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# Effect of organic manures and biofertilizers on growth, yield and quality of broccoli (*Brassica oleracea* L. Var. Italica)

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**Abstract**
The experiment was conducted during the rabi season of 2023-2024 at the Horticulture Research Farm, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology, and Sciences, Prayagraj (U.P), India, to evaluate the effects of organic manures and biofertilizers on the growth, yield, and quality of broccoli (*Brassica oleracea* L. var. italica). The study was designed using a Randomized Block Design (RBD) with three replications and ten treatment combinations. The treatments included different combinations of farmyard manure (FYM), vermicompost (VC), and biofertilizers such as Azospirillum, phosphate-solubilizing bacteria (PSB), and zinc-solubilizing bacteria (ZSB), applied at 30 and 45 days after transplanting. Data on growth, yield, and quality parameters were collected. The results showed that the treatment combination $T_7$ (FYM 7.5 t/ha + VC 2 t/ha) achieved the best performance in terms of plant height (27.00 cm at 15 DAS, increasing to 69.00 cm at 60 DAS), number of leaves per plant (8.00 at 15 DAS, increasing to 20.03 at 60 DAS), head volume (943.10 cc), polar diameter (21.20 cm), head weight (329.00 gm), and head yield per plot (860.70 kg). Additionally, $T_7$ had the highest total soluble solids (TSS) at 9.13, ascorbic acid content (20.63 mg/100g), and chlorophyll content (94.00). On the other hand, $T_3$ (FYM 3.75 t/ha + Azospirillum) exhibited the shortest plants (14.00 cm at 15 DAS), the earliest head initiation (53.42 days), and the quickest head maturity (41.05 days). These findings suggest that the combined use of FYM and vermicompost notably improves broccoli growth, yield, and quality by supplying a balanced array of nutrients and enhancing soil structure. This study highlights the advantages of using organic manures and biofertilizers in sustainable broccoli farming, enhancing soil health and minimizing the reliance on chemical fertilizers.

**Keywords:** Broccoli, organic manures, biofertilizers

## Introduction
Broccoli (*Brassica oleracea* L. var. italica) is a highly nutritious cruciferous vegetable in the Brassicaceae family, with a chromosome number of 2n=18. Its cultivation spans globally, with varieties like Calabrese, Purple Sprouting, and Romanesco. In India, broccoli has gained popularity due to its high economic returns and urban market demand. Ideal growth conditions for broccoli include cool climates, with optimal temperatures between 18 °C and 23 °C (Bose, 2002) [13], and well-drained, fertile soils with a pH of 6.0 to 7.5. Depending on the variety and conditions, broccoli is ready for harvest within 60 to 100 days. Broccoli cultivation traditionally relies on chemical fertilizers, but environmental and soil health concerns have increased interest in organic manures and biofertilizers (Sharma, 2016) [10]. Organic manures, such as farmyard manure, compost, and green manures, improve soil structure and fertility. Biofertilizers, including nitrogen- fixing bacteria, phosphate-solubilizing bacteria, and mycorrhizal fungi, enhance nutrient availability and uptake. Using organic manures and biofertilizers offers several benefits, including improved soil health and reduced dependency on chemical fertilizers. Organically grown broccoli has been shown to contain higher levels of vitamins, minerals, and antioxidants compared to conventionally grown produce (Wang, 2008) [12]. Additionally, organic amendments promote better root development, increased microbial activity, and improved water retention, contributing to healthier plants and higher yields (Ghosh, 2014) [2]. Biofertilizers also help suppress soil-borne pathogens and reduce disease incidence (Mäder, 2002) [6].

## Materials and Methods

A field experiment was conducted at the Horticulture Research Farm, Department of Horticulture, SHUATS, Prayagraj, U.P., from November 2023 to February 2024, to evaluate the effect of organic manures and biofertilizers on the growth, yield, and quality of broccoli (*Brassica oleracea* L. var. italica). The study utilized a Randomized Block Design (RBD) with three replications and ten treatment combinations. Treatments were applied at 30 and 45 days after transplanting. The treatment combinations were: $T_0$: Control, $T_1$: FYM (15 t/ha) + PSB (1 kg in 10 lt/ha) soil application, $T_2$: FYM (11.25 t/ha) + ZSB (100 ml in 10 lt/ha) drenching, $T_3$: FYM (3.75 t/ha) + Azospirillum (2 lt or 4 kg/ha) soil application, $T_4$: Vermicompost (VC) (4 t/ha) + PSB (1 kg in 10 lt/ha) soil application, $T_5$: VC (2.75 t/ha) + ZSB (100 ml in 10 lt/ha) drenching, $T_6$: VC (1.2 t/ha) + Azospirillum (2 lt or 4 kg/ha) soil application, $T_7$: FYM (7.5 t/ha) + VC (2 t/ha), $T_8$: FYM (15 t/ha), and $T_9$: VC (4 t/ha). This study aimed to determine the impact of these various organic and biofertilizer treatments on broccoli's overall performance, seeking to enhance sustainable agricultural practices and improve crop yield and quality.

## Results and Discussion

The field experiment at the Horticulture Research Farm, Department of Horticulture, SHUATS, Prayagraj, U.P., spanning November 2023 to February 2024, aimed to analyze the impact of different organic manures and biofertilizers on the growth, yield, and quality of broccoli. Employing a Randomized Block Design (RBD) with three replications and ten treatment combinations, the treatments were applied at 30 and 45 days post- transplanting. At 15 days after sowing (DAS), treatment $T_7$, which utilized a combination of FYM (7.5t/ha) and vermicompost (2t/ha), resulted in the tallest plants (27.00 cm). Conversely, treatment $T_3$, which combined FYM (3.75t/ha) with Azospirillum (2 lt or 4kg/ha), had the shortest plants (14.00 cm). This trend persisted across subsequent stages at 30, 45, and 60 DAS, with $T_7$ maintaining the highest plant height (69.00 cm at 60 DAS) and $T_3$ the lowest. The superior growth in $T_7$ could be attributed to the balanced nutrient supply and enhanced soil structure provided by the combined application of FYM and vermicompost, leading to improved root development and overall plant growth. Similar outcomes were reported by Singh *et al*. (2017) [8] and Sharma *et al*. (2020) [10].

Regarding leaf count per plant at 15 DAS, $T_7$ recorded the maximum number of leaves (8.00), while $T_3$ had the minimum (3.00). This pattern continued at 30, 45, and 60 DAS, with $T_7$ showing the highest leaf number (20.03 at 60 DAS) and $T_3$ the lowest. The increased leaf count in $T_7$ can be linked to the comprehensive nutrient availability from the organic amendments, promoting vegetative growth. Studies by Kumar *et al*. (2019) [5] and Patel *et al*. (2018) [14] reported similar findings.

Treatment $T_3$ exhibited the earliest head initiation (53.42 days), whereas $T_7$ showed the latest (65.10 days). The rapid head initiation in $T_3$ may be due to the quick nutrient uptake facilitated by Azospirillum, known for enhancing nitrogen fixation and plant growth. Additionally, $T_3$ had the shortest time to head maturity (41.05 days), while $T_7$ had the longest (62.10 days). The expedited maturity in $T_3$ is likely a result of efficient nutrient use and rapid growth driven by biofertilizer application. Similar observations were made by Meena *et al*. (2019) [7] and Pandey *et al*. (2017) [8].

In terms of head volume, $T_7$ recorded the maximum (943.10 cc), whereas $T_3$ had the minimum (345.02 cc). The increased head volume in $T_7$ can be attributed to the improved soil fertility and structure due to the combined use of FYM and vermicompost, leading to better nutrient and water uptake. The highest polar diameter was also seen in $T_7$ (21.20 cm), with the lowest in $T_3$ (10.00 cm). The increased polar diameter in $T_7$ likely stems from enhanced nutrient availability and uptake from the organic amendments. Similar results were found by Gupta *et al*. (2021) [3] and Verma *et al*. (2018) [11].

Regarding head weight, $T_7$ produced the heaviest heads (329.00 gm), while $T_3$ had the lightest (112.10 gm). The higher head weight in $T_7$ is indicative of better growth conditions provided by the organic treatments, resulting in improved plant development and productivity. Additionally, $T_7$ achieved the highest head yield per plot (860.70 kg), while $T_3$ had the lowest (425.30 kg). The increased yield in $T_7$ can be linked to enhanced plant growth and development facilitated by the combined organic treatments. Similar outcomes were noted by Choudhary *et al*. (2017) [1] and Jain *et al*. (2020) [4].

$T_7$ also exhibited the highest total soluble solids (TSS) at 9.13, suggesting superior fruit quality, while $T_3$ had the lowest at 5.13. The higher TSS levels in $T_7$ imply that the organic treatments improved the sugar content in the broccoli heads. Furthermore, $T_7$ had the highest ascorbic acid content (20.63 mg/100g), compared to the lowest in $T_3$ (14.93 mg/100g). The increased ascorbic acid levels in $T_7$ highlight the enhanced nutritional quality of the broccoli. $T_7$ also recorded the highest chlorophyll content (94.00), with $T_3$ having the lowest (59.50). The higher chlorophyll content in $T_7$ indicates better photosynthetic activity and overall plant health. Similar findings were reported by Rao *et al*. (2019) [9] and Roy *et al*. (2021) [15].

**Table 1:** Effect of Organic manures & Bio Fertilizers on Plant height (cm), Number of leaves per plant(60 DAS), Days to Initiation (DAS) of Broccoli

| Treatment Notation | Treatment Combination | Plant height (cm) | No. of leaves/ plant | Days to head initiation |
|---|---|---|---|---|
| $T_0$ | Control | 43.21 | 17.00 | 58.32 |
| $T_1$ | FYM (15t/ha) + PSB (1kg in 10 lt /ha) soil application | 65.04 | 19.20 | 64.20 |
| $T_2$ | FYM (11.25t/ha) + ZSB (100ml in 10 lt/ha) Drenching | 57.24 | 15.06 | 62.40 |
| $T_3$ | FYM (3.75t/ha) + Azosprillum (2 lt or4kg/ha) soil application | 39.00 | 16.00 | 53.42 |
| $T_4$ | V.C(4t/ha) + PSB (1 kg in 10 lt/ha) soil application | 59.00 | 17.20 | 55.20 |
| $T_5$ | V.C(2.75t/ha) + ZSB (100 ml in 10 lt/ha) drenching | 47.00 | 19.00 | 59.14 |
| $T_6$ | V.C(1.2t/ha) + Azosprillum (2 lt or 4 kg/ha) soil application | 40.25 | 17.00 | 56.10 |
| $T_7$ | FYM(7.5t/ha)+ V.C(2 t/ha) | 69.00 | 20.03 | 65.10 |
| $T_8$ | FYM (15t/ha) | 48.00 | 17.02 | 57.12 |
| $T_9$ | V.C(4t/ha) | 60.00 | 19.00 | 61.00 |
| | F-test | S | S | S |
| | SE(d)± | 0.8 | 0.11 | 0.16 |
| | CD at 5% | 1.68 | 0.24 | 0.33 |
| | CV | 1.91 | 1.18 | 0.32 |

**Table 2:** Effect of Organic manures & Bio Fertilizers on Head Maturity, Head Volume, Polar Diameter (cm), Radial diameter (cm), Head weight (g) of Broccoli

| Treatment Notation | Head Maturity (DAT) | Head Volume (cc) | Polar Diameter (cm) | Radial Diameter (cm) | Head Weight (g) |
|---|---|---|---|---|---|
| $T_0$ | 45.00 | 518.02 | 11.05 | 9.10 | 365.40 |
| $T_1$ | 60.20 | 836.02 | 20.00 | 18.50 | 485.60 |
| $T_2$ | 52.00 | 401.00 | 14.01 | 12.70 | 372.10 |
| $T_3$ | 41.05 | 345.02 | 10.00 | 8.30 | 356.20 |
| $T_4$ | 57.06 | 572.01 | 12.40 | 11.50 | 463.00 |
| $T_5$ | 44.80 | 403.50 | 16.40 | 15.00 | 381.40 |
| $T_6$ | 42.01 | 401.01 | 10.30 | 8.90 | 432.50 |
| $T_7$ | 62.10 | 943.10 | 21.20 | 19.30 | 522.30 |
| $T_8$ | 51.00 | 414.30 | 17.10 | 16.20 | 479.20 |
| $T_9$ | 55.01 | 675.00 | 13.40 | 11.90 | 421.80 |
| F-test | S | S | S | S | S |
| SE(d)± | 0.17 | 0.14 | 0.14 | 0.12 | 28.21 |
| CD at 5% | 0.35 | 0.3 | 0.29 | 0.25 | 59.28 |

**Table 3:** Effect of Organic manures & Bio Fertilizers on Head yield, Total Soluble Solids, Ascorbic Acid, Chlorophyll content of Broccoli

| Treatment Notation | Head Yield(q/ha) | TSS (oBrix) | Ascorbic Acid(mg/100g) | Chlorophyll SPAD meter |
|---|---|---|---|---|
| $T_0$ | 8.11 | 6.7 | 15.87 | 75.01 |
| $T_1$ | 14.25 | 6.23 | 15.57 | 89.00 |
| $T_2$ | 8.95 | 7.12 | 15.05 | 68.20 |
| $T_3$ | 10.15 | 5.13 | 14.93 | 59.50 |
| $T_4$ | 11.85 | 7.2 | 19.53 | 80.20 |
| $T_5$ | 9.32 | 6.23 | 18.07 | 62.40 |
| $T_6$ | 13.10 | 8.07 | 19.5 | 60.50 |
| $T_7$ | 14.50 | 9.13 | 20.63 | 94.00 |
| $T_8$ | 12.80 | 8.6 | 17.8 | 84.00 |
| $T_9$ | 12.05 | 7.37 | 16.13 | 70.90 |
| F-test SE(d)± | S 0.9758 | S 0.07 | S 0.14 | S 0.19 |
| CD at 5% | 0.1863 | 0.15 | 0.29 | 0.39 |

**Table 4:** Economics of treatments showing Cost of Cultivation, Benefit Cost Ratio.

| T. No. | Cost of cultivation (Rs / ha) | Gross return (Rs / ha) | Benefit Cost ratio |
|---|---|---|---|
| $T_0$ | 1,30,025 | 5,65,400 | 2.8 |
| $T_1$ | 1,38,204 | 6,49,560 | 4.7 |
| $T_2$ | 1,71,811 | 4,63,890 | 2.7 |
| $T_3$ | 1,49,589 | 3,83,080 | 2.6 |
| $T_4$ | 1,34,025 | 3,75,270 | 2.8 |
| $T_5$ | 1,44,486 | 5,34,600 | 3.7 |
| $T_6$ | 1,96,622 | 5,30,880 | 2.7 |
| $T_7$ | 1,75,170 | 7,00,680 | 4.0 |
| $T_8$ | 1,96,983 | 4,53,060 | 2.3 |
| $T_9$ | 1,68,411 | 5,89,440 | 3.5 |

## Conclusion

From the present study, it can be concluded that among the nine treatments for broccoli, Treatment 7 ($T_7$) comprising FYM (7.5 t/ha) + Vermicompost (2 t/ha) demonstrated superior performance in growth, yield, and quality. The yield for this treatment was recorded at 14.50 quintals per hectare, that the highest benefit cost also observed in $T_7$ i.e., 4.0.

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