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Effect of different nutrients on sweet pepper (*Capsicum annuum*) in mid hills of Himachal Pradesh

ARCHANA SHARMA[1], JAGJEET CHAND SHARMA[1] and KRISHAN LAL GAUTAM[1]*

Dr Yashwant Singh Parmar University of Horticulture and Forestry, Nauni Solan Himachal Pradesh 173 230 India

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ABSTRACT

An experiment was conducted during rainy (*kharif*) season of 2020 and 2021 to study the influence assessment of different nutrients in sweet pepper (*Capsicum annuum* var. Grossum L.) Experiment comprised of 9 treatments laid in randomized block design (RBD) tested against absolute control. Two year pooled data analysis revealed that, application of 150% NPK + FYM produced maximum number of fruits (11.62), fruit length (7.37 cm), fruit width (6.76 cm), average fruit weight (73.0 g), HI (31.60 %), yield (314.3 q/ha) and earned maximum net returns (₹462215.8). Treatment T_9 (150% NPK + FYM) also recorded maximum plant nutrient contents and their uptake, and found to be statistically at par with T_8 (100% NPK + FYM) which also recorded higher benefit-cost ratio. Application of 100% NPK produced 239.2 q/ha capsicum and gave net returns of ₹373618.8 and 3.56 benefit cost (B:C) ratio. Application of 100% NPK + FYM recorded 289.6 q/ha capsicum yield and net returns of ₹435785.4 with B:C of 3.04 and proved as the best treatment for enhancing yield and economics of capsicum under mid hills of Himachal Pradesh. Therefore, the recommended practice, i.e. Application of 100% NPK (100: 76: 54 kg/ha) + FYM (250 q/ha) is the best alternative of NPK inorganic fertilizers and best nutrient management practice to exploit the better eco-friendly economic capsicum yield.

Keywords: Balanced fertilization, Economics, Yield

Capsicum [*Capsicum annuum* (L.)] commonly known as bell pepper or sweet pepper or Shimla mirch belongs to nightshade family, Solanaceae. In Himachal Pradesh, it is an important summer season vegetable crop providing remunerative returns to the farmers. Not only because of its economic importance, capsicum is also gaining popularity due to its nutritional value, viz. high levels of vitamin C, carotene and calcium (Pariari and Khan 2013). Sweet pepper is appreciated worldwide for its flavour, aroma, colour and consumed as raw (salad), mixed and stuffed vegetable. It is also used to cure diseases like dropsy, toothache and cholera. This is a major cash crop for the small and marginal farmer and brings remunerative income. Zero fertilization or imbalanced fertilization is productivity constraint for capsicum. The farmers unsystematically use N fertilizer while P and K fertilizers application is very limited and that of secondary and micronutrients is almost negligible. Hence, resulting in multinutrient deficiencies leads to the yield stagnation. Also over exploitation of chemical fertilizers leads to deterioration of soil health without any appreciable increase in yield level. Substitution or inadequate use of organic manure with high analysis fertilizer like urea for escalating crop productivity have rendered Indian soils deficient in macro and micro nutrients which is an issue of serious concern. The application of organic manures, particularly farm yield manure (FYM), holds the key to finding the solution. FYM has the ability to offer primary, secondary, and micronutrients while also establishing a solid organic matter base, improving soil structure and enabling sustainable vegetable production free of the majority of toxic residues. Under an intensive agricultural system, the application of organic manure in conjunction with the recommended fertiliser rate enhanced the turnover of nutrients in the soil and plant system (Rajiv and Tomar 2022). Therefore, the present investigation was conducted to study the coupled effect of inorganic and organic manures on yield attributed, yield and economics of capsicum under mid hills of Himachal Pradesh.

MATERIALS AND METHODS

The field experiment was conducted during rainy (*kharif*) season of 2020 and 2021 at research farm of Dr Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh. Soils of the study area belongs to typic eutrochrept and sandy loam in texture. At the inception of the experiment, the values of soil physical properties of 0–15 cm depth like bulk density, saturated hydraulic conductivity, moisture retention at 0.33

[1]Dr Yashwant Singh Parmar University of Horticulture and Forestry, Nauni Solan, Himachal Pradesh. *Corresponding author email: krishanlalgautam99@gmail.com

and 0.15 bar suction were 1.32 Mg/m^3, 7.92 cm/hr, 25.0 and 7.32%, respectively. Similarly, Soil chemical properties like *p*H (6.60), EC (0.25 dS/m), organic carbon (13.1 g/kg), available N (350.8 kg/ha), P (98.4 kg/ha), K (489.4 kg/ha), Ca (12.8 cmol (p^+)/kg), Mg (3.53 cmol (p^+)/kg), SO_4^{2-}S (38.8 kg/ha) and available Fe (15.84 ppm), Zn (3.05 ppm), Cu (2.24 ppm), Mn (14.33 ppm) contents.

The experiment was conducted with 9 treatments, viz. T_1, control; T_2, 100% FYM (N equivalent basis); T_3, 100% N; T_4, NP; T_5, NK; T_6, PK; T_7, NPK; T_8, 100% NPK + FYM (recommended practice) and; T_9, 150% NPK + FYM replicated thrice in randomized block design (RBD) in plot size of 3 m × 2.7 m. Recommended dose of fertilizer (NPK) and FYM were applied @100: 76: 54 kg/ha and 250 q/ha. The NPK composition of farm yard manure was 0.48:0.20:0.50. Nitrogen, Phosphorus and Potassium were applied in the inorganic form of urea, single super phosphate (SSP) and muriate of potash (MOP), respectively. Full dose of phosphorus, potassium and half dose of nitrogen was applied at the time of transplanting, whereas remaining half dose of nitrogen was applied in two equal splits at 30 and 60 DAT. Package of practices recommended for the region was followed. The crop was grown for green capsicum fruits. The variety of sweet pepper Kaveri 254-F1 was used. Healthy and uniform size one month old seedlings were transplanted in each plot at recommended spacing 60 cm × 45 cm, accommodating 30 seedlings per plot. Seedlings were transplanted in the last week of April month during both the years of study.

In order to analyse various parameters, including the number of fruits per plant, fruit length, fruit width, average fruit weight, harvest index, and yield, five plants from each treatment were chosen randomly. The initial picking took place in the first week of July and continued through the last week of August. Utilising statistical techniques, the observations recorded for yield attributes and nutrient uptake were analyzed in accordance with Panse and Sukhatme's (2000) analysis of variance (ANOVA). Critical difference (CD), estimated at a 5% threshold of significance, was used to compare treatment means. On the basis of total variable cost, gross return, net returns and B:C ratio were calculated as per methods suggested by Devasenapathy *et al*. (2008).

RESULTS AND DISCUSSION

Effect of integrated use of inorganic and organic manure on yield attributes: Yield attributes of capsicum were significantly influenced by different nutrient management treatments (Table 1). Application 150% NPK + FYM (T_9) proved better for yield attributes which was statistically at par with 100% NPK + FYM (T_8) over a 100% NPK. Based on two consecutive year's pooled data, treatment T_9 (11.62/plant) was recorded with highest number of fruits, while lowest under control (7.83/plant). Treatment T_9 was statistically at par with T_4 (10.37/plant), T_7 (10.80/plant) and T_8 (10.91/plant). In case of fruit length and fruit diameter also, application 150 % NPK + FYM recorded with maximum fruit diameter (6.76 cm) and fruit length (7.37 cm), where respective parameters were under control (5.46 and 5.19 cm). Treatment T_9 was recorded with maximum harvest index (HI) (31.60 %) which was at par with T_2 (27.05%), T_7 (27.14%) and T_8 (25.84%), while minimum was under control (15.57%). Increased fruit length and fruit diameter could be attributed to increase application of NPK and FYM (50 per more of recommended) may be probably due to increase in sufficient amount of food material manufactured by foliage. The results are in line with results of Sharma (2016) and Altaf *et al.* (2019). Maximum HI under 150% NPK + FYM as compared to control might be attributed to balanced fertilization which increase crop yield by directly supplying plant nutrients required for crop growth (Ren *et al*. 2014). Results are in line with the findings of Bekeko (2014) and Purohit *et al*. (2019).

Table 1 Effect of nutrient management treatments on yield attributes and yield of capsicum

Treatment	Yield attributes*					Yield (q/ha)			SYI*
	No. of fruits/ plant	Fruit length (cm)	Fruit width (cm)	Average fruit weight (g)	Harvest index (%)	2020	2021	Pooled	
T_1	7.83	5.19	5.46	51.9	15.57	161.0	122.2	141.6	0.39
T_2	9.69	6.65	6.48	71.6	27.05	232.2	274.6	253.4	0.59
T_3	8.55	5.51	5.91	60.5	19.18	175.1	198.6	186.9	0.40
T_4	10.37	5.70	6.00	56.1	19.93	203.1	219.6	211.4	0.47
T_5	9.21	5.83	6.11	61.1	25.45	200.0	215.3	207.6	0.46
T_6	8.99	6.12	6.00	65.5	22.48	206.8	230.7	218.7	0.49
T_7	10.80	6.44	6.14	59.9	27.14	224.2	254.3	239.2	0.55
T_8	10.91	6.78	6.59	71.7	25.84	277.0	302.1	289.6	0.69
T_9	11.62	7.37	6.76	73.0	31.60	301.1	327.5	314.3	0.76
SEm	0.54	0.15	0.20	4.65	2.4	22.8	29.4	13.5	0.04
CD	1.57	0.44	0.58	NS	7.01	54.6	67.9	39.1	0.05

*Pooled data over 2 years. SYI, Sustainable yield index.

Treatment details are given under Materials and Methods.

Integrated use of inorganic and organic manures on yield and sustainable yield index (SYI): Different treatment significantly influenced the capsicum yield and SYI during both the years and also in pooled analysis (Table 1). Based on pooled analysis, significantly highest capsicum yield was noticed with application of 150% NPK + FYM (314.3 q/ha) which was statistically at par with 100% NPK + FYM (289.6 q/ha), whereas lowest yield (141.6 q/ha) was recorded under control. Application of 100% NPK produced 239.2 q/ha yield. Capsicum SYI followed the order 150% NPK + FYM (0.76)>100% NPK + FYM (0.69)>100% FYM (0.55), respectively. Absolute control was recorded with the lowest values of SYI for capsicum (0.39). Majhi *et al*. (2021) also recorded highest sustainable yield index under conjoint use of inorganic fertilizers and FYM in rice-rice cropping system gave higher crop yield and SYI of system under conjoint application of NPK and FYM indicating high and stable yield. Capsicum yield increase significantly in all the treatments over the absolute control (Table 2) and the margin of appreciation was highest, i.e. 104.1 q/ha or 56.1% in 150% NPK + FYM and lowest, i.e. 1.4 q/ha or 0.7% in 100% N. However, in comparison to 100% NPK through inorganic @100: 76: 54 kg/ha, significant improvement capsicum yield was seen only in all FYM treated plots, i.e. T_2, T_8 and T_9. Margin appreciation or reduction significantly varied in all the treatment over a 100% NPK. The margin of appreciation was highest, i.e. 75.1 q/ha or 31.4% in 150% NPK + FYM followed by 100% NPK + FYM (50.4 q/ha or 21.0%) and lowest, i.e. 14.2 q/ha or 5.9% in T_2. Whereas, margin reduction was lowest (20.5 q/ha or 8.6%) in 100% PK (T_6) and highest (53.7 q/ha or 22.4%) in control. Imbalanced fertilization in treatment T_1, T_3, T_5 and T_6 could not meet the nutritional requirement of crop. The enhanced yield might be related to sufficient application of NPK that significantly influenced the plant performance. It might be due to balanced nutrition, better uptake of nutrients by the plants which helped for better fruit set and fruit yield. The largest fruit production per hectare was ultimately achieved by increasing the quantity of fruits per plant and the fruit yield per plant. By boosting the levels of growth hormones and amino acids, the combined application of NPK and FYM improved the synthesis of photosynthates. The another possible reason for increased yield could be attributed to additional supply and availability of nutrients through FYM and also improved physical, chemical and biological condition of soil (Bhatt *et al.* 2017). The finding of Kavitha and Rao (2010) revealed that in addition to having enough nutrients, organic manure also releases the nutrients gradually to the plants. These organic manures also improve the proliferation of microflora soil and hence have significant effect of nutrient solubility and availability. The results are in close conformity with earlier results obtained by Narayanamma *et al.* (2010), Triveni *et al.* (2015), Alhrout (2017), Ghayal *et al.* (2018), Kharga *et al.* (2019), Altaf *et al.* (2019), Kaur and Rattan (2021).

Effect of integrated use of inorganic and organic manures on economics: The economics of capsicum crop was significantly affected by different treatment (Table 2). Higher cost of cultivation of capsicum was required in application of 150% NPK + FYM (₹166319.2) followed by 10% NPK + FYM (₹143354.5) and 100% FYM on N equivalence basis (₹127425.0). This could be ascribed to higher cost of organic manure, i.e. FYM (Rajiv and Tomar 2022). Similar, higher cost of cultivation was also presented by Narayan *et al*. (2014) in potato.

Gross income and net income were highest (₹628535.0 and 462215.0) with application 150% NPK + FYM followed by 100% NPK + FYM (₹579139.9 and 435785.4) and 100% FYM on N equivalence basis (₹506794.2 and 379369.2). Lowest gross income (₹283200.0) and net income (₹185775.0) were recorded under control. Highest gross income value attributed to higher yield, as capsicum fruit is the only source of income from the capsicum cultivation. In all the treatment combinations, highest B:C ratio was obtained under 100% NPK application (3.56). Organic nutrition sources were shown to be the least lucrative when

Table 2 Effect of nutrient management treatments on yield of capsicum over control and 100% NPK through inorganic sources and economics of capsicum

Treatment	Increase in yield over control (T_1)		Increase/ decrease in yield over 100% NPK (T_7)		Cost of cultivation (₹/ha)	Gross return (₹/ha)	Net return (₹/ha)	B:C ratio
	q/ha	%	q/ha	%				
T_1	-	-	-53.7	-22.4	97425.0	283200.0	185775	1.91
T_2	67.9	36.6	14.2	5.9	127425.0	506794.2	379369.2	2.98
T_3	1.4	0.7	-52.3	-21.9	98712.0	373716.0	275004.1	2.79
T_4	25.9	13.9	-27.8	-11.6	103414.5	422711.9	319297.5	3.09
T_5	22.1	11.9	-31.6	-13.2	100152.0	415246.9	315095.0	3.15
T_6	33.2	17.9	-20.5	-8.6	103567.5	437452.7	333885.2	3.22
T_7	53.7	29.0	-	-	104854.5	478473.3	373618.8	3.56
T_8	104.1	56.1	50.4	21.0	143354.5	579139.9	435785.4	3.04
T_9	128.8	69.4	75.1	31.4	166319.2	628535.0	462215.8	2.78

Treatment details are given under Materials and Methods.

Table 3 Effect of nutrient management treatments on total NPK uptake of capsicum

Treatment	Total uptake (kg/ha)		
	N	P	K
T_1	58.1	10.4	79.0
T_2	109.2	21.2	126.1
T_3	78.2	15.3	97.5
T_4	98.0	19.4	116.4
T_5	90.2	18.4	109.1
T_6	75.5	20.2	122.2
T_7	109.3	22.7	134.3
T_8	124.8	26.2	155.5
T_9	139.1	28.8	167.3
CD	7.8	4.0	21.0

Treatment details are given under Materials and Methods.

NPK and FYM were used together, as compared to when FYM used solely. This is because organically grown crops have higher input costs and lower economic yields. Despite the higher cost of cultivation when NPK and FYM are used together, these treatments are nevertheless profitable because they result in higher crop yields that are dependent on the soil responsiveness. The results are in line with the findings of Tekesangla *et al.* (2015) and Batabyal *et al*. (2016).

Effect of integrated use of inorganic and organic manures on NPK uptake in sweet pepper: Results (Table 3) show that different treatment significantly influenced the nutrient uptake in sweet pepper and significantly highest N (139.1 kg/ha), P (28.8 kg/ha) and K (167.3 kg/ha) uptake under T_9, whereas the lowest NPK uptake was recorded under T_1 (58.1, 10.4 and 79.0 kg/ha), respectively. The increase in NPK uptake in balanced fertilization plots compared to the control could be attributed to external NPK supply, better root proliferation and also improved crop growth and yield. It's possible that the greater P uptake in the FYM-treated plots is due to reduction in P fixation caused by formation of organic chelates with Al^{3+} and Fe^{3+}. In control, lower values of NPK uptake were recorded which may be due to continuous removal of nutrients and no addition nutrients externally (Gourav *et al.* 2019). The soil environment was altered by the combined application of organic and inorganic sources of nutrients, which improved the soil's physical characteristics which increased the availability of nutrients during cropping season and led to higher nutrient uptake (Shah and Wani 2017). The results obtained are in agreement with the findings of Patel *et al*. (2011) and Batabyal *et al.* (2016) in cauliflower.

From present investigation, it can be concluded that conjoint application of inorganic and organic manure to capsicum 150% NPK + FYM recorded significantly higher growth, yield and nutrient uptake. Treatment T_9 (150% NPK + FYM) was found to be statistically at par with T_8 (100% NPK + FYM) which was also recorded with higher benefit-cost ratio. Therefore, 100% NPK + FYM was found suitable for realizing optimum capsicum fruit. Hence, it is recommended for capsicum grower to ensure sustainability in crop production as well as maintaining soil health.

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