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PERFORMANCE OF BELL PEPPER IN NORTH WESTERN HIMALAYAS: COMPARATIVE ASSESSMENT TO INTEGRATED NUTRIENT MANAGEMENT PRACTICES

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ABSTRACT

The present investigation was carried out during the summer season of 2024–25 at the Research Farm, School of Agriculture, Abhilashi University, Mandi (Himachal Pradesh), to study the effect of organic and inorganic fertilizers on the growth, yield, and soil fertility status in bell pepper (*Capsicum annuum* L.). The experiment was laid out in a Randomized Block Design (RBD) with three replications and seven treatment combinations involving organic and inorganic sources of nutrients. The combined application of these treatments significantly influenced the growth and yield attributes of bell pepper. Maximum plant height (54.55 cm), number of leaves per plant (60.34), days to 50% flowering (38.87 days), number of fruits per plant (10.73), average fruit weight (80.11 g), yield per plot (7.73 kg), and yield per hectare (270.70 q/ha) were recorded under treatment T_2 [Vermicompost @ 5 t/ha + 100% Recommended Dose of Fertilizers (RDF)]. Soil nutrient analysis after harvest revealed that the highest available nitrogen (284.11 kg/ha) and organic carbon content (1.05%) were observed in treatment T_2. The maximum available phosphorus content (17.30 kg/ha) and improved soil pH (6.0) were found in treatment T_6 [FYM @ 15 t/ha + Vermicompost @ 5 t/ha + RDF 75%]. The highest available potassium content (258.00 kg/ha) was recorded in treatment T_3 [FYM @ 15 t/ha + RDF 100%]. In terms of economics, the highest gross returns (Rs. 10,82,800/ha), net returns (Rs. 9,16,162/ha), and benefit-cost ratio (5.41) were obtained with the application of treatment T_6. Based on the findings, treatment T_6 [FYM @ 15 t/ha + Vermicompost @ 5 t/ha + RDF 75%] may be recommended for commercial cultivation of bell pepper after validation through on-farm trials across different bell pepper-growing regions of Himachal Pradesh.

Keywords **:** Bell pepper, fertilizers, growth, yield, economics.

Introduction

Bell pepper (*Capsicum annuum* L.) is an important commercial vegetable crop belong to the family Solanaceae having chromosome number 2n = 2x = 24. Bell pepper is generally grown 0as warm seasons crop. It is one of the most important vegetable crops cultivated in India and around the world due to its flavour, colour and nutritional content. Its thick flesh makes it relatively non-pungent or less-pungent. In India it is grown in an area of 9890 hectare with the productions of 81830 MT. (Anonymous, 2019). Being an important vegetable crop of mid hills of Himachal Pradesh, it is grown in an area of about 2.85 thousand hectares with the production of 48.86 thousand MT (Anonymous, 2021). The produce becomes off season to the plains and fetches higher prices to the vegetable growers (Joshi and Shukla, 1997).

The depletion of soil nutrients production and the increasing price of inorganic fertilizer are two issues that can be solved with organic fertilizer, either by

itself or in combination. Integrated nutrient management (INM) is the process of using both organic and inorganic sources to balance soil fertility and give plants sufficient nutrients. The excessive use of chemical fertilizers during the green revolution increased crop yield and seed quality, but their extensive application resulted in risks to the environment, soil degradation and the depletion of energy resources that are not renewable (Chauhan *et al*., 2022). The increasing cost of farming compelled farmers to turn to other sources of nutrition in place of growing vegetables. The cost of chemical fertilizers as well as how it affects soil health environment and public health (Shilpa *et al*., 2022). Additionally, chemical fertilizers decrease the quality of produce, therefore lowering farmer yields and profits. Bell peppers are known to grow well when supplied with nitrogen, phosphorus and potassium fertilizers, yet nutrients are important for their growth and development. A single component that is fundamental to crop productivity involves fertilizer. The growing of vegetables continues to highly benefit from the combination of organic waste products FYM and vermicompost and inorganic fertilizers (NPK mineral fertilization).

Material and Methods

Experimental site

The present study was carried out at Experimental farm, School of Agriculture, Abhilashi University, Mandi (H.P.) during the summer season of 2024.The experimental farm situated at 31º33'31''N latitude and 77º00'50''E longitudes with the elevation of 1,430 m amsl.

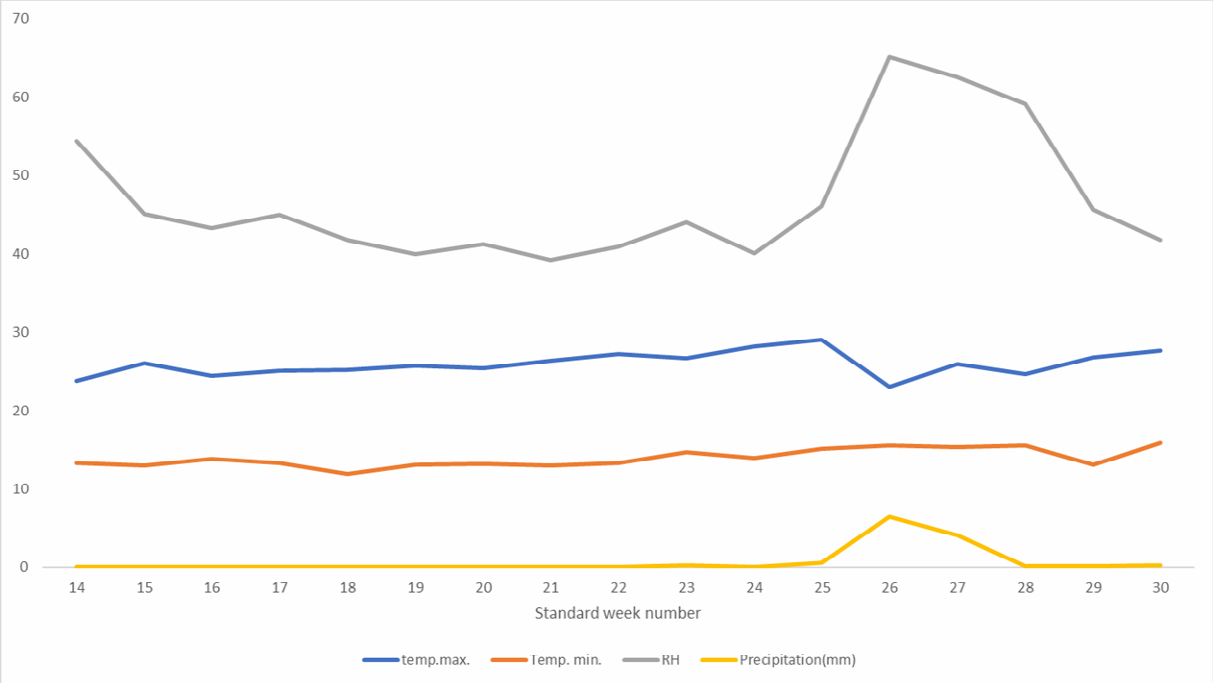

Fig. 1 : Meteorological data of experimental farm was recorded from April to July 2024

Table 1: Treatment details

Treatment code	Treatments
T_1	100 % RDF (200:475:90 kg per hectare of NPK)
T_2	Vermicompost @ 5 t / ha + RDF (100%)
T_3	FYM @ 15 t / ha + RDF (100%)
T_4	FYM @ 15 t / ha + RDF (75 %)
T_5	Vermicompost @ 5 t / ha + RDF (75 %)
T_6	FYM @ 15 t / ha + Vermicompost @ 5 t / ha + RDF (75 %)
T_7	Absolute control

Note: Recommended dose of fertilizers 50: 100: 50 kg/ha N, P_2O_5 and K_2O.

Design of experiment

The experiment was laid out in Randomized Block Design with three replications comprising seven treatment combinations of inorganic fertilizer with organic manures. The layout plan is provided below:

Variety	California wonder
Design	Randomized Complete Block Design (RCBD)
Replications (s)	3
Treatments	7
Plot size	1.60 m × 1.60 m
Spacing	45 cm × 45 cm
Date of sowing	23rd March, 2024
Date of transplanting	23rd April, 2024

Results and Discussion

Growth studies

The maximum plant height (54.55 cm), maximum number of leaves per plant (60.34) and days of 50 percent flowering (59.33) were recorded in treatment T_6 [FYM @ 15 t/ha + vermicompost @ 5 t / ha + RDF (75%] which was followed by treatment T_2 [Vermicompost @ 5 t ha + RDF (100%)]. However, the minimum plant height (36.12 cm), number of leaves per plant (29.43) and days of 50 percent flowering (38.87) were observed in T_7 (Absolute control). The possible reason for maximum values in this treatment might be due to decomposition of organic matter with the subsequent release of available nutrients for the plant growth. The use of higher amount of nitrogen, phosphorus and potassium FYM and vermicompost might have helped vegetative growth, flowering and fruiting plant strength supports enzymes activation and photosynthesis improved plant height and overall growth (Singh *et al.* 2009). Similar results were found by Jamir *et al*. 2017 and Chauhan *et al*. 2024.

Yield studies

The yield parameters were influenced by both the organic manures and inorganic fertilizers. The maximum Number of fruits per plant (10.73 cm), maximum Fruit weight (80.11g), maximum yield per plot (7.73 kg) and maximum yield per hectare (270.70 q) were observed in treatment treatment T_6 [FYM @ 15 t/ha + vermicompost @ 5 t / ha + RDF (75%] which was followed by treatment T_2 [Vermicompost @ 5 t ha + RDF (100). On the other hand, the minimum (25.33 cm), minimum fruit weight (51.31 g), minimum yield per plot (2.96 kg) and minimum yield per hectare (101.95 q) were recorded in T_7 (Absolute control). The increase in yield might be due to the use of NPK, FYM and vermicompost which together has been shown to increase the fruit yield per hectare of bell pepper plants. This combination provides a balanced nutrients supply, promoting healthy and vigorous growth, which leads to higher fruit production improved the vegetative growth, produced more flowers and fruits per plant, provides a synergistic effect, leading to better crop performances (Ramesh *et al.* 2015; Chauhan *et al*. 2023).

Soil studies

The maximum available nitrogen (284.11kg/ha) was recorded in plots supplied with treatment T_2 [Vermicompost @ 5 t / ha + RDF (100%] which was followed by the treatments T_3 [FYM @ 15 t / ha + RDF 100%]. The maximum amount of available phosphorus (17.30 kg/ha) was recorded in treatment which was statistically at par with the treatments T_3 (FYM @ 15 t / ha + RDF (100%). Treatment T_3 (FYM @ 15 t / ha + RDF (100%) shows better availability (258.78kg/ha) of potassium in the soil after harvest, followed by treatment T_6 [FYM @ 15 t / ha + Vermicompost @ 5 t / ha + RDF 75 %]. However, the minimum amount of available nitrogen (110.32 kg/ha), available phosphorus (13.45 kg/ha) and available potassium (128.65 kg/ha) was measured in T_7 (Absolute control). The content of available N, P and K in soil due to application of different manures followed the order vermicompost and farm yard manure. The differences in soil available N, P and K contents in plots treated with different manures might be attributed to the variation in their capacity to supply these nutrients. The beneficial effect of vermicompost and farm yard manure on available K may be ascribed to the direct potassium addition to the potassium pool of the soil besides the reduction in potassium fixation and its release due to interaction of organic matter with clay particles. Similar results were reported by Parmar *et al* 2006, Reddy 2011 and Atal 2017.

The pH higher ranges from (6.1) was recorded in the treatment T_2 [Vermicompost @ 5 t / ha + RDF (100%] and minimum soil pH (5.7) were recorded in the treatment T_7 (Absolute control). Maximum soil EC (0.52 dSm^{-1}) was recorded in the treatment T_3 whereas minimum soil EC (0.47 dSm^{-1}) was recorded in

treatment T_5 (Absolute control). The higher content of organic carbon (1.65 %) in soil was observed in treatment T_6 [FYM @ 15 t / ha + Vermicompost @ 5 t / ha + RDF (75 %] followed by treatment. Whereas, lower content of organic carbon (0.15 %) was observed in T_7 (Absolute control) i.e. (0.59 %). Similar results of this investigation were also in concordance with the findings reported by Jamir *et al*. 2017.

Economics

The highest cost of cultivation cost of cultivation T_6 [FYM @ 15 t / ha + Vermicompost @ 5 t / ha + RDF (75 %] Rs. 166637 was incurred in treatment followed by treatment T_2 Vermicompost @ 5 t / ha + RDF (100%) Rs. 141317. The lowest cost of cultivation Rs. 78067 was observed in treatment T_7 (Absolute Control).

The economics in terms of gross returns (Rs. 108280), net returns (Rs. 916162) and B: C ratio (5.4) was also maximum in T_6 [FYM @ 15 t / ha + Vermicompost @ 5 t / ha + RDF (75 %)] and the minimum gross return (Rs. 407800), net return (Rs. 329732) and B: C ratio (4.1) was incurred in T_7 (Absolute control) respectively.

Conclusion

This experiment concluded that combine use of organic and inorganic fertilizers has a beneficial effect on growth yield and soil. From the present studies, it can be concluded that among all the treatments, treatment T_6: [FYM @ 15 t / ha + Vermicompost @ 5 t / ha + RDF (75 %] performed best for most of the growth, yield and economic status followed by treatment T_2 [Vermicompost @ 5 t ha + RDF (100%)]. Soil available NPK was also improved in treatment T_6: [FYM @ 15 t / ha + Vermicompost @ 5 t / ha + RDF (75 %]. Therefore, it may be concluded that treatment T_6: [FYM @ 15 t / ha + Vermicompost @ 5 t / ha + RDF (75 %] has been proven best for growing capsicum and maintaining soil health.

Table 2: Initial soil chemical parameters of the experimental site

Sr. No.	Parameters	Values obtained	Method of analysis
1.	Soil PH	6.1	Glass electrode method (Jackson 1967)
2.	Electrical conductivity (dS/m)	0.52	Electrical conductivity meter 1:2.5 soil water suspension (Jackson1973)
3.	Organic carbon (%)	1.05	Rapid titration method (Walkely and Black 1934)
4.	Available N (kg/ha)	284.11	Alkaline potassium permanganate method (Subbiah and Asija 1956)
5.	Available P (kg/ha)	15.82	Olsen's method of extraction with 0.51 $NaHCO_3$ at pH 8.5 (Olsen *et al.* 1954)
6.	Available K(kg/ha)	258.78	Ammonium acetate extraction method (Merwin and Peech 1950)

Table 3: Effect of organic and inorganic sources of nutrients on plant height (cm), number of leaves per plant and days of 50 percent flowering.

Treatment code	Treatments	Plant height (cm)	Number of leaves per plant	Days of 50 percent flowering
T_1	100 % RDF (100:60:52 kg per hectare of NPK)	40.78	37.76	54.64
T_2	Vermicompost @ 5 t / ha + RDF (100%)	50.55	52.17	42.56
T_3	FYM @ 15 t / ha + RDF (100%)	45.76	47.97	46.78
T_4	FYM @ 15 t / ha + RDF (75 %)	42.29	41.56	51.98
T_5	Vermicompost @ 5 t / ha + RDF (75 %)	45.81	43.89	49.11
T_6	FYM @ 15 t / ha + Vermicompost @ 5 t / ha + RDF (75 %)	54.55	60.34	38.87
T_7	Absolute control	36.12	29.43	59.33
	SE(m) (±)	0.50	0.38	1.06
	$CD_{(0.05)}$	1.55	1.64	3.28

Table 4: Effect of organic and inorganic sources of on number of fruits per plant, fruit weight (g), yield per plot (kg) and yield per hectare (q).

Treatment code	Treatments	Number of fruits per plant	Fruit weight (g)	Yield per plot (kg)	Yield per hectare (q)
T_1	100 % RDF (100:60:52kg per hectare of NPK)	7.61	58.21	3.98	137.10
T_2	Vermicompost @ 5 t / ha + RDF (100%)	9.41	73.36	6.21	217.10
T_3	FYM @ 15 t / ha + RDF (100%)	8.91	68.20	5.46	189.84
T_4	FYM @ 15 t / ha + RDF (75 %)	7.87	60.28	4.26	147.65
T_5	Vermicompost @ 5 t / ha + RDF (75 %)	8.68	64.57	5.04	175.78
T_6	FYM @ 15 t / ha + Vermicompost @ 5 t / ha + RDF (75 %)	10.73	80.11	7.73	270.70
T_7	Absolute control	6.30	51.31	2.96	101.95
	SE(m) (±)	0.07	0.97	0.08	3.16
	CD $_{(0.05)}$	0.21	3.01	0.27	9.75

Table 5: Effect of organic and inorganic sources of nutrients on available N, P and K, soil pH, electrical conductivity (dsm^{-1}) and organic carbon (%).

T_1	Treatment	Soil pH	Electrical conductivity (dsm^{-1})	Organic carbon (%)	Available Nitrogen (kg/ha)	Available Phosphorus (kg/ha)	Available potassium (kg/ha)
T_2	100 % RDF (100:60:52 kg per hectare of NPK)	5.8	0.50	0.44	201.84	15.72	148.05
T_3	Vermicompost @ 5 t / ha + RDF (100%)	6.1	0.42	1.05	284.11	17.2	243.56
T_4	FYM @ 15 t / ha + RDF (100%)	6.1	0.52	0.45	230.97	15.82	258.78
T_5	FYM @ 15 t / ha + RDF (75 %)	6.0	0.48	0.41	190.2	14.21	179.87
T_6	Vermicompost @ 5 t / ha + RDF (75 %)	5.9	0.47	0.35	188.1	15.29	197.11
T_7	FYM @ 15 t / ha + Vermicompost @ 5 t / ha + RDF (75 %)	6.0	0.48	0.44	210.43	17.3	245.34
T_1	Absolute control	5.7	0.48	0.15	110.32	13.45	128.65
	SEm (±)	0.09	0.02	0.22	2.56	0.28	2.46
	CD (P=0.05)	NS	0.07	0.19	7.89	0.88	7.58

Table 6: Economics

Treatment code	Treatments	Cost of Cultivation (Rs./ha)	Gross returns (Rs. /ha)	Net returns (Rs./ha)	Benefit: Cost ratio
T1	100 % RDF (200:475:90 kg per hectare of NPK)	913178	548400	457082.2	5.0:1
T2	Vermicompost @ 5 t / ha + RDF (100%)	1413178	868400	727082.2	5.1:1
T3	FYM @ 15 t / ha + RDF (100%)	1213178	759360	638042.2	5.2:1
T4	FYM @ 15 t / ha + RDF (75 %)	1166378	590600	473962.2	4.6:1
T5	Vermicompost @ 5 t / ha + RDF (75 %)	1366378	703120	566482.2	4.1:1
T6	FYM @ 15 t / ha + Vermicompost @ 5 t / ha + RDF (75 %)	1666378	1082800	916162.2	5.4:1
T7	Absolute control	78067.8	407800	329732.2	4.2:1

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