**Impact of integrated nutrient management on growth and yield of capsicum (*Capsicum annuum* L. var. *grossum*)**

**ABSTRACT**

The present investigation was conducted during the autumn-winter season of 2024–2025 to evaluate the effect of integrated use of organic manures, inorganic fertilizers, and plant growth-promoting rhizobacteria (PGPR) on the growth, yield, and quality of sweet pepper (*Capsicum annuum* L.). The experiment was laid out in a Randomized Block Design (RBD) with nine treatments and three replications. The treatment combinations were as follows: T₁: Control, T₂: RDF + FYM @ 20 t/ha + PGPR, T₃: 75% RDF + Vermicompost @ 2.5 t/ha, T₄: 50% RDF + Vermicompost @ 2.5 t/ha, T₅: 75% RDF + PGPR, T₆: 50% RDF + PGPR, T₇: 75% RDF + Vermicompost @ 2.5 t/ha + PGPR, T₈: 50% RDF + Vermicompost @ 2.5 t/ha + PGPR. The results revealed that the treatment T₂ (RDF + FYM @ 20 t/ha + PGPR) recorded the best performance across various parameters, including: Plant height: 68.00 cm, Number of branches per plant: 4.56, Days to 50% flowering: 27.46, Days to first harvest: 58.10, Fruit length: 6.58 cm, Fruit breadth: 4.88 cm, Pericarp thickness: 5.24 mm, Number of fruits per plant: 22.56, Fruit weight: 52.64 g, Yield per plot: 22.14 kg, Maximum yield per hectare: 291.54 q/ha, Total Soluble Solids (TSS): 4.78 °Brix, Benefit-Cost Ratio (B:C): 1.90. Based on the results, it can be concluded that the integrated nutrient management (INM) approach involving RDF + FYM + PGPR significantly enhances the growth, yield, and quality of capsicum. Therefore, the use of INM practices is recommended for sustainable and profitable production of sweet pepper under similar agro-climatic conditions.

***Keywords:*** Capsicum, nutrient management, Growth and Yield parameters

**INTRODUCTION**

 Bell pepper (*Capsicum annuum* var. *grossum*) is a widely cultivated Solanaceous vegetable crop with significant medicinal value and export potential. The genus Capsicum has a diploid chromosome number of 2n = 2x = 24, while *C. annuum glabriusculum*, the wild progenitor of cultivated pepper, is a tetraploid species (2n = 4x = 48) (Carrizo et al., 2016). Bell peppers differ from conventional hot peppers in fruit size, shape, capsaicin content, and usage. The fruit typically has three to four lobes, is large and blocky with thick flesh and a basal depression, and is available in a variety of colors (Aslam et al., 2022).

Capsicum is gaining popularity not only due to its economic significance but also for its nutritional value, which includes high levels of vitamin C, carotenoids (provitamin A), and calcium (Pariari and Khan, 2013; Appireddy et al., 2008). The crop is believed to have originated in tropical South America, particularly Brazil, and is now extensively cultivated in Central and South America, Peru, Bolivia, Costa Rica, Mexico, almost all of Europe, Hong Kong, and India.

Though the winter season is more suitable for its growth, the year-round demand has encouraged its cultivation under protected conditions, including greenhouses and polyhouses (Wani et al., 2011). Bell pepper is recognized for its unique flavor profile and numerous health benefits. It contains, per 100 g fresh weight, Vitamin A (8493 IU), Vitamin C (283 mg), and essential minerals like calcium (13.4 mg), magnesium (14.9 mg), phosphorus (28.3 mg), and potassium (263.7 mg).

Integrated Nutrient Management (INM) is a holistic approach to nutrient management, involving the efficient and judicious use of organic, inorganic, and biological sources of plant nutrients. It aims to maximize economic yields while maintaining or improving the physicochemical and biological health of the soil. Alongside chemical fertilizers, organic manures and Plant Growth Promoting Rhizobacteria (PGPR) play a crucial role in INM strategies.

Organic manures help mitigate multiple nutrient deficiencies and enhance soil organic matter. PGPR contribute to plant growth through both direct and indirect mechanisms. Direct mechanisms include biological nitrogen fixation, production of plant growth regulators (e.g., auxins, cytokinins, gibberellins), phosphate solubilization, mineralization of organic nutrients, and synthesis of organic compounds such as amino acids and enzymes. “PGPR also stimulate plant defense mechanisms, including systemic acquired resistance (SAR) and induced systemic resistance (ISR). Indirectly, they suppress phytopathogens by producing antibiotics, siderophores, and hydrogen cyanide, thereby enhancing plant health and productivity” (Glick et al., 2007).

**MATERIALS AND METHODS**

The present investigation, was conducted at the Agricultural Research Farm of Rama University, Mandhana, Kanpur, during the 2024–2025 growing season.

The experiment was laid out in a Randomized Block Design (RBD) with eight treatments and three replications. The treatments included different combinations of organic, inorganic, and biological nutrient sources, as follows: T₁: Control, T₂: RDF + FYM @ 20 t/ha + PGPR, T₃: 75% RDF + Vermicompost @ 2.5 t/ha, T₄: 50% RDF + Vermicompost @ 2.5 t/ha, T₅: 75% RDF + PGPR, T₆: 50% RDF + PGPR, T₇: 75% RDF + Vermicompost @ 2.5 t/ha + PGPR, T₈: 50% RDF + Vermicompost @ 2.5 t/ha + PGPR. The seeds of cultivar ‘Solan Bharpur’ were sown with special care in raised nursery beds of size 1.5 × 1 × 0.15 m. Transplanting was done on August 9, 2024, maintaining a spacing of 45 cm between rows and 30 cm between plants using a hand tool (khurpi). Observations were recorded on twelve characters, which included: Plant height (cm), Number of branches per plant, Days to 50% flowering, Days to first harvest, Fruit length (cm), Fruit breadth (cm), Pericarp thickness (mm), Number of fruits per plant, Average fruit weight (g), Yield per plot (kg), Yield per hectare (q/ha), Total soluble solids (TSS in °Brix).

**RESULT AND DISCUSSION**

The experimental findings revealed significant variations among the treatments for all observed parameters of capsicum (*Capsicum annuum* L. var. *grossum*) during the study.

**Plant Height (cm)**

The maximum plant height (68 cm) was recorded under T₂ (RDF + FYM @ 20 t/ha + PGPR), followed by T₇ (65 cm), T₈ (62 cm), and T₃ (60 cm). The minimum plant height (54 cm) was observed in T₁ (Control). These results align with the findings of Kanchana et al. (2014) and Rani et al. (2015).

**Number of Branches**

The highest number of branches (4.56) at maturity was recorded in T₂, followed by T₇ (4.14). The minimum number of branches (2.54) was noted in the control. Similar results were reported by Kanchana et al. (2014) and Rani et al. (2015).

**Days to 50% Flowering**

The earliest flowering (27.46 days) was observed in T₂, followed by T₇ (29.52 days) and T₈ (30.58 days). The maximum number of days to 50% flowering (35.64) was recorded in the control. These observations corroborate the findings of Kanchana et al. (2014), Rani et al. (2015), and Jamir et al. (2017).

**Days to First Harvest**

The shortest duration to first harvest (58.1 days) was recorded in T₂, followed by T₇ (59.32 days) and T₈ (60.14 days). The longest period (65.42 days) was noted in the control. These findings are in agreement with Kanchana et al. (2014) and Rani et al. (2015).

**Fruit Length (cm)**

The longest fruits (6.58 cm) were produced in T₂, followed by T₇ (6.28 cm). The shortest fruits (4.45 cm) were recorded under the control treatment. Similar findings were reported by Kanchana et al. (2014) and Rani et al. (2015).

**Fruit Breadth (cm)**

The highest fruit breadth (4.88 cm) was observed in T₂, followed by T₇ (4.66 cm) and T₈ (4.60 cm). The minimum breadth (4.02 cm) was noted in the control. These results support the findings of Kanchana et al. (2014) and Rani et al. (2015).

**Pericarp Thickness (mm)**

The thickest pericarp (5.24 mm) was recorded in T₂, followed by T₇ (4.96 mm) and T₈ (4.88 mm). The thinnest pericarp (4.32 mm) was observed in the control. These results are in line with those of Kanchana et al. (2014), Rani et al. (2015), and Shilpa et al. (2018).

**Number of Fruits per Plant**

The maximum number of fruits per plant (22.56) was observed in T₂, followed by T₇ (21.88) and T₈ (21.26). The minimum number (16.24) was recorded in the control. This observation is corroborated by Kanchana et al. (2014) and Rani et al. (2015).

**Fruit Weight (g)**

The highest average fruit weight (52.64 g) was found in T₂, followed by T₇ (50.28 g) and T₈ (49.92 g). The lowest fruit weight (43.12 g) was observed in the control. These results agree with Kanchana et al. (2014), Rani et al. (2015), and Shilpa et al. (2018).

**Yield per Plot (kg)**

Maximum yield per plot (22.14 kg) was achieved in T₂, followed by T₇ (20.94 kg). The control treatment recorded the minimum yield (15.34 kg). These findings are in accordance with Kanchana et al. (2014) and Rani et al. (2015).

**Yield per Hectare (q/ha)**

The highest yield per hectare (291.54 q/ha) was recorded in T₂, followed by T₇ (278.54 q/ha). The minimum yield (240.26 q/ha) was noted in the control. Similar results were reported by Kanchana et al. (2014), Rani et al. (2015), and Shilpa et al. (2018).

**Total Soluble Solids (TSS °Brix)**

The highest TSS (4.78 °Brix) was recorded in T₂, followed by T₇ (4.71 °Brix) and T₈ (4.67 °Brix). The lowest TSS (4.32 °Brix) was observed in the control. These results support the findings of Kanchana et al. (2014) and Rani et al. (2015).

**Benefit-Cost Ratio (B:C)**

The highest B:C ratio (1.90) was recorded under T₇, which was significantly superior to all treatments except T₂ (1.78). The lowest B:C ratio (0.80) was recorded in the control. These findings are supported by Rani et al. (2015).

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| **S. No.** | **Plant height (cm)** | **Number of branches** | **Days to 50 % flowering** | **Days to Ist harvest** | **Fruit length (cm)** | **Fruit breadth (cm)** | **Pericarp thickness** | **Number of fruits/plants** | **Fruit weight (g)** | **Yield per plot (kg)** | **Yield per hectare (q)** | **TSS** | **Cost benefit ratio** |
| **T1** | 54 | 2.54 | 35.64 | 65.42 | 4.45 | 4.02 | 4.32 | 16.24 | 43.12 | 15.34 | 240.26 | 4.32 | 0.8 |
| **T2** | 68 | 4.56 | 27.46 | 58.1 | 6.58 | 4.88 | 5.24 | 22.56 | 52.64 | 22.14 | 291.54 | 4.78 | 1.78 |
| **T3** | 60 | 3.7 | 31.74 | 60.92 | 5.88 | 4.54 | 4.81 | 20.96 | 49.44 | 19.88 | 266.64 | 4.62 | 1.48 |
| **T4** | 59 | 3.58 | 32.46 | 61.48 | 5.67 | 4.48 | 4.74 | 20.68 | 48.62 | 19.46 | 260.46 | 4.6 | 1.34 |
| **T5** | 57 | 3.32 | 33.12 | 62.12 | 5.11 | 4.32 | 4.66 | 20.44 | 46.58 | 18.32 | 254.62 | 4.56 | 1.24 |
| **T6** | 56 | 2.98 | 33.88 | 63.8 | 4.78 | 4.24 | 4.58 | 19.68 | 45.32 | 17.54 | 250.54 | 4.44 | 0.92 |
| **T7** | 65 | 4.14 | 29.52 | 59.32 | 6.28 | 4.66 | 4.96 | 21.88 | 50.28 | 20.94 | 278.54 | 4.71 | 1.9 |
| **T8** | 62 | 3.96 | 30.58 | 60.14 | 6.2 | 4.6 | 4.88 | 21.26 | 49.92 | 20.12 | 271.42 | 4.67 | 1.64 |
| **C.D.** | 2.347 | 0.188 | 1.253 | 2.662 | 0.253 | 0.179 | 0.170 | 0.762 | 2.391 | 0.957 | 7.690 | 0.227 | 0.072 |
| **SEm (±)** | 0.766 | 0.061 | 0.409 | 0.869 | 0.083 | 0.058 | 0.055 | 0.249 | 0.781 | 0.313  | 2.511 | 0.105 | 0.024 |

**Table 1 Impact of integrated nutrient management on Capsicum**

**CONCLUSION**

 Based on the results obtained from the present investigation, it can be concluded that the treatment T₂ (RDF + FYM @ 20 t/ha + PGPR) recorded the highest values for growth, yield, and quality parameters in capsicum. These included plant height (68 cm), number of branches (4.56), minimum days to 50% flowering (27.46), minimum days to first harvest (58.1), fruit length (6.58 cm), fruit breadth (4.88 cm), pericarp thickness (5.24 mm), number of fruits per plant (22.56), fruit weight (52.64 g), yield per plot (22.14 kg), maximum yield per hectare (291.54 q/ha), total soluble solids (TSS: 4.78 °Brix), and benefit-cost ratio (1.90). Therefore, the integrated application of RDF with FYM and PGPR proves to be the most effective nutrient management strategy and is recommended for enhancing the productivity and profitability of capsicum cultivation. This approach may be suggested to farmers for sustainable capsicum production under similar agro-climatic conditions.

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