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RESEARCH ARTICLE

Evaluation of Different Organic Manures on Growth and Yield Performance of Capsicum in the Garhwal Himalayan Region

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ABSTRACT

Capsicum (*Capsicum annuum* L.), commonly known as bell pepper or Shimla mirch, is a high-value vegetable crop in India, particularly in Uttarakhand, where yields have fluctuated amid rising chemical fertilizer use and environmental concerns. This study evaluated the impact of nine organic manure treatments on the growth, phenology, and yield of the California Wonder capsicum variety during the 2022 kharif season at the Department of Rural Technology, Chauras Campus, HNB Garhwal University. Laid out in a Randomized Block Design with three replications, treatments included farmyard manure (FYM), vermicompost, poultry manure, and their combinations. Results showed significant improvements over control (T_0) maximum plant height, flowers per plant (20.30), fruits per plant (15.33), fruit weight (92.33 g), and yield (1.31 kg/plant; 22.76 t/ha) in T_6 (50% poultry manure + 50% vermicompost). This treatment also promoted earliness (first flowering: 35.66 days; fruit set 50.00 days) and longer pedicels (2.32 cm). Organic manures enhance nutrient availability, soil health, and assimilate partitioning, offering a sustainable alternative to chemical inputs for boosting productivity while mitigating soil degradation.

Keywords: *Capsicum annuum, Organic manure, Poultry manure, Vermicompost, Yield*

INTRODUCTION

Vegetables hold a significant position in the Indian economy, yielding greater returns per unit area and time. They serve as crucial contributors to both nutritional and economic stability (Mohan *et al.,* 2021; Thakur *et al*., 2024). (*Capsicum annuum L.*) A member of the family Solanaceae, commonly known as Shimla mirch, holds significant agricultural and commercial value in India. It is native to Mexico, with the centre of diversity in South America (Mehain Martinez *et al.,* 2010; Aguilar Melendez *et al.,* 2009; Hegde *et al.,* 2017). The bell pepper is a vegetable well known for its high nutritional value, abundant in vital nutrients such as Vitamin C and Vitamin A, and serves a medicinal purpose. Antioxidants play a pivotal role in enhancing the local diet, thereby improving overall nutrition and health outcomes. Their subtle taste, pleasing aroma, diverse array of colours, and nutritional benefits contribute to their worldwide popularity (Mekdes *et al.,* 2017; Olutumise, 2022; Schipmann and Qaim, 2011; Imran *et al.,* 2019; Bajya 2017; Akhtar *et al.,* 2019). In nations such as India, China, Mexico, Spain, Romania, Italy, the United States, Hong Kong, and other European, Central, and South American countries, capsicum is among the most lucrative crops

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grown (Valenzuela-García *et al.,* 2019). In India, bell pepper is cultivated over about 37 thousand hectares with a production of 586 thousand metric tonnes and productivity of 14.59 MT/ha (Thakur *et al* 2019; Brar *et al.,* 2020; Negi *et al.,* 2018). In India, Capsicum is estimated to occupy an area of 38000 hectares, with production of 563000 metric tonnes; the share is highest in West Bengal, followed by Karnataka, Haryana, Jharkhand, and Himachal Pradesh (APEDA 2023; Thakur *et al.,* 2024).

In Uttarakhand, Capsicum yields were about 11.5 in 2015, 14.6 in 2016, slightly declined to 13.8 in 2017–2018, and then increased steadily to 15.7 in 2019, 16.0 in 2020, reaching a peak of around 16.5 in 2021–2022. After this peak, the value dropped sharply to 13.5 in 2023 and further declined to about 10.9 in 2024 and 2025 (Department of Agriculture & Farmers Welfare, 2025). Due to the growing population, there is a pressing need to increase crop production significantly. Consequently, farmers are resorting to extensive chemical use, including fertilizers and pesticides, without paying heed to the potential impacts on soil and human health. This intensified chemical application in farming has not only led to contamination of both groundwater and surface water but has also disrupted the delicate balance among soil, plants, and microbial communities (Hossain *et al.,* 2022*;* Tripathi *et al.,* 2020; Aloo, 2024)

Public apprehension regarding the detrimental effects of pesticides and fertilizers on the environment, as well as on food safety and quality, has been steadily increasing. The utilization of organic manures can encourage the growth of beneficial organisms in the soil, fostering a healthy soil ecosystem. On the other hand, biofertilizers represent a cost-effective and renewable source of essential plant nutrients (Singh *et al.,* 2020; Thakur, 2017). A prudent application of both organic manures and bio-fertilizers has the potential not only to sustain crop productivity but also to preserve soil health. Numerous studies have shown that using organic manures and biofertilizers increases yields and improves the quality characteristics of vegetables. Organic manure can serve as a viable alternative to mineral fertilizers for improving soil structure and microbial biomass (Verma *et al*., 2024; Sindhu *et al.,* 2020; Thakur, 2017; Liaqat *et al.,* 2018). Organic manure directly contributes to plant growth by supplying all the essential macro and micronutrients in readily accessible forms during the mineralization process. Additionally, it enhances the soil's physical and chemical characteristics (Aulakh et al., 2022).

Therefore, to achieve high-quality capsicum production, it is crucial to employ organic manure for optimal fertilization, considering the adverse effects of inorganic cultivation on the environment, soil, and human health. The present experiment was conducted to evaluate the effect of different organic manures on the growth and yield of capsicum and to identify the most suitable organic treatment for its cultivation.

MATERIALS AND METHODS

Experimental Site

The study was carried out during the kharif season of 2022 at the Rural Technology Demonstration Unit, located at Chauras Campus, HNB Garhwal University, Srinagar Garhwal, Uttarakhand. Its objective was to investigate how organic fertilizers influenced the growth and yield of capsicum in open-field conditions.

Geographical location

The Demonstration Unit of the Department of Rural Technology is located at Chauras Campus, Tehri Garhwal District, Uttarakhand. It is located at 78º83'82'' E longitude and 30º20'66'' N latitude at an altitude of 560 m above sea level.

Experimental details

The experiment on the Capsicum variety California Wonder was laid out in a Randomized Block Design (RBD) with three replications and nine treatments per replication. The treatments were T_0, Control; T_1, FYM @ 20t/h; T_2,Vermicompost@5t/h; T_3, Poultry Manure @10t/h; T_4, FYM+ Vermicompost (Both 50%) @10t/h+2.5t/h; T_5, FYM+ Poultry Manure (Both 50%) @10t/h+5t/h; T_6, Poultry Manure + Vermicompost (50%) @ 2.5t/h +5t/h; T_7, FYM+Vermicompost+ Poultry Manure (Each 75%)@15t/h+7.5t/h+1.25t/h; T_8, FYM+Vermicompost+ Poultry Manure (Each 50%)@ 10t/h+ 2.5t/h + 5t/h.

Crop and Field details

The experiment was conducted during the Kharif season of 2022 (April to August) using the variety California Wonder. Capsicum was planted at 45 × 45 cm spacing in plots measuring 135 × 180 cm, accommodating 12 plants per plot. Transplanting was carried out on 11 April 2022.

RESULTS AND DISCUSSION

Plant height, number of flowers, days to first flowering, days to first fruit set, fruit number per plant, and yield per plant are presented in Table 1, and pedicel length, fruit weight, and yield attributes are shown in Table 2. The data revealed a significant influence of different organic manure treatments on growth, flowering, fruiting, and yield parameters of capsicum. Plant height increased progressively with crop age (30, 60, and 90 DAS) across all treatments, with the maximum plant height recorded in T_6 (Poultry manure + Vermicompost, both at 50%) and was significantly superior to the control (T_0). The lowest plant height was consistently observed under the control. The number of flowers per plant was also significantly affected by treatments. The highest number of flowers (20.30) was recorded in T_6 (Poultry Manure + Vermicompost (50%)), followed by T_5 (FYM+ Poultry Manure (Both 50%)) and T_7 (FYM + Vermicompost+ Poultry Manure (Each 75%)), while the minimum number of flowers (13.00) was observed in the control. About the phenological parameters, early flowering and fruit setting were promoted by combined organic manure applications. The minimum days to first flowering (35.66 days) and first fruit setting (50.00 days) were observed in T_6 (Poultry Manure + Vermicompost (50%)), indicating earliness. In contrast, the control treatment took the longest time to first flowering (41.31 days) and fruit setting (56.33 days). The number of fruits per plant differed significantly among treatments. The highest fruits per plant (15.33) were recorded in T_6, followed by T_7 (14.00) and T_2 (Vermicompost) (12.33), while the lowest number (8.33) was noted in the control. Similarly, yield per plant was prominently influenced by treatments. The maximum yield per plant (1.31 kg) was obtained in T_6, followed by T_7 (1.21 kg) and T_5 (1.20 kg). The minimum yield (0.61 kg) was recorded in the control.

The length of the pedicel varied significantly among treatments. The maximum pedicel length (2.32 cm) was recorded under T_3 (Poultry manure) and T_6 (Poultry manure + Vermicompost, both 50%), which were statistically at par with T_4 and T5, while the minimum pedicel length (2.04 cm) was observed in the control (T_0). In fruit weight, an increase was observed with the application of organic manures. The highest fruit weight (92.33 g) was recorded in T_6, which was significantly higher than all other treatments. This was followed by T_7 (FYM+Vermicompost + Poultry Manure (Each 75%)) (83.00 gm) and T_5 (82.66 g). The lowest fruit weight (61.00 gm) was observed under T_2 (Vermicompost), and the next lowest was under T_0 (62.33 gm). Similarly, maximum yield per plot (5.53 kg) was obtained with T_6, followed by T_7 (4.83 kg) and T_5 (4.34 kg), whereas the minimum yield per plot (3.05 kg) was recorded in the control. The highest yield (22.76 t/ha^{-1}) was recorded in T_6, which was significantly higher than all other treatments. This was followed by T_7 (19.88 t/ha^{-1}) and T_5 (17.86 t ha^{-1}). The lowest yield (12.55 t ha^{-1}) was obtained in the control. The critical difference (CD) and coefficient of variation (CV) values indicated that the observed differences among treatments were statistically significant.

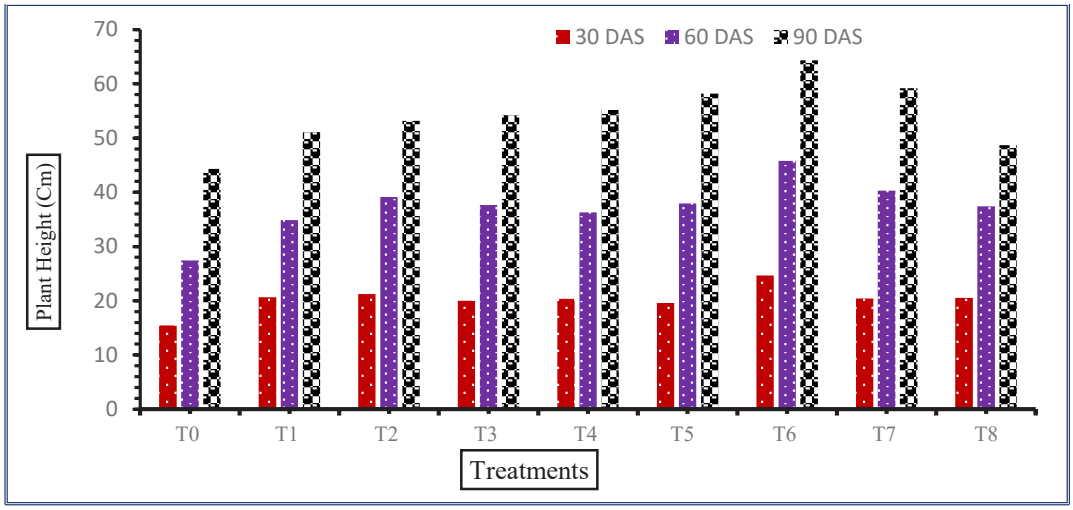

Figure1: Effect of Different Treatments on Plant Height of Capsicum

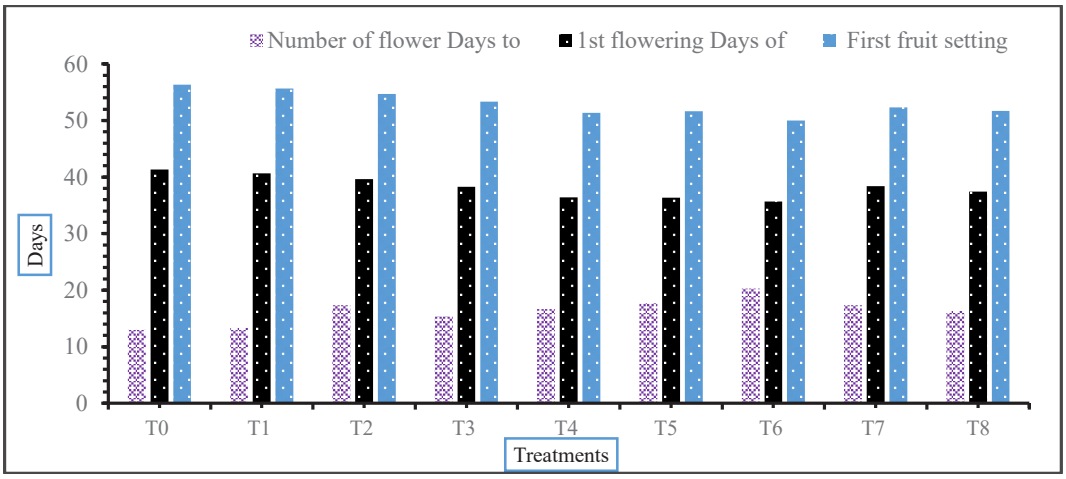

Figure 2: Influence of Different Treatments on Days to Flower Initiation, First Flowering, and First Fruit Set in Capsicum

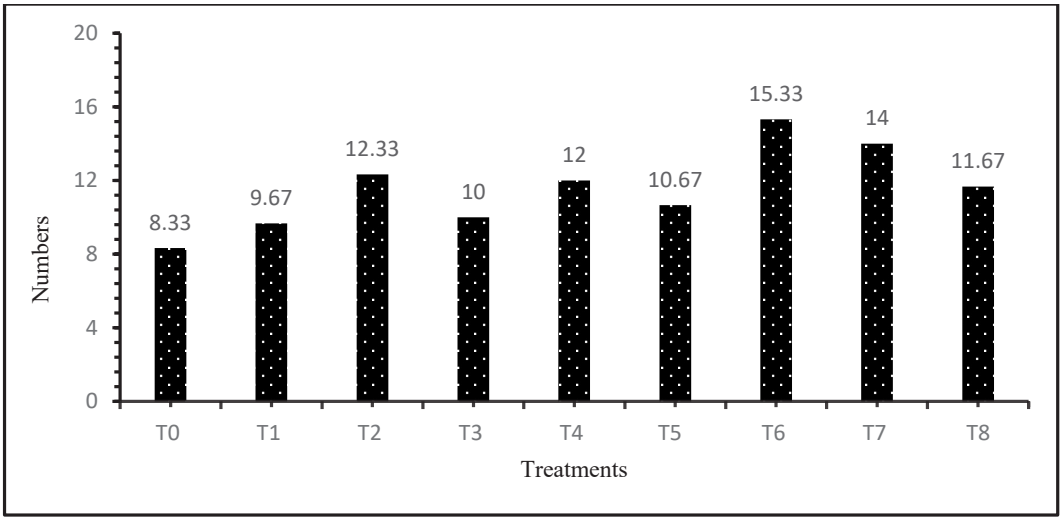

Figure 3: Effect of Different Treatments on Fruits per plants

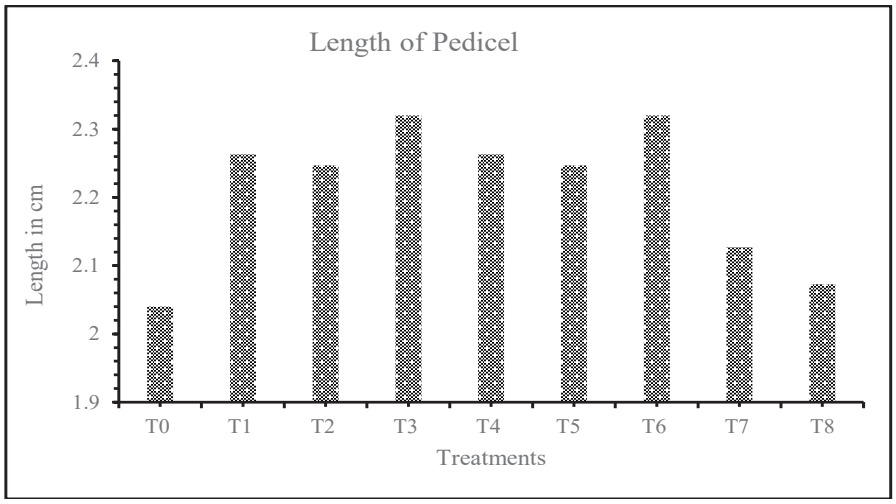

Figure 4: Effect of Different Treatments on Length of Pedicel

Table 1: Influence of different treatments on plant height, number of flowers, days to first flowering, days to first fruit set, fruit number per plant, and yield per plant in capsicum

Name of Treatment	Plant height (Cm)			Number of Flower Days to	1st flowering Days of	Days First fruit setting	Fruits/ plant	Yield/ Plant (Kg)
	30 DAS	60 DAS	90 DAS					
T_0 (Control)	15.46	27.41	44.34	13.00	41.31	56.33	8.33	0.61
T_1 (FYM)	20.66	34.87	51.10	13.34	40.66	55.66	9.67	0.67
T_2 (Vermicompost)	21.21	39.10	53.16	17.33	39.66	54.67	12.33	0.75
T_3 (Poultry Manure)	20.00	37.63	54.26	15.35	38.30	53.34	10.00	0.85
T_4 (FYM+ Vermicompost (Both 50%))	20.35	36.32	55.18	16.68	36.40	51.37	12.00	1.02
T_5 (FYM+ Poultry Manure- (Both 50%))	19.58	37.96	58.20	17.67	36.33	51.66	10.67	1.20
T_6 (Poultry Manure + Vermicompost (Both 50%)	24.66	45.82	64.36	20.30	35.66	50.00	15.33	1.31
T_7 FYM+Vermicompost + Poultry Manure (Each 75%)	20.44	40.30	59.20	17.35	38.40	52.32	14.00	1.21
T_8 FYM+Vermicompost + Poultry Manure (Each 50%)	20.50	37.43	48.68	16.31	37.41	51.68	11.67	0.94
C.D.	2.18	2.09	1.72	2.57	1.16	1.59	1.87	0.09
SE(m)	0.72	0.69	0.57	0.85	0.38	0.53	0.62	0.03
SE(d)	1.02	0.98	0.81	1.20	0.54	0.75	0.87	0.04
C.V.	6.16	3.21	1.82	9.01	1.74	1.72	9.29	5.46

Table 2: Response of capsicum to different treatments with respect to pedicel length, fruit weight, and yield attribute

Name of Treatment	Length of Pedicel (cm)	Fruit Weight (gm)	Yield/plot (kg)	Yield (t/h^{-1})
T_0 (Control)	2.04	62.33	3.05	12.55
T_1 (FYM)	2.26	69.33	3.33	13.70
T_2 (Vermicompost)	2.25	61.00	3.73	15.35
T_3 (Poultry Manure)	2.32	79.33	3.80	15.64
T_4 (FYM+ Vermicompost (Both 50%))	2.26	80.66	4.20	17.28
T_5 (FYM+ Poultry Manure- (Both 50%))	2.25	82.66	4.34	17.86
T_6 (Poultry Manure + Vermicompost (Both 50%)	2.32	92.33	5.53	22.76
T_7 FYM+Vermicompost + Poultry Manure (Each 75%)	2.13	83.00	4.83	19.88
T_8 FYM+Vermicompost+ Poultry Manure (Each 50%)	2.07	80.33	4.30	17.70
C.D.	0.172	6.29	0.62	3.37
SE(m)	0.057	2.08	0.20	1.03
SE(d)	0.080	2.94	0.29	1.46
C.V.	4.614	4.69	8.69	18.15

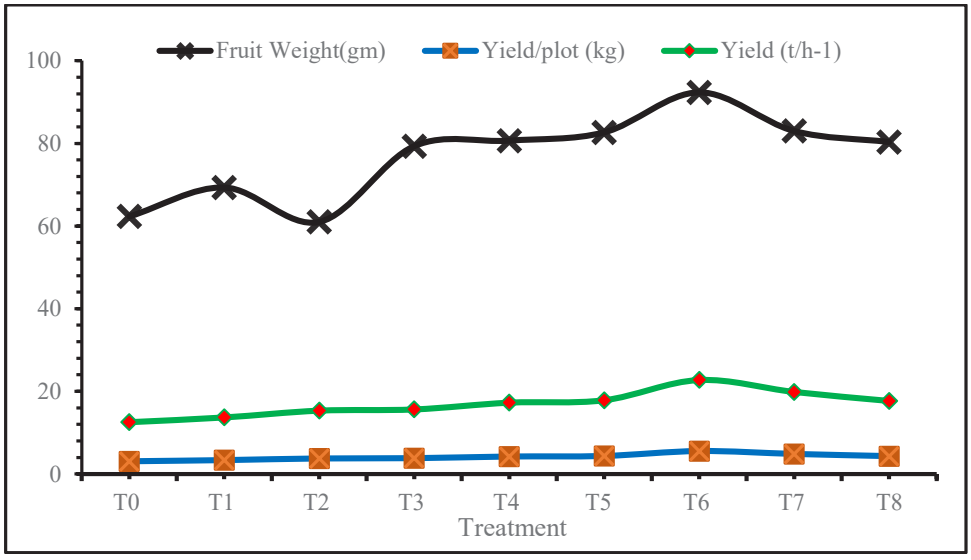

Figure 5: Effect of Different Treatments on Fruit Weight, Yield per Plot, and Yield per Hectare of Capsicum

Plant height progressed gradually across 30, 60, and 90 DAS under all treatments, high in T_6 (Poultry Manure + Vermicompost (50%)) due to improved nutrient availability and soil microbial activity from poultry manure, rich in nitrogen for vegetative growth, and vermicompost's humic acids, which enhance root development and water retention. This aligns with studies showing that organic amendments boost crop stature by 20-30% compared to controls (Jaipaul et al., 2011; Sen et al., 2022; Mukesh *et al.,* 2023; Suman *et al.,* 2024; Aliyu, 2000). Early flowering (35.66 days) and fruit set (50.00 days) in T_6 reflect accelerated phenology from balanced macro and micronutrients, reducing maturity time versus the control's 41.31 and 56.33 days, likely due to vermicompost's plant growth regulators and poultry manure's rapid mineralization (Reddy *et al*., 2024; Fajinmi and Adebode, 2007; Gangadhar *et al.,* 2020; Jamir *et al.,* 2017; Appireddy *et al.,* 2008).

Plate 1: A view of the field before harvesting and a close view of the fruit

Plate 2: A view of the irrigation of young seedlings after transplanting and during the irrigation of mature plants

The superior flower count (20.30 per plant) in T_6, followed by T_5 and T_7, stems from enhanced hormonal signaling and pollen viability promoted by these blends, outperforming single manures like T_2 (Vermicompost). The number of fruits per plant (15.33 in T_6) mirrors this trend, as nutrient synergy supports more reproductive sinks. Control's low values (13.00 flowers, 8.33 fruits) highlight inorganic limitations without organics' slow-release benefits (Ghimire *et al.,* 2023; Reddy *et al.,* 2017; Jakhar *et al.,* 2022; Hazarika *et al.,* 2022)

The T_6 treatment (poultry manure with 50% vermicompost) achieved a top yield of 1.31 kg per plant, equivalent to 22.76 tonnes per hectare. This significantly exceeds previously reported yields of 18–20 t/ha from farmyard manure-poultry manure mixtures. The superior yield is attributed to the production of heavier individual fruits (92.33 gm), resulting from enhanced assimilate partitioning, and longer pedicels (2.32 cm), which improve light interception and reduce fruit shading. Treatments T_7 and T_5 also showed strong, closely trailing performance. In contrast, the control plot yielded only 12.55 t/ha, underscoring the critical role of organic amendments in overcoming inherent soil nutrient deficiencies (Khandaker *et al.,* 2017; Ali *et al.,* 2022; Reddy *et al.,* 2017; Jakhar *et al.,* 2022; Hazarika *et al.,* 2022; Hossaen *et al.,* 2012)

CONCLUSION

Overall, the experiment's results show that treatment T_6 (50% poultry manure + 50% vermicompost) significantly outperformed in plant height, flowers per plant, days to first flowering, maximum yield per plant, fruit weight, and maximum yield per plot. The control treatment (T_0) shows the lowest overall growth and yield performance in capsicum plants under Uttarakhand's mid-hill conditions. These findings advocate shifting from chemical-intensive farming to organic practices, sustaining soil microbial health, reducing environmental risks, and supporting nutritional security amid Uttarakhand's declining yields (10.9 t/ha in 2024–2025). Farmers can adopt T_6 for cost-effective, high-return cultivation, with future research exploring long-term soil resilience and varietal interactions.

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Conflict of Interests

The authors declare no conflict of interest related to this research.

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Ethics Statement:

Ethical approval was not applicable for this research experiment as only plant materials were used.

Originality and Plagiarism:

Authors confirm that this manuscript is an original work. No parts of the manuscript have been previously published. There is no known plagiarism in any form in this article

Consent for Publication:

All authors must agree to the content of the article and its publication in the journal.

Competing Interests:

The authors declare no conflict of interest related to this research.

Data Availability:

The data presented in this study are openly available in https://orcid.org/0000-0002-8706-1441

Author Contributions:

SD, SS and RSN conceptualized the study and designed the research framework; SD, PS and KR carried out the field study; SD, SS and RSN contributed to the implementation and logistical support of the research; SD, SS, and RSN drafted the original manuscript; SD and SS coordinated the review and editorial revisions. All authors have read and approved the final version of the manuscript.

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