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**Influence of bio-fertilizer (*Rhizobium radiobacter*) in
association with organic manures on Growth and Yield
of broccoli (*Brassica oleracea* L. var. *italica* Plenck) cv.
Palam Samridhi under Lucknow conditions**

**Mahendra Kumar Atal, Deepa H Dwivedi, SL Narolia, Navaldehy Bharty
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Abstract

The field experiment was conducted at Horticultural Research Farm of the Department of Applied Plant Science (Horticulture), Babasaheb Bhimrao Ambedkar University (A Central University), Vidya-Vihar, Rai-Bareilly Road, Lucknow (U.P.) – 226025, India during Rabi season of 2016-17. The experiment comprised of 8 treatments replicated three times in a Randomized Block Design. The plant height was found maximum (64.07 cm) recorded in treatment T₆. At harvest stage maximum number of leaves (20.16 cm), Length of leaves (47.73cm), Leaves width (23.46 cm), Stem diameter (3.20 cm), Plant spread (59.91 cm), Curd diameter (13.46 cm) Weight of curd (355 g), Total number of secondary curds (10.08) Weight of curds (3.19 kg/plot), Curd yield (175.49 q/ha), Fresh weight of plant (1132.66 g), Dry weight of plant (0.203 g), Fresh weight of root (82 g) Dry weight of root (0.021 g), Root length (17.80 cm), Root spread (24.7 cm), was maximum recorded under T₇ (Biofertilizer + Vermicompost) treatment. It is recommended for higher production of sprouting broccoli was under Lucknow conditions.

Keywords: Broccoli, growth, yield, bio-fertilizer, FYM, vermi-compost, and NPK

Introduction

Cruciferous vegetables are large and increasingly important vegetables. Broccoli (*Brassica oleracea* L. var. *italica* Plenck) a member of Brassicaceae (Cruciferae) family originated from the Mediterranean region (Thamburaj and Singh, 2001) ^[17] having basic chromosome number $x=9$ ($2n=18$). It is also known as multiple harvesting crops which is used as culinary purpose, pickles and also in the form of salad. It is one of the most nutritious cole crops and contains vitamin A (130 times and 22 times higher than cauliflower and cabbage, respectively), thiamin, riboflavin, niacin, vitamin C and minerals like Ca, P, K and Fe. Sprouting broccoli (*Brassica oleracea* var. *italica* L. Plenck) is one of the most nutritious vegetable amongst the cole crops grown for its tender curds. United States of America (USA) is the largest producer of Sprouting broccoli in the world. It is a new crop in India and its cultivation is negligible but now it is becoming increasingly popular in hotels in Mumbai, Calcutta, Delhi and Chennai. It is a winter season rare vegetable in India, commonly known as *Harigobhi*. Broccoli contains phytochemicals which help create immune and antioxidant support in the body by inducing enzymes that are involved in detoxifying carcinogens to flush them out of the body. These important enzymes include quinone reductase and glutathione S-transferase, with sulphoraphane (Shiwani *et al.*, 2016) as the major and potent enzyme. Organic and inorganic sources of fertilizer play an important role in increasing agriculture production and the standardization of the organic farming practices and availability of required nutrients and plant protection measure is becoming important. Biofertilizer are natural fertilizer containing carrier based microorganisms which help to enhance productivity by biological nitrogen fixation or solubilization of insoluble phosphate or producing hormones, vitamins, and other growth factors required for plant growth.

Use of organic manures to meet the nutrient requirement of crops would be an inevitable practice in the years to come for sustainable agriculture. Although the organic manures contain major nutrients in small quantities as compared to the chemical fertilizers, but the presence of organic carbon and growth promoting principles like enzymes and hormones, make them a preferential choice for improvement of soil fertility and productivity (Bhuma, 2001) [2]. Farmyard Manure (FYM) refers to the decomposed mixture of dung and urine of the farm animals along with litter and left over material from roughages or fodder fed to the cattle. On an average well decomposed farmyard manure contains 0.5 per cent N, 0.2 per cent P₂O₅ and 0.5 percent K₂O. Vermicompost has a higher level of available nutrients like nitrate or ammonium nitrogen, exchangeable phosphorous and soluble potassium, calcium and magnesium derived from the wastes (Buchanan *et al.*, 1988) [3].

Materials and Methods

The detail of material used and methodology followed during present investigation entitled “Influence of bio-fertilizer (*Rhizobium radiobacter*) in association with organic manures on performance of broccoli (*Brassica oleracea* L. var. *italica* Plenck) cv. Palam Samridhi under Lucknow conditions” was carried out at the Horticulture Research Farm-I of Department of Applied Plant Science (Horticulture), Babasaheb Bhimrao Ambedkar University, Vidya Vihar, Rae Bareilly Road, Lucknow (U.P.), India. The location of the farm is situated in the main campus of the University. The field experiment was conducted at Rabi season of 2016-17. The seed of broccoli collected from Dr. Yashwant Singh Parmer University of Horticulture and Forestry, Sloan (H.P.). Broccoli seeds Palam Samridhi were sown in the nursery beds of Horticulture Research Farm-I, BBAU, Lucknow, by sowing in row method on 7 October 2016. Raised bed about 5-6 meter long, one meter width and 15 cm above ground level, was prepared. A thin layer of powdered leaf mould was applied to cover the seeds. Regular watering, hoeing, weeding, plant protection measures etc. were done time to time. The seedlings were ready for transplanting within five-six weeks. The NPK done by RDF method (100:60:60) and organic manures viz. Farm Yard Manure (FYM) @ 20t/ha, Vermicompost @ 8t/ha were applied before transplanting as per the treatment and mixed thoroughly in the soil. Biofertilizer (*Rhizobium radiobacter*) was obtained from the Department of Environmental microbiology, Babasaheb Bhimrao Ambedkar University, Lucknow. Before transplanting the seedlings were treated with bio-fertilizer (*Rhizobium radiobacter*) for 30 minutes by dipping the roots of seedlings in the solution culture. The full dose of FYM & vermicompost should be applied in the soil before the transplanting. The distance between row to row and plant to plant was kept as 45 × 30 cm, respectively. Thus, nine plants were accommodated in each plot. The experiment was laid out in Randomized Block Design (RBD) with three replication and experiment comprised of 8 treatment combinations. The growth parameters (plant height (cm), number of leaves, length of leaves (cm), width of leaves (cm), stem diameter (mm), plant spread (cm), curd diameter (cm),

width of curd (cm), total no secondary curds, root length of root (cm) and root spread (cm)), yield parameters (head weight, yield per plot and yield per hectare). The statistical analysis of the data was carried out as per the method described by Cochran and Cox, 1963. The treatment effect was tested at 5% level of significance. The data obtained from selected plants were subjected to analysis of variance.

Result and Discussion

Growth attributes

The results obtained during the investigation in respect to bio-fertilizers and organic manures on vegetative growth parameters and Various treatment showed significant variations in growth attributes viz., plant height, number of leaves per plant, leaf length, leaf width, stem diameter, plant spread, days to head initiation, yield per plot and yield per hectare. The data on plant height and number of leaves per plant recorded at different intervals (30, 45, 60, 75 DAT and at harvesting time) revealed that these parameters in general progressively increased with the increase in age of crop till maturity

Plant height

Data recorded in respect of plant height of plant show that the effect of organic manure and bio-fertilizer, on plant height was significantly at all stages of plant growth. The maximum plant height at 30, 45, 60, 75 DAT and at harvesting time was (24.20 cm, 39.35 cm, 57.55 cm, 63.84 cm and 64.07 cm) respectively, observed in the treatment T₆ (Biofertilizer 50% + Farmyard Manures 50%) and the minimum plant height noted at 30, 45, 60, 75 and at harvesting time (13.08 cm, 25.13 cm, 35.52 cm, 41.90 cm and 43.68 cm, respectively) under T₁ (Control). The different treatment combinations showed significant variation with respect to plant height. In the present investigation, maximum plant height at maturity was recorded in treatment T₆ (Farmyard manure + Biofertilizers). This may be attributed to better water holding capacity, supply of micro-nutrient and availability of major nutrients due to favourable soil conditions offered by the farmyard manure. Chaudhary *et al.*, (2012) [5]. The present findings are in line with the results of Chatterjee *et al.*, (2005) [12] in broccoli. The present findings are in line with those of Sharma (2008) [15] in broccoli and Magd *et al.*, (2006) [11] in broccoli.

Stem Diameter

Regarding the stem diameter was also recorded under different treatment, Table 1 indicates that the increasing stem diameter maximum data was recorded in T₇ (1.40 cm), followed by T₈ (1.32 cm) and T₁ (0.96 cm) at 30 days after transplanting. At 60 days after transplanting maximum stem diameter was also recorded in T₇ (1.82 cm) followed by T₈ (1.67 cm) and T₁ (1.42 cm). Similarly, at harvesting stage the maximum stem diameter is observed in T₇ (3.20 cm) followed by T₈ (3.07 cm) and minimum stem diameter was recorded in T₁ (2.62 cm). Similar results due to effect of organic manure and bio-fertilizer were recorded by Ghulam *et al.*, 2012 [7] and Kshum *et al.*, (2017).

Table 1: Influence of bio-fertilizer (*Rhizobium radiobacter*) in association with organic manures on growth and yield traits of broccoli.

Treatments	Treatment combinations	Plant height (cm)					Stem diameter (cm)				
		30 DAT	45 DAT	60 DAT	75 DAT	At harvest	30 DAT	45 DAT	60 DAT	75 DAT	At harvest
T ₁	Control	13.08	25.13	35.52	41.90	43.68	0.96	1.42	2.01	2.47	2.62
T ₂	Bio. (<i>Rhiz.</i>)	15.62	26.66	40.39	45.87	46.96	1.05	1.57	2.09	2.57	2.78
T ₃	NPK	21.75	34.38	48.47	55.20	55.82	1.21	1.52	2.30	2.64	2.80

T ₄	FY M	14.80	27.57	37.48	44.58	45.78	1.17	1.48	2.21	2.55	2.74
T ₅	Vermi.	14.44	25.48	36.35	43.70	45.20	1.10	1.46	2.12	2.47	2.78
T ₆	Bio. + FYM	24.20	39.35	57.550	63.84	64.07	1.32	1.67	2.48	2.90	3.07
T ₇	Bio + Vermi	23.59	37.62	56.40	62.54	63.28	1.40	1.82	2.59	3.00	3.20
T ₈	Bio.+ NPK	21.14	35.72	49.29	51.20	52.77	1.26	1.74	2.40	2.82	3.00
S.Em±		0.99	0.81	1.32	0.64	0.48	0.04	0.05	0.06	0.07	0.08
CD(P=0.05)		2.14	1.76	2.87	1.40	1.05	0.12	0.15	0.18	0.21	0.24

Length of leaves

Regarding the leaf length (cm), It was observed that the effect of different treatment of organic manure and bio fertilizer. Table 2 indicated that at 30 days the maximum leaf length was recorded in T₇ (21.57 cm) followed by T₆ (20.80 cm) and minimum leaf length was T₁ (9.70 cm). At 60 DAT maximum length of leaves (46.62 cm) was recorded under treatment T₇ Followed by T₆ (39.56 cm) and minimum (26.55 cm) observation was recorded under T₁. At harvesting stage maximum length was T₇ (47.73 cm) followed by T₈ (42.72 cm) and minimum length of leaves T₁ (34.16 cm). These results are in agreement with the findings of Maurya *et al.*, 2008.

Width of leaves

Leaf width was influenced by the application of organic manure and bio fertilizer under different treatments, Table 2 indicates that at 30 days after transplanting the pattern of increasing maximum width of leaves T₇ (9.96 cm) treatment, followed by T₆ (9.47 cm) and T₁ (5.05 cm). At 60 days after the maximum width recorded in T₇ (17.42 cm) followed by T₆ (16.25 cm) and minimum width was recorded in T₁ (11.95 cm) treatment. At harvest stage the maximum number of leaves is observed in T₇ (23.46 cm) followed by T₆ (22.30 cm) and minimum number of leaves was recorded in T₁ (16.98 cm).

Table 2: Influence of bio-fertilizer (*Rhizobium radiobacter*) in association with organic manures on growth and yield traits of broccoli.

Treatments	Treatment combinations	Length of leaves (cm)					Width of leaves (cm)				
		30 DAT	45 DAT	60 DAT	75 DAT	At harvest	30 DAT	45 DAT	60 DAT	75 DAT	At harvest
T ₁	Control	9.70	19.13	26.55	32.94	34.16	5.05	9.05	11.95	13.69	16.98
T ₂	Bio (<i>Rhiz.</i>)	11.53	21.52	28.97	35.36	36.23	6.67	12.23	13.81	15.85	18.33
T ₃	NPK(RDF)	13.22	23.96	34.30	41.30	42.41	8.16	12.78	15.08	17.10	19.86
T ₄	FYM	14.30	28.39	31.79	34.85	35.67	7.88	10.82	16.01	18.26	19.92
T ₅	Vermi.	15.73	29.63	31.10	35.09	36.08	6.39	11.22	15.23	18.28	21.12
T ₆	Bio.+ FYM	20.80	35.50	39.56	41.44	42.71	9.47	13.10	16.25	18.64	22.30
T ₇	Bio+Vermi	21.57	37.46	46.62	46.87	47.73	9.96	14.94	17.42	20.61	23.46
T ₈	Bio.+ NPK	12.04	22.38	32.49	41.10	42.72	9.04	11.84	14.28	16.16	19.16
S.Em±		0.82	0.90	0.44	0.88	0.79	0.50	0.41	0.40	0.44	0.32
CD(P=0.05)		1.78	1.94	0.94	1.92	1.72	1.08	0.88	0.86	0.96	0.71

Number of leaves

Regarding the number of leaves, it was observed that the effect of different treatment of organic manure and biofertilizer. Table 3 indicated that the maximum numbers of leaves was recorded in T₇ (7.24), followed by T₈ (7.01), T₆ (6.62) and T₁ (6.14cm) at 30 days after transplanting. At 60 days after transplanting maximum number of leaves was also recorded in T₇ (16.39) followed by T₃ (14.58), T₈ (13.96) and T₁ (11.40). At harvesting time the maximum number of leaves was observed in T₇ (20.16) followed by T₆ (19.25) and minimum number of leaves was recorded in T₁ (16.83). Chumyani *et al.*, (2012) [6] conducted experiment on integrated nutrient management and found that 50% NPK +

50% FYM + Biofertilizers recorded maximum plant height, number of leaves and number of branches in tomato.

Plant spread

Leaf width was influenced by the application of organic manure and biofertilizer under different treatments, Table 3 indicates that the data at 30 days was after transplanting maximum plant spread in T₇ (25.97 cm) followed by T₆ (23.51 cm) and T₁ (13.08 cm). At 60 days after maximum plant spread in T₇ (51.75 cm) followed by T₆ (45.13 cm) and T₁ (31.13 cm). At harvest stage the maximum plant spread was recorded in T₇ (59.91 cm) followed by T₆ (50.41 cm) and minimum plant spread was recorded in T₁ (44.66 cm).

Table 3: Influence of bio-fertilizer (*Rhizobium radiobacter*) in association with organic manures on growth and yield traits of broccoli.

Treatments	Treatment combinations	No of leaves					Plant spread (cm)				
		30 DAT	45 DAT	60 DAT	75 DAT	At harvest	30 DAT	45 DAT	60 DAT	75 DAT	At harvest
T ₁	Control	4.86	7.52	11.40	15.00	16.83	16.46	25.41	31.13	42.48	44.66
T ₂	Bio (<i>Rhizo</i>)	5.03	8.27	12.31	16.91	18.08	19.17	27.75	34.10	45.17	46.15
T ₃	NPK (RDF)	5.98	9.50	14.58	17.30	18.66	20.56	32.48	39.75	47.56	49.30
T ₄	FYM	5.23	8.86	12.79	17.76	18.33	18.53	24.94	32.45	44.37	46.18
T ₅	Vermi.	5.66	9.41	13.93	16.89	17.99	20.59	26.92	37.29	45.50	47.02
T ₆	Bio + FYM	6.62	10.50	14.91	18.23	19.25	23.51	34.75	45.33	49.25	50.41
T ₇	Bio +Vermi	7.24	11.45	16.39	19.25	20.16	25.97	36.77	51.75	57.16	59.91
T ₈	Bio +NPK	7.01	9.88	13.96	16.50	17.33	23.10	32.40	39.52	47.24	50.05
S.Em±		0.43	0.64	0.40	0.68	0.44	1.29	1.03	1.17	1.25	1.19
CD(P=0.05)		0.94	1.38	0.86	1.48	0.97	2.79	2.23	2.54	2.70	2.59

Yield and yield attributing traits**Weight of curd (g)**

Weight of curd was influenced by the application of organic manure and biofertilizer under different treatments, Table 4 indicates that the curd weight (355 g) observed maximum in Treatment T₇ was significantly superior over all treatment and as well as on the control, Minimum net weight of the curd (188.33 g) was observed under the control treatment T₁. The present findings are in line with those of Bhardwaj *et al.*, (2007) [1] in broccoli.

Curd diameter (cm)

Table 4 indicates that the curd diameter was influenced by the application of organic manure and biofertilizer under different treatments, Table 4 indicates that the data curd diameter was recorded maximum (13.46 cm) under treatment T₇ followed by T₆ (13.08 cm) and (8.73 cm) curd diameter was minimum recorded in the treatment T₁ (control). Kanwar *et al.*, (2002) [8] reported significant increase in curd weight, curd diameter, plant height and curd yield of cauliflower with application of 50% NPK + organic manure.

Total number of secondary curds

Table 4 indicates that the maximum total number of secondary curds (10.08) was recorded under T₇ (Biofertilizer

+ Vermicompost) treatment followed by T₆ Biofertilizer + Farmyard Manure) (9.58) and minimum total no of secondary curds (6.33) was recorded under the treatment T₁ (control).

Weight of curd per plot (kg)

Table 4 indicates that the maximum curd weight per/kg was recorded (3.19 kg) in treatment T₇. It was significantly superior over all treatment and as well as on the control while minimum of the curd weight (1.69 kg) per plot was observed under treatment T₁.

Yield (q/ha)

Table 4 indicates that the maximum curd yield/ha was recorded (175.49 q/ha) in treatment T₇. It was significantly superior over all treatment and as well as on the control and minimum net weight of the curd (85.66 q/ha) was observed under treatment T₁. Singh and Singh (2004) [16] in cauliflower. Sharma *et al.* (2008) [15] in sprouting broccoli. Padamwar and Dakore (2009) [13] conducted field trial on cauliflower and applied organic manures (farmyard manure, vermicompost and biofertilizers) to observe their effect on growth, yield and nutritional value. Application of vermicompost was found to be most beneficial in increasing the yield and quality of cauliflower.

Table 4: Influence of bio-fertilizer (*Rhizobium radiobacter*) in association with organic manures on growth and yield traits of broccoli.

Treatments	Treatment combinations	Weight of Curd (gm)	Diameter of curd (cm)	Total no of secondary curds	Yield per plot (kg)	Yield per hectare (q.)
T ₁	Control	188.33	8.73	6.33	1.69	85.66
T ₂	Bio. (<i>Rhizobium</i>)	218.33	11.50	8.33	1.96	108.68
T ₃	NPK (RDF)	241.66	12.13	8.75	2.16	120.42
T ₄	Farmyard Manure	209.00	10.83	8.08	1.88	103.34
T ₅	Vermicompost	207.66	10.23	7.50	1.86	101.56
T ₆	(Bio + FYM)	328.33	13.08	9.58	2.95	160.97
T ₇	(Bio +Vermicompost)	355.00	13.46	10.08	3.19	175.49
T ₈	(Bio + NPK)	255.00	11.66	8.58	2.02	112.70
S.Em±		10.47	0.20	0.26	0.02	1.57
CD(P=0.05)		22.68	0.43	0.57	0.06	3.42

Fresh weight of plant (g)

In Table 5 that the maximum fresh weight of plant was (1132.66 g) under treatment T₇ followed by (940 g) under treatment T₇ and the minimum observation (264 g) curd weight was recorded under treatment T₁ (control).

Dry weight of plant (g)

The dry weight of plant takes just after plants are drying. In Table 5 that the maximum dry weight of plant (0.203 g) under treatment T₇ followed by (0.181 g) under treatment T₆ and the minimum observation (0.90 g) curd weight was recorded under treatment T₁ (control).

Fresh weight of root (g)

The fresh weight of root takes at harvesting time and left the roots for drying. In Table 5 that the fresh weight of root was maximum (82 g) under treatment T₇ followed by (73 g) under treatment T₆ and the minimum observation (27 g) curd weight was recorded under treatment T₁ (control).

Dry weight of root (g)

The dry weight of root takes just after drying of roots. In Table 5 that the dry weight of root was maximum (0.021 g) under treatment T₇ followed by (0.020 g) under treatment T₆ and the minimum observation (0.008 g) curd weight was recorded under treatment T₁ (control).

Root length (cm)

The root spread take at harvesting time and left the roots for drying The root length take at the time of harvesting In Table 5 that the root length was maximum (17.80 cm) under treatment T₇ followed by (15.10 cm) under treatment T₆ and the minimum observation (11.80 cm) curd weight was recorded under treatment T₁ (control).

Root spread (cm)

The root spread take at harvesting time. In Table 5 that the maximum root spread was (24.7 cm) under treatment T₇ followed by (21.16 cm) under treatment T₆ and the minimum observation (15.86 cm) was recorded under treatment T₁ (control).

Table 5: Influence of bio-fertilizer (*Rhizobium radiobacter*) in association with organic manures on growth and yield traits of broccoli.

Treatments	Treatment combinations	Fresh weight of plant (g)	Dry weight of plant (g)	Fresh weight of roots (g)	Dry weight of roots (g)	Root spread (cm)
T ₁	Control	264.33	0.09	27.66	0.008	15.86
T ₂	Bio. (<i>Rhizobium</i>)	587.66	0.12	44.66	0.012	17.80
T ₃	NPK (RDF)	708.33	0.16	65.66	0.019	19.93
T ₄	Farmyard Manure	552.00	0.12	32.33	0.010	17.06
T ₅	Vermicompost	489.66	0.10	30.00	0.010	16.80
T ₆	(Bio + FYM)	940.00	0.18	73.66	0.020	21.16
T ₇	(Bio + Vermicompost)	1132.66	0.20	82.00	0.021	24.70
T ₈	(Bio + NPK)	660.66	0.14	51.00	0.017	19.26
S.Em±		45.73	0.01	2.34	0.001	0.43
CD(P=0.05)		99.04	0.02	5.07	0.003	0.95

Conclusion

On the basis of present investigation it can be concluded that the application of T₇ (Biofertilizer 50% + Vermicompost 50%) followed by T₆ in (Biofertilizer 50% + Farm yard manures 50%) proved best for higher curd yield. It is recommended for higher production of broccoli in Lucknow condition.

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