

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 effect of different biofertilizers on growth parameters of broccoli was carried out 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 of twelve treatments along with 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 T₇ (RDF + VAM (50% + 50% Each) as compared to T₀ (Control) treatment.

Keywords: Broccoli, India, Growth, Leaf.

Commented [NB1]: Should include the word biofertilizer

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 belongs to the family cruciferae. The United States is the largest producer of sprouting broccoli followed by India. In Italy, it has been used as vegetable from early times but their economic importance becomes appreciable only since the thirties of the century when this vegetable become popular in U.S.A. It is a winter season vegetable and commonly known as hari gobhi, In India morphologically, sprouting broccoli resembles cauliflower except secondary heads which develops in the axils of leaves and may contribute up to 50 per cent 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 obtained it the title "Crown of Jewel Nutrition." Since broccoli is also a great source of numerous vitamins and minerals, including calcium, folic acid, carotenoids, fiber, vitamin

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A and C and 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 as 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, Uttarakhand, Uttar Pradesh, Jammu and Kashmir, Nilgiri hills (Tamil Nadu) and Northern plains. Broccoli is heavy feeder and it requires large amount of nutrients like nitrogen, phosphorus and potassium for better development of curd and quality in addition to checking the various disease and physiological disorders. To increase agricultural yield, the current farming system only relies on the application of chemical pesticides, fertilizers and growth regulators. In an effort 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 nutrient. Bio-fertilizers contain microorganism which are capable of mobilizing nutritive elements from non-usable form to usable form through biological processes. These biofertilizers are organic in origin and thus are absolutely safe, organic manures and biofertilizers so as to minimize the cost of production and to maintain biological productivity of soil (Choudhary *et al.*, 2012). Hence, the present study was undertaken to evaluate the effect of various biofertilizers on 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, (A Central University), Vidya-Vihar, Rae Bari Road, Lucknow-226025 (U.P.), India by adopting Randomized Block Design (RBD) with three replications. Lucknow's geographic coordinates are 26° 50' N latitude, 80° 52' E longitude and 123 meters above mean sea level (MSL). Lucknow experiences 50–70% relative humidity and 700 mm of annual rainfall on average due to its humid subtropical climate. Summer is hot

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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 drawn 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. Raised bed about 5-6 meter 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 condition, 30 days after sowing, seedlings were ready for transplanting. These healthy seedling uniform shape and size were selected and transplanting 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. Thick slurry of each of bio-fertilizer viz. *Azotobacter*, *Azospirillum*, *Vesicular Arbusicular Mycorrhize* (VAM) and Phosphate Solubilizing Bacteria (PSB) was prepared before transplanting. Broccoli seedling was inoculated by dipping them in the slurry of these bio-fertilizers for 20 minutes. VAM was applied in soil near about the roots of seedling at the time of transplanting. The details of treatment used in 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).

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Table 1: Details of Treatment

Treatment Components	Symbol
Control	: T ₀
RDF (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

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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-1 revealed significant variations among the different treatments on 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 T₇-(RDF + VAM 50% + 50% each) followed by treatment T₆-(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 T₀- control treatment. The favorable environmental conditions that occurred during the crop's first growth may have contributed to the results. Plant height variations between cultivars are mostly caused by differences in genotype, cultivars. Similar findings have been reported by Shree *et al.* (2014) and Giri *et al.* (2013) in broccoli.

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The perusal of data indicated that number of leaves at 30 DAT influenced significantly by application of different bio-fertilizer treatments. The significantly maximum number of leaf (8.25) was recorded under treatment T₇-(RDF + VAM 50% + 50% each) and minimum number of leaf (5.79) observed in T₀- 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 in line with Kaur and Sharma (2018) who reported that increase in number of leaves could be due to beneficial effect of VAM which promotes the meristemic activity and hence, increase the number of tissues and organs (leaves).

The data pertaining in Table.2 revealed that significant effect of different bio-fertilizer on leaf length of broccoli. The significantly highest leaf length (26.81 cm) was recorded under treatment T₇-(RDF + VAM 50% + 50% each) and lowest leaf length (17.02 cm) recorded in T₀- control treatment. Leaf length at 30 DAS (26.81 cm) in T₇-(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 T₇-(RDF + VAM 50% + 50% each) and lowest leaf length (31.64 cm) recorded in T₀- control treatment at 60 DAT.

The data of leaf width revealed that treatment T₇-(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., T₁, T₂, T₃, T₄, T₅, T₆, T₈, T₉, T₁₀ and T₁₁ 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, T₀ (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 T₇-(RDF + VAM 50% + 50% each). It was followed by treatment T₆-(RDF + *Azospirillum* 50% + 50% each) showing the value (16.98 cm). Similarly, at 60 and 90 DAT in treatment T₇-(RDF + VAM 50% + 50% each) maximum plant spreading East-West per plant shows 27.98 and 46.63 cm, respectively. The remaining treatment viz., T₁, T₂, T₃, T₄, T₅, T₆, T₈, T₉, T₁₀ and T₁₁ recorded length of 44.28, 44.32, 46.21, 43.20, 41.86, 45.96, 41.89, 44.89, 45.21 and 45.48 cm, respectively at 90 Days After Transplanting (DAT). 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 less rivalry for resources between plants as opposed to closer distance.

The maximum stem diameter per plant (2.97cm) was recorded under the treatment T₇-(RDF + VAM 50% + 50% each) at 30 DAT. It was followed by treatment T₆-(RDF + *Azospirillum* 50% + 50% each) showed a value (1.99cm). While the minimum stem diameter per plant was recorded under the treatment, T₀-(control) showed a value of (1.64cm) at 30 DAT. Similarly, maximum stem diameter was observed in treatment T₇-(RDF + VAM 50% + 50% each) at 60 and 90 DAT.

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The maximum stem length per plant (18.25 cm) was recorded under the treatment T₇-(RDF + VAM 50% + 50% each) at 30 DAT. It was followed by treatment T₆-(RDF + *Azospirillum* 50% + 50% each) showed a value (17.45 cm). While the minimum stem length per plant was recorded under the treatment, T₀-(control) showed a value of (10.28 cm) at 30 DAT. Similarly, maximum stem length was observed in treatment T₇-(RDF + VAM 50% + 50% each) at 60 and 90 DAT.

Conclusion

On the basis of the present experimentation, it was concluding that the treatment T₇-(RDF 50%+ VAM 50%) was found superior in terms of different growth parameter such as height of plant, canopy spread, length of leaves, width of leaves, number of leaves, diameter of stem and stem length. The next better treatment was T₆-(RDF + *Azospirillum* 50% + 50% each).

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Table 2: Effect of various bio-fertilizer 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

T₀ - Control T₁-RDF (100%), T₂-Azotobacter (100%), T₃-Azospirillum (100%), T₄-VAM (100%), T₅ -RDF + Azotobacter (50% + 50% Each), T₆- RDF + Azospirillum (50% + 50% Each), T₇- RDF + VAM (50% + 50% Each), T₈- Azotobacter + Azospirillum (50% + 50% Each), T₉-Azotobacter + VAM (50% + 50% Each), T₁₀-Azospirillum + VAM (50% + 50% Each), T₁₁- RDF + Azotobacter + Azospirillum + VAM (25 + 25 + 25 + 25 Each)

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