**Effect of different organic manures and biofertilizers on production and associated traits of Chilli *(Capsicum annuum* l.*)***

**ABSTRACT**

A field trial was carried out at the Horticulture Research Farm, Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, from July to October 2024 to assess how various organic manures and biofertilizer influence the growth, yield, and quality of chilli (*Capsicum annuum* L.). The experiment followed a randomized block design with three replications and nine treatments: T0: 100% recommended NPK (100:50:50 kg ha⁻¹), T1: Farm yard manure (20 t ha⁻¹) + Azotobacter (2 g plant⁻¹), T2: Poultry manure (15 t ha⁻¹) + Azotobacter (2 g plant⁻¹), T3: Vermicompost (5 t ha⁻¹) + Azotobacter (2 g plant⁻¹), T4: Azotobacter (2 g plant⁻¹) alone, T5: 50% FYM (10 t ha⁻¹) + 50% poultry manure (7.5 t ha⁻¹) + Azotobacter, T6: 50% FYM (10 t ha⁻¹) + 50% vermicompost (2.5 t ha⁻¹) + Azotobacter, T7: 50% poultry manure (7.5 t ha⁻¹) + 50% vermicompost (2.5 t ha⁻¹) + Azotobacter, T8: FYM : poultry manure : vermicompost (1 : 1 : 1 at 5 + 3.75 + 1.25 t ha⁻¹) + Azotobacter.

Across all treatments, T8, the combined application of FYM, poultry manure and vermicompost in equal proportions in addition to Azotobacter, produced significant improvements in vegetative growth, the highest fruit yield, and superior quality attributes. This treatment also delivered the highest benefit–cost ratio of 3.97, underscoring its economic as well as agronomic superiority.

**Keywords:- organic manure, biofertilizers, growth, yield, quality and chilli**

**INTRODUCTION**

Vegetables are critical to Indian agriculture, combating malnutrition while also supporting rural livelihoods and national food security. Vegetables are labor-intensive crops that generate significant employment in villages and small towns. India is second only to China in vegetable production, accounting for approximately 12% of global output (Nayak et al., 2016).

Chilli (Capsicum annuum L.), a Solanaceae member with 2n = 24 chromosomes, exemplifies the dual vegetable-spice function. Capsicum, which was domesticated in South and Central America around 7000 BC, now has 30 species, five of which are cultivated: C. annuum L., C. frutescens L., C. chinense Jacq., C. pubescens Raf., and C. baccatum L. (Patel et al., 2016).

India is the world's leading producer, consumer, and exporter of chillies, which are appreciated for their pungency and vibrant colors. According to the Spices Board of India's First Advance Estimates (2024-25), global chilli farming covers 18.03 lakh hectares, yielding 58.22 lakh tonnes at 3 229 kg/ha. India alone produced 27.82 lakh tonnes, followed by Bangladesh (6.63 lakh tonnes), Thailand (3.29 lakh tonnes), China (3.26 lakh tonnes), and others. Major export destinations include China, Sri Lanka, Malaysia, Bangladesh, Singapore, Thailand, and the United Arab Emirates.

Beyond its culinary use, chilli has industrial and health benefits. Its oleoresin, which is valuable in food coloring and flavoring, fuels a robust processing industry. Green and red fruits are high in antioxidants and provitamins A, C, and E, which have been associated to cancer prevention and pain relief (Khushal et al., 2023).

It is not yet possible to totally eliminate the use of chemical fertilizers, but they should be minimized and balanced with organic manures such as FYM, vermicompost, chicken manure, and oil cakes, which enhance soil fertility and chilli crop output (Khushal et al., 2023; Nakhro and Dkhar, 2010). Combining organic, inorganic, and bio-fertilizers promotes soil health and sustainable output.  
  
Vermicompost enhances soil structure, promotes beneficial microorganisms, and provides nutrients such as nitrogen, phosphate, and potassium, hence increasing plant development and yield (Singh et al., 2020; Govindapillai et al., 2018). It also enhances aeration, porosity, and water infiltration while serving as a natural soil conditioner.

Poultry manure slowly releases essential nutrients such as NPK and molybdenum, offering ongoing advantages to following crops (Jarvan et al., 2017). FYM improves soil fertility and physicochemical qualities while minimizing hazardous metal desorption through the formation of insoluble compounds (Pavlikova et al., 2006). Biofertilizers such as Azotobacter also contribute by fixing atmospheric nitrogen and creating growth-promoting phytohormones such auxins, which drive plant development (Raut et al., 2021).

**MATERIALS AND METHODS**

The study, titled "Effect of Different Organic Manures and Biofertilizers on Production and Associated Traits of Chilli (Capsicum annuum L.)," was conducted at the Horticulture Research Farm, Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (formerly Allahabad), during the winter (kharif) season of 2024-25. The location is located in the subtropical area of southern Uttar Pradesh, with an average annual rainfall of 1,013.4 mm, relative humidity ranging from 20-94%, maximum summer temperatures of 32-34 °C, and winter minimums of 4-5 °C.

A randomized complete block design (RCBD) with three replications and nine treatments (including an unfertilized control) was used to assess the impact of organic manures and the biofertilizer Azotobacter on chilli. Seedlings of cv. Sadabahar were transplanted into 1 × 1 m plots with 30 × 45 cm spacing (6 plants per plot).

The treatments were: T0 – 100 % recommended NPK (100:50:50 kg ha⁻¹) T1 – Farmyard manure (20 t ha⁻¹) + Azotobacter (2 g plant⁻¹) T2 – Poultry manure (15 t ha⁻¹) + Azotobacter (2 g plant⁻¹) T3 – Vermicompost (5 t ha⁻¹) + Azotobacter (2 g plant⁻¹) T4 – Azotobacter alone (2 g plant⁻¹) T5 – 50 % FYM (10 t ha⁻¹) + 50 % poultry manure (7.5 t ha⁻¹) + Azotobacter (2 g plant⁻¹) T6 – 50 % FYM (10 t ha⁻¹) + 50 % vermicompost (2.5 t ha⁻¹) + Azotobacter (2 g plant⁻¹) T7 – 50 % poultry manure (7.5 t ha⁻¹) + 50 % vermicompost (2.5 t ha⁻¹) + Azotobacter (2 g plant⁻¹) T8 – FYM : poultry manure : vermicompost (1 : 1 : 1 at 5 + 3.75 + 1.25 t ha⁻¹) + Azotobacter (2 g plant⁻¹)

Observations were made on five randomly chosen plants each plot. • Vegetative traits: plant height (cm), number of leaves and branches per plant. • Phenology: days until first flowering, 50% blooming, and first harvest. • Yield components: number of fruits per plant, number of seeds per fruit, fruit yield per plant (g) and per plot (kg). • Fruit shape and quality: length (cm), diameter (mm), total soluble solids (°Brix), and ascorbic acid (mg/100g).   
  
Data were analyzed using two-way classification analysis of variance (ANOVA) as described by Panse and Sukhatme (1985). Where the F-test was significant, treatment means were compared using the crucial difference (CD) at the 5% confidence level.

**RESULTS AND DISCUSSION**

Table 1 summarizes the findings on growth parameters at 90 days after transplantation (DAT). The source of nutrients had a substantial effect on all three vegetative traits—plant height, leaf number, and branch number per plant. The organic-biofertilizer treatment (T8: FYM: poultry manure: vermicompost in 1: 1: 1 at 5 + 3.75 + 1.25 t ha⁻¹ + Azotobacter 2 g plant⁻¹) resulted in the tallest plants (43.00 cm), the most leaves (175.08 leaves plant⁻¹), and the most branches (12.33 branches plant⁻¹). These results were statistically comparable to T7 (50% poultry manure + 50% vermicompost + Azotobacter) and, for height alone, T2 (100% poultry manure + Azotobacter).

The only NPK treatment (T0) resulted in the lowest vegetative growth, with only 32.54 cm of height, 88.50 leaves, and 7.80 branches per plant. The increased growth under T8 is most likely due to the simultaneous advantage of easily available nutrients from organic manures and Azotobacter's nitrogen-fixing activities, which stimulate cell division and enlargement.

Phenological traits (days to first flowering, 50% blooming, and first harvest) differed considerably between treatments (Table 1). T8 again had the earliest flowering (first flower at 44.58 days), which was closely followed by T7, whereas the NPK control (T0) flowered the later (50.17 days). Organic additions, particularly vermicompost and chicken manure, when combined with Azotobacter, can boost nutrient mineralization and microbial activity in the rhizosphere, elevating root-zone temperature and hastening floral commencement. These findings are consistent with those of Adhikari et al. (2016), Turemis (2002), and Abu-Zahra (2012), who found that organic manures decrease the time to flowering by improving soil biological and thermal parameters.

Table 1 shows that T8 (FYM: P.M.: V.C. at 1: 1: 1 with Azotobacter) significantly accelerated phenology while increasing yield and quality attributes in chilli. T8 had the shortest days to 50% flowering (53.67 d), substantially less than the NPK control (T0: 60.67 d), followed by T2 (100% poultry manure + Azotobacter, ~56.4 d) and T6 (50% FYM + 50% vermicompost + Azotobacter, ~57.3 d). Organic manures increase soil structure, moisture retention, and nutrient availability, whereas vermicompost contains humic acids and bio-regulators that promote floral initiation (Bajeli et al., 2016; Okokoh & Bisong, 2011). Days to first harvest paralleled flowering trends: earliest under T8 and latest under T0, with T1 and T2 statistically comparable to T8.Fruits per plant increased from 59.3 (T0) to 71.3 (T8), reflecting more flowers, higher fruit set, and reduced abscission (Tripathy & Maity, 2011). Seeds per fruit rose from 60.6 (T0) to 70.6 (T8), indicating improved pollination and assimilate flow.

Fruit length expanded from 7.81 cm (T0) to 9.16 cm (T8) and diameter from 7.75 mm to 9.39 mm. Vermicompost’s ready to release N, P, and K boost protoplasmic protein synthesis and cell enlargement, while Azotobacter enhances nitrogen fixation, jointly spurring pericarp growth (Theunissen et al., 2010; Jaipaul et al., 2011).

Yield per plant observed from 601.6 g (T4: Azotobacter alone) to 710.0 g (T8).

Total soluble solids and ascorbic acid also peaked under T8, attributable to balanced nutrient supply, elevated microbial biomass and enhanced phytohormone production from vermicompost (Canellas et al., 2000; Atiyeh et al., 2001).

The superior fruit size under T8—9.16 cm length and 9.39 mm diameter versus 7.81 cm and 7.75 mm in the NPK control—can be attributed to vermicompost’s steady release of N, P and K in readily available forms, combined with Azotobacter’s biological N fixation. This nutrient synergy accelerates protoplasmic protein synthesis and cell division in the pericarp, while humic acids and microbial metabolites further promote meristematic activity and create a favorable rhizosphere (Theunissen et al., 2010; Jaipaul et al., 2011).

Yield per plant peaked at 710.01 g under T8—versus 601.62 g with Azotobacter alone—and plot yield reached 2.84 kg compared to 2.41 kg. The long-term fertility retention of organic manures, elevated microbial biomass and enriched humate content boost phytohormone production, flower retention and fruit set, driving higher yields (Canellas et al., 2000; Atiyeh et al., 2001; Prabha et al., 2007). Similar positive effects of vermicompost (and neem cake) on growth and yield have been reported by Dhanalakshmi et al. (2014) and Veena et al. (2017).

Nutritional quality also improved markedly under T8: ascorbic acid reached 120.00 mg 100 g⁻¹ (vs. 104.67 mg 100 g⁻¹ in NPK), and TSS climbed to 3.87 °Brix (vs. 2.43 °Brix with Azotobacter alone). Treatments T2, T5 and T7 were statistically at par with T8 for these parameters. The balanced nutrient supply and enhanced enzymatic activity during fruit ripening likely underpin these gains.

**CONCLUSION**

Based on the current investigation, it is concluded that treatment T8, which consists of farmyard manure (5 t/ha), poultry manure (3.75 t/ha), vermicompost (1.25 t/ha), and Azotobacter (2 g/plant), performed the best. This treatment showed significant improvements in various parameters, including the number of leaves, number of branches, plant height, days taken to first flowering, days taken to 50% flowering, days to the first harvest, number of fruits per plant, fruit length, fruit diameter, fruit weight, fruit yield per plot, ascorbic acid content, and total soluble solids (TSS).

Additionally, the highest benefit-cost ratio of 3.97 was recorded for this treatment. Therefore, the T8 treatment combination is recommended for farmers in the Prayagraj region (U.P.) as it provides the best fruit yield and quality, enhances soil health, and serves as a sustainable, chemical-free option for cultivation.

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1.

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**Table1: Effect of different organic manures and biofertilizers on production and associated traits of Chilli *(Capsicum annuum* l.*)***

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Notation** | **Growth and flowering** | | | | | |  |
| **Plant height (cm)** | **Number of leaves**  **/plant** | **Number of branches**  **/plant** | **Days 1st flowering** | **Days to 50% flowering** | **Days to 1st harvest** | **No. of fruits per plant** | | **No. of seeds per fruit** | **Fruit Length (cm)** | **Fruit Diameter (mm)** | **Fruit Yield/**  **Plant (g)** | **Fruit Yield/**  **Plot (kg)** | **Ascorbic Acid (mg/100g)** | **TSS (0Brix)** |
| T0 | 44.71 | 88.50 | 7.80 | 7.80 | 60.67 | 85.33 | 59.29 | | 60.56 | 7.81 | 7.75 | 632.34 | 2.53 | 104.67 | 2.50 |
| T1 | 51.33 | 98.67 | 8.50 | 8.50 | 57.00 | 77.83 | 60.09 | | 63.80 | 8.32 | 7.81 | 619.43 | 2.48 | 108.00 | 2.70 |
| T2 | 51.79 | 104.33 | 8.43 | 8.43 | 55.00 | 77.58 | 61.67 | | 66.85 | 8.22 | 8.19 | 654.06 | 2.62 | 112.00 | 3.10 |
| T3 | 50.50 | 96.67 | 8.92 | 8.92 | 58.00 | 79.92 | 63.47 | | 62.47 | 8.18 | 7.75 | 652.69 | 2.61 | 109.33 | 2.90 |
| T4 | 48.92 | 89.42 | 8.25 | 8.25 | 59.00 | 81.67 | 59.69 | | 59.53 | 7.63 | 7.52 | 601.62 | 2.41 | 102.00 | 2.43 |
| T5 | 53.33 | 123.58 | 8.67 | 8.67 | 56.67 | 79.25 | 63.47 | | 64.57 | 8.27 | 8.10 | 642.08 | 2.61 | 113.33 | 3.27 |
| T6 | 55.00 | 151.83 | 8.58 | 8.58 | 55.33 | 78.25 | 65.17 | | 65.80 | 8.29 | 8.10 | 658.76 | 2.64 | 109.67 | 3.03 |
| T7 | 49.88 | 97.00 | 10.42 | 10.42 | 57.33 | 78.42 | 68.00 | | 67.83 | 8.54 | 8.53 | 695.66 | 2.78 | 116.00 | 3.33 |
| T8 | 57.84 | 175.08 | 12.33 | 12.33 | 53.67 | 76.42 | 71.25 | | 70.55 | 9.16 | 9.39 | 710.01 | 2.84 | 120.00 | 3.87 |
| **F Test** | **S** | **S** | **S** | **S** | **S** | **S** | **S** | | **S** | **S** | **S** | **S** | **S** | **S** | **S** |
| **S.E (d) (±)** | **1.94** | **3.23** | **0.33** | **0.33** | **0.61** | **0.38** | **1.00** | | **0.73** | **0.19** | **0.25** | **7.76** | **0.02** | **3.85** | **0.06** |
| **CD (P = 0.05)** | **4.11** | **6.85** | **0.70** | **0.70** | **1.30** | **0.81** | **2.11** | | **1.55** | **0.41** | **0.53** | **16.45** | **0.04** | **8.16** | **0.13** |
| **CV%** | **4.60** | **3.50** | **4.40** | **4.40** | **1.30** | **0.60** | **1.9** | | **1.40** | **2.9** | **3.80** | **1.50** | **0.09** | **4.30** | **2.40** |

**Table 2: Effects of different organic manures and biofertilizers on economics of Chilli (*Capsicum annuum* L.)**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Notation** | **Yield(t/ha)** | **Selling price (rs/t)** | **Cost of cultivation (rs/ha)** | **Gross return** | **Net return**  **(rs/ha)** | **B:c ratio** |
| **T0** | 29.19 | 30000 | 186488 | 875760 | 689271 | 3.70 |
| **T1** | 28.62 | 30000 | 202229 | 858452 | 656223 | 3.24 |
| **T2** | 30.23 | 30000 | 200229 | 906913 | 706684 | 3.53 |
| **T3** | 30.12 | 30000 | 207229 | 903452 | 696222 | 3.36 |
| **T4** | 27.81 | 30000 | 182229 | 834222 | 651992 | 3.58 |
| **T5** | 30.12 | 30000 | 201229 | 903452 | 702222 | 3.49 |
| **T6** | 30.46 | 30000 | 204729 | 913836 | 709107 | 3.46 |
| **T7** | 32.08 | 30000 | 203729 | 962297 | 758568 | 3.72 |
| **T8** | 32.77 | 30000 | 197979 | 983066 | 785087 | 3.97 |