# Effect of Bio-fertilizers on growth attributes of broccoli (*Brassica oleracea* var. *italica* L.)

***Abstract:*** Broccoli (*Brassica oleracea* var. *italica*; 2n = 18), which is originated from the Mediterranean region commonly known as hari gobhi in Hindi and a member of cole group, belongs to the family Brassicaceae or cruciferae. The present research work on the effect of different biofertilizers on the growth parameters of broccoli was carried out at the Horticultural Research Farm-1, Department of Horticulture, Babasaheb Bhimrao Ambedkar University (A central University) Vidya Vihar, Raebareli Road, Lucknow-226025 (U.P.) during the rabi season, 2022-2023. The research material comprised twelve treatments and three replications in Randomized Block Design. The highest plant height (55.97 cm), number of leaves per plant (21.72), leaf length (48.27 cm), leaf width (23.51 cm), plant spreading east-west (46.63 cm), plant spreading north-south (46.32 cm), stem diameter (6.89 cm), stem length (26.53 cm) was observed at 90 DAT in $T_7$ (RDF + VAM (50% + 50% Each) as compared to $T_0$ (Control) treatment.

***Keywords:*** Broccoli, Growth, Biofertilizer, Cruciferous vegetables

## Introduction

Cruciferous vegetables are grown and used in different cultures around the world due to their good adaptability to environmental conditions (Samec *et al*., 2018). Sprouting broccoli (*Brassica oleracea* var. *italica* L.) is an important cole crop belonging to the family Cruciferae. The United States is the largest producer of sprouting broccoli followed by India. In Italy, it has been used as a vegetable from early times but its economic importance has become appreciable only since the thirties of the century when this vegetable become popular in the U.S.A. It is a winter season vegetable and commonly known as hari gobhi, In India morphologically, sprouting broccoli resembles cauliflower except for secondary heads which develop in the axils of leaves and may contribute up to 50 percent of the total yield. Broccoli is highly nutritious due to its high ascorbic acid, vitamins B1 and B2, calcium and phosphorus minerals contents (Regar *et al*., 2018). Broccoli's high vitamin and mineral content was obtained as "Crown of Jewel Nutrition" (Zhao *et al.*, 2918). Since broccoli is also a great source of numerous vitamins and minerals, including calcium, folic acid, carotenoids, fiber, vitamins A and C eating of broccoli may also have additional benefits. Approximately 130 times more vitamin A is present in it than in cabbage. It has certain significant phytochemicals, including indole-3-carbinol and beta-carotene, which aid in the prevention of lung and breast cancer (Anonymous, 2006). In India, it is mostly cultivated in the areas of Himachal Pradesh, Uttrakhand, Uttar Pradesh, Jammu and Kashmir, Nilgiri hills (Tamil Nadu) and Northern plains. Broccoli is a heavy feeder and it requires large amounts of nutrients like nitrogen, phosphorus and potassium for better development of curd and quality in addition to checking the various diseases and physiological disorders. To increase agricultural yield, the current farming system only relies on the application of chemical pesticides, fertilizers and growth regulators. To maximize broccoli yield, farmers frequently apply chemical fertilizers. Farmers are dealing with the issue of degrading soil, which has an impact on the fauna and flora of the soil as well as the final broccoli production and quality. Globally, there is increasing concern about the harmful effects of using agrochemicals such as pesticides, herbicides and other inorganic fertilizers indiscriminately. Therefore, using biofertilizers is a substitute that can lessen the negative effects of chemical fertilizers while maintaining crop productivity. Biofertilizers have a great potential to bridge the gap between demand and supply of nutrients. Bio-fertilizers contain microorganisms that are capable of mobilizing nutritive elements from non-usable form to usable from through biological processes. These biofertilizers are organic in origin and thus are safe, organic manures and biofertilizers to minimize the cost of production and to maintain the biological productivity of soil (Choudhary *et al*., 2012). Hence, the present study was undertaken to evaluate the effect of various biofertilizers on the growth parameters of broccoli.

**Materials and Methods**

The research investigation was carried out in the field during the rabi season of 2022-23 at the Horticultural Research Farm-1, School of Agricultural Sciences, Babasaheb Bhimrao Ambedkar University, Lucknow-226025 (U.P.), India by adopting Randomized Block Design (RBD) with three replications. Lucknow's geographic coordinates are 260 50´ N latitude, 800 52´ E longitude and 123 meters above mean sea level (MSL). Lucknow experiences an average 50–70% relative humidity and 700 mm of annual rainfall due to its humid subtropical climate.

Summer is hot and dry, while winter is harsh. Even in the winter, there are sporadic showers. In general, the temperature fluctuates between 5°C and 42°C. January is the coldest and May and June are the hottest months of the year, respectively. The field was prepared by deep ploughing, harrowing and leveling and these operations were done by tractor drown implements. Standard agronomic practices followed during the experimental investigation. Broccoli seeds were sown in the nursery beds of Horticulture Research Farm-I, by sowing in row method during October month. A raised bed about 5-6 meters long, one meter width and 15 cm above ground level, was prepared. The seed beds were covered with compost, mulching and thatches with polythene over the bed to protect the young seedlings from adverse climatic conditions, 30 days after sowing, seedlings were ready for transplanting. These healthy seedlings of uniform shape and size were selected and transplanted in well prepared field. A spacing of 45 x 30 cm was adopted for transplanting. Seedlings of bold and uniform size were selected from the nursery for this purpose. Before transplantation, a thick slurry of each biofertilizer—*Azotobacter*, *Azospirillum*, Vesicular *Arbusicular Mycorrhize* (VAM), and Phosphate Solubilizing Bacteria (PSB)—that was obtained from the Department of Microbiology at ICAR-IARI, New Delhi, was made. For 20 minutes, broccoli seedlings were submerged in the slurry containing these biofertilizers to inoculate them. At transplanting, VAM was sprayed on the soil close to the seedling roots. The depicts treatment used in the experimental investigation are depicted in Table-1. The observations were recorded on plant height, number of leaves per plant, leaf length (cm), leaf width (cm), plant spreading and stem diameter (cm).

**Table 1: Details of Treatment**

| **Treatment Components** | | **Symbol** |
|---|---|---|
| Control | : | $T_0$ |
| Recommended Dose of Fertilizers (100%) | : | $T_1$ |
| Azotobacter (100%) | : | $T_2$ |
| Azospirillum (100%) | : | $T_3$ |
| VAM (100%) | | $T_4$ |
| RDF + Azotobacter (50% + 50% Each) | : | $T_5$ |
| RDF + Azospirillum (50% + 50% Each) | : | $T_6$ |

| | | |
|---|---|---|
| RDF + VAM (50% + 50% Each) | : | $T_7$ |
| Azotobacter + Azospirillum (50% + 50% Each) | : | $T_8$ |
| Azotobacter + VAM (50% + 50% Each) | : | $T_9$ |
| Azospirillum + VAM (50% + 50% Each) | : | $T_{10}$ |
| RDF + Azotobacter + Azospirillum + VAM (25 + 25 + 25 + 25 Each) | : | $T_{11}$ |

**Results and Discussion**

The data presented in Table-2 revealed significant variations among the different treatments on the growth parameters of Broccoli. The data from the experimental results revealed that

maximum plant height (24.51, 44.52 and 55.97 cm) was observed in treatment $T_7$-(RDF + VAM 50% + 50% each) followed by treatment $T_6$-(RDF + Azospirillum 50% + 50% each) showed a value 24.39, 44.51 and 54.07 cm plant height at 30, 60 and 90 days after transplanting (DAT), respectively. While the minimum plant height (19.04, 37.44 and 46.31 cm) was recorded in $T_0$-control treatment. Plant height variations between cultivars are mostly caused by differences in genotype and cultivars. Similar findings have been reported by Shree *et al*. (2014) and Giri *et al*. (2013) in broccoli.

The perusal of data indicated that the number of leaves at 30 DAT was influenced significantly by the application of different bio-fertilizer treatments. The significantly maximum number of leaves (8.25) was recorded under treatment $T_7$-(RDF + VAM 50% + 50% each) and minimum number of leaf (5.79) was observed in $T_0$- control treatment. More or less similar trends observed at 60 and 90 Days After Transplanting (DAT). The increase in the number of leaves could be attributable to the impacts of treatments on vegetative development, which led to higher photosynthetic activities. The present results are in line with Kaur and Sharma (2018) who reported that an increase in the number of leaves could be due to the beneficial effect of VAM which promotes the meristem activity and hence, increases the number of tissues and organs (leaves).

The data pertaining in Table.2 revealed the significant effect of different bio-fertilizer on leaf length of broccoli. The significantly highest leaf length (26.81 cm) was recorded under treatment $T_7$-(RDF + VAM 50% + 50% each) and the lowest leaf length (17.02 cm) was recorded in $T_0$- control treatment. Leaf length at 30 DAS (26.81 cm) in $T_7$-(RDF + VAM 50% + 50% each) was found significantly superior over the rest of the treatments. Similarly, the significantly highest leaf length (36.86 cm) was recorded under treatment $T_7$-(RDF + VAM 50% + 50% each) and the lowest leaf length (31.64 cm) was recorded in $T_0$- control treatment at 60 DAT.

The data of leaf width revealed that treatment $T_7$-(RDF + VAM 50% + 50% each) shows maximum leaf width (11.38, 17.14 and 23.51 cm) at 30, 60 and 90 DAT, respectively. The remaining treatment viz., $T_1$, $T_2$, $T_3$, $T_4$, $T_5$, $T_6$, $T_8$, $T_9$, $T_{10}$ and $T_{11}$ recorded length of 22.04, 22.11, 22.45, 22.78, 22.95, 23.44, 22.77, 23.24, 20.72 and 22.30 cm, respectively at 90 Days After Transplanting (DAT). However, the width of leaf was recorded under the treatment, $T_0$ (control) showed a value of 19.01 cm which was considerably lowest as compared to the remaining treatment.

The data on the plant spreading (cm) East-West are presented in Table 2. The data revealed that significantly affected by various treatments. The maximum plant spreading (cm) East-West (17.98 cm) during 2022–23 was recorded under the treatment $T_7$-(RDF + VAM 50% + 50% each). It was followed by treatment $T_6$-(RDF + *Azospirillum* 50% + 50% each) showing the value (16.98 cm). Similarly, at 60 and 90 DAT in treatment $T_7$-(RDF + VAM 50% + 50% each) maximum plant spreading East-West per plant shows 27.98 and 46.63 cm, respectively.  More or less similar data was observed in North-South plant spreading. Improvement in growth and yield of broccoli in VAM inoculation may be due to more availability and uptake of nutrients, particularly N, P, Zn, Fe and other micronutrients, water and production of growth promoting substances as reported by Zhao and Li (1994). The maximum spread was caused by either soil fertility, growth conditions or genetic inheritance. According to Tessema *et al*. (2012), potato canopy width rose at wider spacing because of less rivalry for resources between plants as opposed to closer distance.

The maximum stem diameter per plant (2.97cm) was recorded under the treatment $T_7$-(RDF + VAM 50% + 50% each) at 30 DAT. It was followed by treatment $T_6$-(RDF + *Azospirillium* 50% + 50% each) showed a value (1.99cm). While the minimum stem diameter per plant was recorded under the treatment, $T_0$-(control) showed a value of (1.64cm) at 30 DAT. Similarly, maximum stem diameter was observed in treatment $T_7$-(RDF + VAM 50% + 50% each) at 60 and 90 DAT.

The maximum stem length per plant (18.25 cm) was recorded under the treatment $T_7$-(RDF + VAM 50% + 50% each) at 30 DAT. It was followed by treatment $T_6$-(RDF + *Azospirillium* 50% + 50% each) showed a value (17.45 cm). While the minimum stem length per plant was recorded under the treatment, $T_0$-(control) showed a value of (10.28 cm) at 30 DAT. Similarly, maximum stem length was observed in treatment $T_7$-(RDF + VAM 50% + 50% each) at 60 and 90 DAT.

**Conclusion**

Based on the present study, the treatment $T_7$ (50% Recommended Dose of Fertilizers [RDF] + 50% Vesicular-Arbuscular Mycorrhiza [VAM]) demonstrated superior performance across various growth parameters, including plant height, canopy spread, leaf length, leaf width, number of leaves, stem diameter and stem length. The second most effective treatment was $T_6$ (50% RDF + 50% Azospirillum), which also exhibited significant improvements in these parameters.

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1.

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**Table 2: Effect of various bio-fertilizers on different growth parameters of Broccoli**

| Treatment | Plant height (cm) | | | No. of leaves | | | Leaf length (cm) | | | Leaf width (cm) | | | Plant spread East – West (cm) | | | Plant spread North – South (cm) | | | Stem Diameter (cm) | | | Stem length (cm) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 30* | 60* | 90* | 30 | 60 | 90 | 30 | 60 | 90 | 30 | 60 | 90 | 30 | 60 | 90 | 30 | 60 | 90 | 30 | 60 | 90 | 30 | 60 | 90 |
| $T_0$ | 19.04 | 37.44 | 46.31 | 5.79 | 12.20 | 17.71 | 20.90 | 31.64 | 41.47 | 8.00 | 14.36 | 19.01 | 13.59 | 21.45 | 35.29 | 12.18 | 21.26 | 41.20 | 1.64 | 1.39 | 3.32 | 10.28 | 18.63 | 21.35 |
| $T_1$ | 23.49 | 42.03 | 52.24 | 6.63 | 12.68 | 19.53 | 22.92 | 34.08 | 47.29 | 9.96 | 16.64 | 22.04 | 14.55 | 25.46 | 38.76 | 14.26 | 22.06 | 44.28 | 1.75 | 2.14 | 4.04 | 12.35 | 20.16 | 22.52 |
| $T_2$ | 23.05 | 41.68 | 53.75 | 8.01 | 13.02 | 19.73 | 23.84 | 34.48 | 46.38 | 10.02 | 16.11 | 22.11 | 14.67 | 24.13 | 41.89 | 13.38 | 23.75 | 44.32 | 1.91 | 2.59 | 4.84 | 11.28 | 19.45 | 23.56 |
| $T_3$ | 23.24 | 42.42 | 53.57 | 7.15 | 12.77 | 19.77 | 24.42 | 35.05 | 47.45 | 10.22 | 16.39 | 22.45 | 15.36 | 22.88 | 39.54 | 14.21 | 23.78 | 46.21 | 1.88 | 2.55 | 3.38 | 13.75 | 20.87 | 25.81 |
| $T_4$ | 24.16 | 42.75 | 53.77 | 7.12 | 13.00 | 19.21 | 22.49 | 35.18 | 44.64 | 9.62 | 15.98 | 22.78 | 15.86 | 24.30 | 39.55 | 15.36 | 24.48 | 43.20 | 1.98 | 2.68 | 4.65 | 12.66 | 22.16 | 23.54 |
| $T_5$ | 22.38 | 39.58 | 49.46 | 6.87 | 12.59 | 19.22 | 22.01 | 34.25 | 45.52 | 9.73 | 16.43 | 22.95 | 16.85 | 26.65 | 43.96 | 14.65 | 25.17 | 41.86 | 1.96 | 2.65 | 3.24 | 15.78 | 23.20 | 23.75 |
| $T_6$ | 24.39 | 44.51 | 54.07 | 8.10 | 15.44 | 20.70 | 25.75 | 35.42 | 47.77 | 10.63 | 16.69 | 23.44 | 16.98 | 26.88 | 45.11 | 14.97 | 26.65 | 45.96 | 1.99 | 2.70 | 5.85 | 17.45 | 23.42 | 25.94 |
| $T_7$ | 24.51 | 44.52 | 55.97 | 8.25 | 16.79 | 21.72 | 26.81 | 36.86 | 48.27 | 11.38 | 17.14 | 23.51 | 17.98 | 27.98 | 46.63 | 15.98 | 27.89 | 46.32 | 2.97 | 3.54 | 6.89 | 18.25 | 24.15 | 26.53 |
| $T_8$ | 23.46 | 43.64 | 52.89 | 7.60 | 14.82 | 20.04 | 24.01 | 34.73 | 45.78 | 10.36 | 15.78 | 22.77 | 16.34 | 25.66 | 42.97 | 13.33 | 23.65 | 41.89 | 1.84 | 2.44 | 4.08 | 14.36 | 21.35 | 23.21 |
| $T_9$ | 24.35 | 43.52 | 53.18 | 7.62 | 14.58 | 19.98 | 22.98 | 34.30 | 44.81 | 10.31 | 16.47 | 23.24 | 15.41 | 21.41 | 43.88 | 14.39 | 25.44 | 44.89 | 1.92 | 3.20 | 5.34 | 13.65 | 20.59 | 23.16 |
| $T_{10}$ | 20.91 | 39.65 | 48.15 | 6.89 | 12.58 | 18.88 | 23.66 | 32.12 | 41.50 | 9.43 | 16.05 | 20.72 | 14.20 | 23.94 | 44.61 | 14.65 | 22.45 | 45.21 | 1.99 | 2.40 | 3.50 | 12.76 | 20.47 | 22.15 |
| $T_{11}$ | 21.21 | 40.84 | 48.76 | 6.67 | 12.33 | 18.82 | 21.79 | 31.84 | 42.00 | 9.31 | 15.57 | 22.30 | 13.88 | 24.96 | 42.11 | 13.17 | 24.56 | 45.48 | 1.90 | 2.78 | 4.02 | 14.54 | 21.39 | 24.46 |
| SE(m) E± | 0.88 | 1.17 | 1.21 | 0.13 | 0.19 | 0.21 | 0.76 | 0.58 | 0.53 | 0.33 | 0.30 | 0.32 | 0.15 | 0.28 | 0.54 | 0.14 | 0.26 | 0.50 | 0.03 | 0.10 | 0.04 | 0.14 | 0.25 | 0.22 |
| CD at 5% | 2.60 | 3.60 | 3.99 | 0.39 | 0.55 | 0.63 | 2.25 | 1.72 | 1.48 | 0.97 | 0.86 | 0.99 | 0.45 | 0.84 | 1.59 | 0.43 | 0.77 | 1.49 | 0.08 | 0.30 | 0.14 | 0.41 | 0.74 | 0.66 |

*: Days after transplanting

**$T_0$ -** Control **$T_1$-**RDF (100%), **$T_2$ -**Azotobacter (100%), **$T_3$ -***Azospirillum* (100%), **$T_4$ -**VAM (100%), **$T_5$ -**RDF + Azotobacter (50% + 50% Each), **$T_6$ -** RDF + *Azospirillum* (50% + 50% Each), **$T_7$ -** RDF + VAM (50% + 50% Each), **$T_8$ -** Azotobacter + *Azospirillum* (50% + 50% Each), **$T_9$ -**Azotobacter + VAM (50% + 50% Each), **$T_{10}$ -***Azospirillum* + VAM (50% + 50% Each), **$T_{11}$-** RDF + Azotobacter + *Azospirillum* + VAM (25 + 25 + 25 + 25 Each)