 2 reveals that under different levels of N, P and K manganese removal by cherry tomato fruit showed significant influence of all the treatments over the control. The maximum removal of Mn by cherry tomato fruit (79.29 g ha^{-1}) was under treatment T_6, whereas minimum amount of Mn (57.93 g ha^{-1}) removal was recorded under treatment T_1 (control).

Similar results of micronutrient (Cu, Fe, Zn, Mn) uptake in tomato fruits were obtained by Nangliya (2014) [8].

3.3 Macronutrient nutrient uptake by shoot

3.3.1 Nitrogen

An examination of data indicates that nitrogen uptake (Table 3) by cherry tomato shoot shows that under levels of N, P and K all the treatments had a significant influence on the N uptake by cherry tomato shoot when compared with T_1 treatment. The maximum N uptake (39.54 kg ha^{-1}) was obtained under treatment T_6 where the highest of levels of N, P and K was applied. However, the lowest value of N uptake (34.03 kg ha^{-1}) by tomato shoot was recorded under T_1 treatment.

Table 3: Effect of levels of N, P and K on macronutrient uptake (kg ha^{-1}) by shoot in cherry tomato

Treatment	N			P			K		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
T_1	33.38	34.69	34.03	2.87	3.01	2.94	22.72	23.81	23.26
T_2	34.74	36.01	35.37	3.34	3.56	3.45	24.35	25.18	24.76
T_3	35.90	37.16	36.53	3.75	3.94	3.84	25.61	26.31	25.96
T_4	36.98	38.27	37.62	4.12	4.36	4.24	26.34	27.12	26.73
T_5	37.98	39.30	38.64	4.54	4.79	4.66	27.21	27.87	27.54
T_6	38.91	40.16	39.54	4.95	5.10	5.03	27.91	28.64	28.28
C.D. (0.05)	1.23	0.81	0.95	0.17	0.18	0.17	0.80	0.56	0.64

The highest uptake of N was recorded under treatment T_6 where the highest dose of NPK was applied (Table 3). The uptake of N by the shoot went on increasing with the successive increase in the levels of NPK. Since the uptake is a resultant of concentration and biological yield. Mamonova (1978) [7], Belicheki *et al.* (1982) [2] and Subbiah and Perumal (1986) [12] have also reported increased uptake of N with the increasing levels of applied N fertilizer doses.

3.3.2 Phosphorus
A glance on data in table 3 shows the highest uptake of phosphorus (5.03 kg ha^{-1}) by the cherry tomato shoot under treatment T_6. The minimum P uptake was recorded under T_1 (2.94 kg ha^{-1}). The effect of N, P & K on phosphorus uptake was significant.

Similar to N, P uptake also increased with the increasing fertilizer doses and this may be due to improved absorption and utilization P at higher rates of application. These findings are in line with those of Cannel *et al.* (1960) [3] and Anand and Muthukrishnan (1974) [1].

3.3.3 Potassium
Potassium uptake in cherry tomato shoot has been presented in table 3. An inquisition of data indicates that maximum K uptake (28.28 kg ha^{-1}) by cherry tomato shoot recorded under treatment T_6, where the highest of levels of N, P and K was applied. The minimum K uptake of 23.26 kg ha^{-1} was observed in treatment T_1.

Potassium uptake also went on increasing with increasing NPK levels; this may be due to improved absorption and utilization of K at higher rates of application. These findings are also in line with those of Cannel *et al.* (1960) [3] and Anand and Muthukrishnan (1974) [1].

3.4 Micronutrient nutrient uptake by shoot
3.4.1 Copper
The perusal of data presented in the table 4 reveals the highest uptake of copper (118.60 g ha^{-1}) by the cherry tomato shoot was recorded under treatment T_6. The effect of levels of N, P and K in treatments found to exert a significant effect on the Cu removal by cherry tomato shoot. The minimum Cu (105.76 g ha^{-1}) uptake was recorded under T_1 treatment.

Table 4: Effect of levels of N, P and K on micronutrient uptake (g ha^{-1}) by shoot in cherry tomato

Treatment	Cu			Fe			Zn			Mn		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
T_1	103.95	107.57	105.76	191.66	198.66	195.15	27.32	28.28	27.80	46.96	48.75	47.85
T_2	107.26	110.85	109.06	198.05	204.73	201.39	28.23	29.23	28.73	48.68	50.29	49.49
T_3	110.10	113.66	111.88	203.41	210.02	206.72	29.07	30.03	29.55	49.98	51.59	50.78
T_4	112.55	116.10	114.33	208.00	214.55	211.27	29.78	30.76	30.27	51.12	52.72	51.92
T_5	114.85	118.32	116.59	212.30	218.85	215.57	30.48	31.41	30.94	52.15	53.89	53.02
T_6	116.85	120.35	118.60	216.16	222.65	219.40	31.06	32.02	31.54	53.21	54.82	54.02
C.D. (0.05)	3.84	2.73	2.79	6.83	4.23	5.04	2.34	2.08	1.14	1.74	1.03	1.24

3.4.2 Iron
An inquisition of data in table 4 indicates that maximum iron uptake (219.40 g ha^{-1}) by cherry tomato shoot recorded under treatment T_6. The effect of levels of N, P and K in all the treatments exerted a significant influence on the Fe removal by cherry tomato shoot. The lowest amount of Fe removal by tomato shoot was obtained under T_1 (195.15 g ha^{-1}).

3.4.3 Zinc
The data presented in the table 4 reveals that maximum uptake (31.54 g ha^{-1}) by cherry tomato shoot recorded under treatment T_6. The levels of N, P and K in all the treatments were found to exert a significant effect on the Zn removal by cherry tomato shoot. The minimum Zn uptake of 27.80 g ha^{-1} was observed under treatment T_1 (control).

3.4.4 Manganese
An evinced from the table 4 shows that different levels of N, P and K had a significant influence on the manganese uptake by cherry tomato shoot. The maximum Mn uptake (54.02 g ha^{-1}) was obtained under treatment T_6. The lowest value of Mn uptake (47.85 g ha^{-1}) by cherry tomato shoot was recorded under T_1 (control) treatment. Shoot micronutrients (Cu, Fe, Zn, Mn) uptake are in line with results obtained by Nangliya (2014) [8].

3.5 Macronutrients uptake by root
3.5.1 Nitrogen
Nitrogen uptake in cherry tomato root has been presented in table 5. An examination of data revealed that the maximum amount of uptake of N (7.79kg ha^{-1}) by cherry tomato root was recorded under treatment T_6. Application of all the treatments were found to exert a significant effect on the N removal by cherry tomato root over the control treatment T_1, under which the minimum amount of N removal (5.76kg ha^{-1}) was recorded.

Table 5: Effect of levels of N, P and K on macronutrient uptake (kg ha^{-1}) by root in cherry tomato

Treatment	N			P			K		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
T_1	5.55	5.98	5.76	0.79	0.82	0.80	5.58	5.85	5.71
T_2	6.05	6.53	6.29	0.93	0.99	0.96	5.98	6.26	6.12
T_3	6.53	6.99	6.76	1.04	1.10	1.07	6.27	6.59	6.43
T_4	6.94	7.40	7.17	1.15	1.22	1.18	6.52	6.86	6.69
T_5	7.29	7.69	7.49	1.26	1.33	1.30	6.69	7.07	6.88
T_6	7.57	8.01	7.79	1.34	1.43	1.39	6.84	7.22	7.03
C.D. (0.05)	0.13	0.14	0.13	0.16	0.16	0.15	2.63	2.61	2.53

The uptake of N by the root went on increasing with the successive increase in the levels of NPK. The effects are quite supportive since the uptake is a resultant of concentration and biological yield. Mamonova (1978) [7], Belicheki *et al.* (1982) [2] and Subbiah and Perumal (1986) [12] have also reported increased uptake of N with the increasing levels of applied N fertilizer doses.

3.5.2 Phosphorus
A perusal of data reveals that phosphorus uptake in cherry tomato root (Table 5) reveals that the P removal of 1.39 kg ha^{-1}, found to be the maximum under treatment T_6. Imposition of all the treatments exerted a significant influence on the P removal by cherry tomato root, over the control. The lowest

amount of P removal by cherry tomato root was recorded under T_1 (0.80 kg ha^{-1}).

Phosphorus uptake also went on increasing with increasing NPK levels; this may be due to improved absorption and utilization of P at higher rates of application. These findings are in line with those of Cannel *et al.* (1960) [3] and Anand and Muthukrishnan (1974) [1].

3.5.3 Potassium

Potassium uptake in cherry tomato root has been presented in table 5 revealed that K removal by cherry tomato root was significantly affected by N, P & K treatments. An inquisition of data indicates that maximum removal of K by tomato root (7.03 kg ha^{-1}) was under treatment T_6, whereas The minimum amount of K (5.71 kg ha^{-1}) was removed under treatment T_1 (control).

Similar to N and P, K uptakes also increased with the increasing fertilizer doses and this may be due to improved absorption and utilization K at higher rates of application. These findings are in line with those of Cannel *et al.* (1960) [3] and Anand and Muthukrishnan (1974) [1].

3.6 Micronutrient uptake by root

3.6.1 Copper

The perusal of data presented in the table 6 reveals that the maximum amount of uptake of copper (23.26 g ha^{-1}) by cherry tomato root was recorded under treatment T_6. The effect of levels of N, P and K in treatments found to exert a significant effect on the Cu removal by cherry tomato root. The minimum amount of Cu removal (19.66 g ha^{-1}) was recorded under T_1 treatment (control).

3.6.2 Iron

An inquisition of data in table 6 indicates that iron removal of 56.57 g ha^{-1} was 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 influence on the Fe removal by cherry tomato root. The lowest amount of P removal by tomato root was obtained under T_1 (39.96 g ha^{-1}).

Table 6: Effect of levels of N, P and K on micronutrient uptake (g ha^{-1}) by root in cherry tomato

Treatment	Cu			Fe			Zn			Mn		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
T_1	19.18	20.14	19.66	38.77	41.16	39.96	9.95	10.47	10.21	9.97	10.36	10.17
T_2	20.21	21.19	20.70	42.14	43.91	43.02	10.52	11.06	10.79	10.47	11.03	10.75
T_3	20.88	21.94	21.41	44.62	46.58	45.59	11.13	11.59	11.36	10.90	11.54	11.22
T_4	21.89	22.64	22.26	47.08	48.84	47.96	11.50	11.96	11.73	11.23	11.88	11.55
T_5	22.38	23.20	22.79	52.38	54.35	53.36	11.81	12.39	12.10	11.60	12.22	11.91
T_6	22.81	23.70	23.26	55.51	57.63	56.57	12.21	12.53	12.37	12.01	12.60	12.30
C.D. (0.05)	1.44	1.20	1.30	10.46	10.46	10.46	0.81	0.90	0.79	0.89	0.69	0.78

3.6.3 Zinc

An evinced from the table 6 shows the maximum amount of uptake of zinc (12.37 g ha^{-1}) by cherry tomato root was recorded under treatment T_6. The levels of N, P and K in all the treatments were found to exert a significant effect on the Zn removal by cherry tomato root. The minimum amount of Zn removal (10.21 g ha^{-1}) was recorded under T_1 treatment (control).

3.6.4 Manganese

The data presented in the table 6 reveals that under different levels of N, P and K manganese removal by cherry tomato root was significantly affected. The maximum removal of Mn by cherry tomato root (12.30 g ha^{-1}) was under treatment T_6, whereas minimum amount of Mn (10.17 g ha^{-1}) removal was recorded under treatment T_1 (control).

The uptake of micronutrients in tomato roots are in line with by the findings of Hampton *et al.*, (1994) [4] and Takahashi and Sugiura (2001) [13].

3.7 Total Nutrient uptake by plant

The total nutrient uptake by cherry tomato plant was obtained by the summation of the individual uptake by fruit, shoot and root of the nutrient concerned.

3.7.1 Total Macronutrient uptake

3.7.1.1 Nitrogen

The total nitrogen uptake in cherry tomato plants has been presented in table 7. An examination of data revealed that the maximum amount of uptake of N (90.06 kg ha^{-1}) by cherry tomato plant was recorded under treatment T_6. Application of all the treatments were found to exert a significant effect on the N removal by cherry tomato plant over the control treatment T_1, under which the minimum amount of N removal (69.66 kg ha^{-1}) was recorded.

Table 7: Effect of levels of N, P and K on total (fruit+shoot+root) macronutrient uptake (kg ha^{-1}) by plant of cherry tomato.

Treatment	N			P			K		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
T_1	67.76	71.59	69.66	7.27	7.75	7.51	52.68	55.74	54.20
T_2	72.90	77.78	75.32	8.56	9.35	8.95	58.78	62.35	60.55
T_3	76.91	82.32	79.59	9.63	10.60	10.11	63.08	67.49	65.26
T_4	80.65	86.76	83.67	10.62	11.89	11.24	66.13	71.70	68.88
T_5	84.03	90.15	87.06	11.64	12.95	12.28	68.97	74.90	71.89
T_6	86.97	93.22	90.06	12.54	13.88	13.19	71.45	77.65	74.50
C.D. (0.05)	2.63	2.61	2.53	0.32	0.47	0.34	2.10	2.14	2.05

The total nutrient removal was worked out as a summation of each by N, P and K nutrient removals by fruits, shoot and root and signifies that portion of the nutrient reserve which is regularly removed out of the system at a particular yield level. The total nutrient removal was found to increase linearly with the increased NPK levels. The results on the uptake of nutrient elements N by tomato plants are in line with those of Mamonova (1978) [7], who also observed the nutrient uptake by tomato plants increases with the increasing levels of fertilizer application.

3.7.1.2 Phosphorus
A perusal of data reveals that phosphorus uptake in cherry tomato plant (Table 7) reveals that the P removal of 13.19 kg ha^{-1}, was found to be the maximum under treatment T_6. Imposition of all the treatments exerted a significant influence on the P removal by cherry tomato plant, over the control. The lowest amount of P removal by cherry tomato plant was recorded under T_1 (7.51 kg ha^{-1}).

Phosphorus uptake by tomato plants increases with the increasing levels of fertilizer application, and attributed this to the adequate nutrient availability, higher uptake and higher yield and, also, to the role played by the positive interactions amongst different nutrient elements to enhance the uptake. The results on the uptake of nutrient elements by cherry tomato plants are in line with those of Voogt (1993) [14], Yadav and Batra (1991) [15] and Subbiah and Perumal (1986) [12], who also observed the nutrient uptake by tomato plants increases with the increasing levels of fertilizer application.

3.7.1.3 Potassium
Potassium uptake in cherry tomato plant presented in table 7 reveals that K removal by cherry tomato plant showed significant influence of all the treatments over the control. An inquisition of data indicates that maximum removal of K by cherry tomato plant (74.50 kg ha^{-1}) was under treatment T_6, whereas The minimum amount of K (54.20 kg ha^{-1}) was removed under treatment T_1 (control).

Potassium uptake by tomato plants are in line with those of Mamonova (1978) [7], Voogt (1993) [14], Yadav and Batra (1991) [15] and Subbiah and Perumal (1986) [12], who also observed the nutrient uptake by tomato plants increases with the increasing levels of fertilizer application.

3.7.2 Total Micronutrient uptake by plant
3.7.2.1 Copper
The perusal of data presented in the table 8 reveals that the maximum amount of uptake of copper (316.09 g ha^{-1}) by cherry tomato plant was recorded under treatment T_6. The effect of levels of N, P and K in treatments found to exert a significant effect on the Cu removal by cherry tomato plant over the control treatment T_1, under which the minimum amount of Cu removal (253.73 g ha^{-1}) was recorded.

3.7.2.2 Iron
An inquisition of data in table 8 indicates that iron removal of 585.51 g 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 influence on the Fe removal by cherry tomato plant, over the control. The lowest amount of P removal by tomato fruit was obtained under T_1 (462.40 g ha^{-1}).

Table 8: Effect of levels of N, P and K on total (fruit+shoot+root) micronutrient uptake (g ha^{-1}) by plant of cherry tomato.

Treatment	Cu			Fe			Zn			Mn		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
T_1	247.61	259.90	253.73	450.97	473.95	462.40	66.20	69.77	67.97	113.11	118.82	115.95
T_2	264.77	281.27	272.96	483.49	513.08	498.19	70.76	75.40	73.06	121.19	128.83	124.98
T_3	276.97	295.64	286.24	506.79	540.37	523.47	74.60	79.44	77.00	127.03	135.65	131.31
T_4	288.44	309.29	298.78	528.23	566.28	547.09	77.88	83.26	80.54	132.17	142.08	137.08
T_5	298.03	318.63	308.25	550.12	587.82	568.82	80.63	86.11	83.35	136.71	146.65	141.64
T_6	305.66	326.67	316.09	566.51	604.79	585.51	82.98	88.41	85.68	140.70	150.61	145.61
C.D. (0.05)	10.49	10.91	9.77	18.46	18.54	17.86	4.60	3.73	2.92	4.68	5.40	4.48

3.7.2.3 Zinc
An evinced from the table 8 shows the maximum amount of uptake of zinc (85.68 g ha^{-1}) by cherry tomato plant was recorded under treatment T_6. The levels of N, P and K in all the treatments were found to exert a significant effect on the Zn removal by cherry tomato plant. The minimum amount of Zn removal (67.97 g ha^{-1}) was recorded under T_1 treatment (control).

3.7.2.4 Manganese
The data presented in the table 8 reveals that under different levels of N, P and K manganese removal by cherry tomato plant showed significant influence of all the treatments over the control. The maximum removal of Mn by cherry tomato plant (145.61 g ha^{-1}) was under treatment T_6, whereas minimum amount of Mn (115.95 g ha^{-1}) removal was recorded under treatment T_1 (control).

The total micronutrients uptake by plant are in line with the findings of Kleiber and Grajek (2015) [5] and Nangliya (2014) [8].

3.8 Tomato Yield
3.8.1 Fruit dry matter
The perusal of data presented in the table 9 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 9: 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

3.8.2 Shoot dry matter
The data presented in table 9 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.

3.8.3 Root dry matter
An inquisition of data in table 9 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 (Table 9). 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) [9].

4. Conclusions
The investigation conducted to assess the effect of levels of N, P and K on nutrient uptake and yield 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, revealed that maximum fruit yield and the nutrient contents in the fruit, shoot and root were found in the treatment comprising of 125% RDF (T_6) followed by 100% RDF (T_5) and minimum values were recorded under the treatment without fertilizer (T_1 – control).

5. References

1. Anand DN, Muthukrishnan CR. Effect of nitrogen fertilization on tomato (*Lycopersicon esculentum* Mill). South Indian Horticulture. 1974; 22:86-91.
2. Belicheki J, Rankov V, Dimitrov G. The uptake of N, P_2O_5 and K_2O from soil in to early tomato plants receiving mineral fertilizers. Pochvoznanie 2 Agrokimiya. 1982; 17:41-49.
3. Cannel GH, Bingham FT, Garber MJ. Effects of irrigation and phosphorus on vegetative growth and nutrient composition of Tomato leaves. Soil Science. 1960; 89:53-60.
4. Hampton MO, Schaffer B, Bryan HH. Nutrient concentration, growth and yield of tomato and squash in municipal solid waste amended soil. Horticulture Science. 1994; 29:785-788.
5. Kleiber T, Grajek M. Tomato reaction on excessive manganese nutrition. Bulgarian Journal of Agricultural Science. 2015; 21:118-125.
6. Lenucci MS, Cadinu D, Taurino M, Piro G, Dalessandro G. Antioxidant composition in cherry a high pigment tomato cultivars. Journal of agriculture food chemistry. 2006; 54:2606-2613.
7. Mamonova LG. The productivity and utilization of nutrient elements by tomato plants receiving different rates of mineral fertilizers. Toudy Ural SKNII S. Kh. 1978; 23:66-71.
8. Nangliya AK. Evaluation of organic and inorganic inputs on soil health and quality parameters of tomato. M.Sc. Thesis. Dr. YS Parmar University of Horticulture and Forestry, Nauni Solan (Himachal Pradesh) India, 2014.
9. Pandey RP, Salanki PN, Saraf PK, Parihar MS. Effect of nitrogen and phosphorus on growth and yield of tomato (*Lycopersicon esculentum* Mill.). Punjab Vegetable Grower. 1996; 31:1-5.
10. Potaczek H, Michalak H. Pigmenty roœlinne iich wp³yw na barwê owoców pomidora. Mat. Symp. 30-lecia Inst. Warz., Skierniewice, 1994, 41-44.
11. Shukla V, Naik LB. Agrotechniques for solanaceous vegetables, In: Advances in Horticulture, Malhotra Publishing House, New Delhi, India. 1993; 5:364-399.
12. Subbiah BV, Perumal R. Effect of NPK and $CaCl_2$ on the yield and nutrient uptake in tomato. South Indian Journal of Horticulture. 1986; 34:82-99.
13. Takahashi M, Sugiura M. Strategies for uptake of a soil micronutrient, manganese, by plant roots. Riken Review. 2001; 35:76-77.
14. Voogt W. Nutrient uptake of year round tomato crops. Acta Horticulture. 1993; 339:99-112.
15. Yadav BS, Batra BR. Response of spring planted tomato varieties to N and P fertilization and spacing. Indian Journal of Agriculture Research. 1991; 34:182-184.
16. Yawalkar KS, Jakate PN, Srivastava RS. Commercial Fertilizers in India: Some Recommendations for Efficient Use. Agri-Horticultural Publishing House, Nagpur, India, 1961.