Journal of Crop and Weed, 14(2): 72-76 (2018)

Efficiency of bio-organic nutrition on vegetative growth, yield and quality of Broccoli (*Brassica oleracea* L. var. *italica* Plenck)

R. RAWAT AND S. MAJI

Department of Horticulture, Babasaheb Bhimrao Ambedkar University
Vidya- Vihar, Rae Bareli Road, Lucknow-226025, Uttar Pradesh

Received : 18-09-2017 ; Revised : 26-03-2018 ; Accepted : 10-05-2018

ABSTRACT

The present experiment was conducted during rabi season of 2015-16 with an aim to study the effect of biofertilizers and organic nutrition on broccoli production. The experimental site has annual rainfall of 750 mm, 60-90 per cent relative humidity with high pH soil (pH 8.2). The experiment was carried out in a Randomized Block Design with ten treatments (control, Recommended dose of fertilizer, Rhizobium, Azotobacter, Azosprillium, PSB, VAM, FYM, Vermicompost and Farm compost) by three replication. Observations were recorded for growth parameters like plant height, stem circumference, plant spreading, number of leaves, length and width of leaves, yield (kg plot^{-1} and q ha^{-1}), quality parameters viz., curd weight, curd diameter, Vitamin C, T.S.S., Total sugars, Reducing sugar, Non-reducing sugar, Titratable acidity etc. The experimental result revealed that the use of biofertilizers improved the production of broccoli in general as compared to untreated control. Among the treatments, application of Azospirillum can be suggested to broccoli growers for obtaining better growth, yield and quality improvement of broccoli cv. KTS-1 under Lucknow subtropical condition.

Keywords **:** Biofertilizers, broccoli, organics, quality, yield

Broccoli (*Brassica oleracea* var. *italica* Planck) of *Brassicaceae* (*Cruciferae*) family is a *rabi* season cole crop. Apart from other nutritional antioxidants, broccoli is a significant source of calcium, folic acid, carotenoids, ascorbic acid and known to reduce risk of breast and prostate cancer (Beecher, 1994). Thus, importance of broccoli production is increasing day by day. Farmers are repeatedly using chemical fertilizers to obtain maximum yield in broccoli, which is creating problems of soil deterioration, affecting soil flora and fauna and ultimately affecting yield and quality of broccoli. There is a growing concern throughout the world on adverse effect of indiscriminate use of inorganic fertilizer, pesticide, herbicide *etc*. to the environment and human health. Therefore, a combination strategy of using judicious chemical fertilizer, organic manures and bio-fertilizers may be helpful in increasing production with less hazard. Such efforts will be effective not only in supplementing a part of chemical fertilizers requirement of the crops and yield, but also influence quality attributes in several vegetables, besides minimum use of inorganic fertilizers.

There are abundant microorganisms living in soil, especially in the rhizosphere of plants. It is well known that a considerable number of bacterial and fungal species possess a functional relationship and constitute a holistic system with plants having beneficial effects on plant growth (Vessey, 2003). Bio-fertilizers are natural fertilizer containing carrier based beneficial microorganisms which help to enhance productivity by biological nitrogen fixation or solubilization of insoluble phosphate or producing growth hormones, vitamins and other growth factors required for plant and thus, help to reduce the application of chemical fertilizers. Among these bio-fertilizers, Rhizobium is an aerobic and heterotrophic bacteria that induces nodule formation on the roots of their host plants and symbiotically fixes atmospheric nitrogen and can increase the yield by 25-30 per cent in succeeding crop (Sunda, 2011). Azotobacter fix atmospheric nitrogen under free living condition and promote plant growth activities like phosphate solubilization, production of plant growth hormones like auxins, gibberellins, cytokines, vitamins and amino acids (Kloepper and Schroth, 1978). Azospirillum a free-living, nitrogen-fixing bacteria, secretes phytohormones (auxins, gibberellins, cytokinins, and nitric oxide) as signals of plant growth promotion (Cecagno *et al*., 2015). Phosphate solubilizing bacteria (PSB) biofertilizer are life forms that can help in improving the phosphate uptake of plants in various ways. PSB also has the potential to enable the utilization of India's abundant rock phosphate deposits, much of which is not enriched (Ghosh, 2004). Vesicular Arbuscular Mycorrhizae (VAM) are symbiotic soil fungi which colonize the roots of approximately 80 per cent of plant families. They impart to their hosts a variety of benefits like increased growth and yield due to enhanced nutrient acquisition, water relations, pH tolerance and

Email: majisutanu@gmail.com

disease and pest resistance. The most common beneficial effect of mycorrhizae is increased uptake of immobile nutrients, notably P, from soil. Vermicompost is another kind of organic source of nutrients has been found to effectively enhance the root formation, elongation of stem (Edwards, 1988). Farm Yard Manure (FYM) and farm compost promote soil microbes that aid plant growth. Now a day the people are more concerning the hazards of indiscriminate use of chemical inputs (fertilizers and pesticides *etc*.) and are more attracted to the organically produced products as well as the organic and bio-fertilizers is good for crop and soil also (Ray *et al*., 2017 and Sau *et al*., 2017). With the available resources different kinds of bio-fertilizers and organic manures are taken in the present study. Thus, keeping these views the present experiment was conducted with an aim to produce good quality broccoli by application of different bio- fertilizer doses and organic manuring at high pH soil of Lucknow.

MATERIALS AND METHODS

The field experiment was conducted at Department of Horticulture, Babasaheb Bhimrao Ambedkar University (A Central University), Vidya-Vihar, Rai-Bareli Road, Lucknow - 226025 (U.P.), India during *Rabi* season of 2015-16. Experimental site is under subtropical agro-climatic zone, having 25.7ºC to 44.3ºC temperature during summer and 1.5ºC to 18.9ºC during winter and has annual rainfall of 896.2mm and 60-90 per cent relative humidity. The soil of experimental field had high pH of 8.2. Seeds of broccoli cv. Pusa KTS-1 were sown on nursery beds after treated with thiram and bavistin mixed in 2:1 ratio @ 3.0 g kg^{-1} of seeds. Seeds were sown on 29th October 2015 and the soil of seed bed was covered with organic mulching (grass) to protect the young seedlings from adverse climatic condition and keep soil moist. Covering materials were removed from the bed after seed germination (5 days after sowing) for optimum growth of seedlings. 30 days old healthy seedlings with uniform growth were transplanted on 25th November 2015 at a spacing of 45 x 35 cm accommodating 9 plants $plot^{-1}$ (1.35 × 1.05 m^2 plot size). The observations on plant height, stem circumference, plant spreading, number of leaves, length of leaves, width of leaves were taken as vegetative growth parameter. Yield parameters *viz*., weight of curd with and without guard leaf, yield (kg $plot^{-1}$) and (q ha^{-1}), quality parameters *viz*., curd diameter, vitamin – C, T.S.S. (Total soluble solids) (0Brix), Total sugars (%), Reducing sugars (%), Non-reducing sugars (%), Titratable Acidity (%) were estimated in the departmental laboratory, following the standard method (AOAC, 2000). The experiment was laid out in Randomized Block Design with ten treatments and three replications. The treatments were T_0- Control, T_1- Rcommeneded dose of fertilizers (RDF), T_2– Rhizobium, T_3- *Azotobacter*, T_4- *Azosprillium*, T_5– PSB, T_6– VAM, T_7- FYM, T_8– Vermicompost and T_9– Farm compost. Application of biofertilizer *viz*., *Rhizobium, Azotobacter, Azospirillum* and PSB inoculants @ 10 g $litre^{-1}$ of water were mixed and required quantity of solution was prepared. The roots of uprooted broccoli seedlings were dipped in this solution for (at least) 20 minutes before transplantation. VAM inoculants @10 kg ha^{-1} was applied in soil near to the root zone of seedling at the time of transplanting. For inoculating seedlings of sprouting broccoli, 10% solution of Jaggery in pre-boiled but cool water was made with biofertilizers (as per the treatment) to dip the roots of seedling. Fertilizers were also applied one day prior to sowing as per treatment i.e. at the rate of 150 Kg N, 60 Kg P_2O_5, 60 kg K_2O $hectare^{-1}$ applied only at treatment T_1. Different organic manures *viz*. FYM @ 20 t ha^{-1}, Vermicompost and Farm compost @ 8t ha^{-1} were applied before transplanting as per the treatment and mixed thoroughly in the soil. The recorded data on vegetative growth, yield and curd quality parameters were statistically analyzed using ANOVA at 5% level of significance following the standard method as suggested by Sahu and Das (2014).

RESULTS AND DISCUSSION

Experimental results presented in the table 1 clearly showed that at 30 and 60 days after transplanting (DAT) plant height was maximum (27.76 and 45.50 cm, respectively) under the treatment T_4 (Application of *Azospirillum*) followed by T_1 *i.e*. Recommended dose of fertilizers (RDF) but were statistically very close to each other. However, the treatment effects due to T_4, T_1, T_3 and T_6 were statistically at par for increase in plant height at 60 DAT. The minimum plant height of 20.38 and 37.26 cm was noted at 30 and 60 DAT, respectively under the treatment T_0 (control). Amirthalingam (1988) also studied the effect of *Azospirillum* and noticed that inoculation of *Azospirillum* to seed, soil and seedling increased the plant height of chilli. Gupta and Samnotra (2004) also reported that application of *Azospirillum* resulted in the highest plant height (25.08 cm) in Golden Acre cabbage. The stem diameter was measured maximum (2.16 cm) at 30 DAT under T_1 (RDF), while T_4 (*Azospirillum*) caused maximum stem diameter (4.16 cm) followed by T_1 at 60 DAT.

Plant canopy spreading was measured at both directions *i.e*. East-West and North –South directions at 30 and 60 DAT. It was seen that plant treated with *Azospirillum* (T_4) recorded maximum canopy spreading (32.68 cm in East-West, 37.34 cm North-South direction at 30 DAT and 45.23 cm in East-West, 48.28 cm North-

Table 1: Effects of bio-organic nutrition on vegetative growth of broccoli

Treatments	Plant height (cm)		Stem diam. (cm)		No. of leaves plant^{-1}		Plant spreading (cm)			
							30 DAT		60 DAT	
	30 DAT	60 DAT	30 DAT	60 DAT	30 DAT	60 DAT	East-West	North-South	East-West	North-South
T_0	20.38	37.26	1.23	2.17	7.11	12.22	25.67	30.23	36.67	41.56
T_1	27.53	45.14	2.16	4.04	8.44	17.33	31.80	33.45	44.45	47.89
T_2	21.72	38.48	1.55	2.37	6.67	13.33	31.65	32.45	41.45	44.23
T_3	25.22	44.31	1.19	2.51	7.11	13.67	30.23	35.57	40.35	47.35
T_4	27.76	45.50	1.89	4.16	8.78	17.89	32.68	37.34	45.23	48.28
T_5	22.12	39.31	1.86	3.68	7.44	13.33	31.34	33.67	44.00	46.38
T_6	26.53	42.62	1.29	3.58	7.33	12.67	31.67	34.56	42.78	47.68
T_7	24.42	40.51	1.18	2.96	5.78	12.11	28.68	34.23	38.23	46.56
T_8	22.69	39.87	1.50	2.46	7.00	13.11	29.34	31.24	37.67	43.45
T_9	24.78	39.49	1.36	2.45	7.44	14.11	28.46	32.45	38.23	43.80
SEm (±)	**0.92**	**1.35**	**0.13**	**0.20**	**0.56**	**0.82**	**1.17**	**1.12**	**1.27**	**0.77**
LSD (0.05)	**2.78**	**4.06**	**0.39**	**0.62**	**1.65**	**2.45**	**3.51**	**3.35**	**3.83**	**2.31**

Note: T_0 - (Control), T_1 –RDF, T_2 – Rhizobium, T_3 - Azotobacter, T_4 - Azosprillium, T_5 – PSB, T_6 – VAM, T_7- FYM, T_8 – Vermicompost, T_9 – Farm compost

Table 2: Effects of bio-organic nutrition on vegetative growth and curd yield of broccoli

Treatments	Average length of leaf (cm)		Average width of leaf (cm)		Curd weight (g)		Curd yield	
	30 DAT	60 DAT	30 DAT	60 DAT	With guard leaves	Without guard leaves	kg plot^{-1}	q ha^{-1}
T_0	22.97	31.11	11.36	21.66	229.00	190.33	1.71	121.27
T_1	24.63	35.47	12.09	23.56	327.00	269.00	2.42	171.39
T_2	21.82	31.44	12.56	23.82	261.00	209.00	1.88	133.33
T_3	24.45	32.95	11.78	22.73	281.67	207.00	1.86	131.91
T_4	26.13	35.97	13.19	26.12	346.67	288.33	2.59	183.92
T_5	23.24	31.23	12.15	24.66	314.67	256.00	2.30	163.11
T_6	24.07	33.11	11.58	23.27	320.33	259.00	2.33	165.01
T_7	23.91	32.58	12.20	23.52	278.00	207.00	1.86	131.67
T_8	23.17	33.52	11.62	23.36	265.33	205.33	1.84	130.73
T_9	24.58	34.60	11.82	22.87	269.00	229.33	2.06	146.33
SEm (±)	**0.68**	**0.70**	**0.44**	**0.69**	**18.59**	**16.11**	**0.14**	**10.33**
LSD (0.05)	**2.06**	**2.11**	**1.30**	**2.08**	**55.67**	**48.25**	**0.43**	**30.95**

South direction at 60 DAT) at both directions followed by T_1 *i.e*. (RDF). However, the treatment effects due to all the biofertilizer and organic supplement applications are statistically very close to each other as compared to the minimum spreading observed under control plant (Table 1).

Similar trend was also observed in case of increase in number of leaves. It was clearly found that treatment T_4 showed maximum leaf production per plant at 30 and 60 DAT. Chattoo *et al*. (1997) observed that bacterial inoculants responded better for increase in leaf number of leaves and plant spreading and *Azosprillium* proved better than *Azotobacter* while experiment in Knol-khol cv. Early White Vienna. The length and width of leaves was also recorded maximum under T_4 (*Azospirillum*) whereas, the minimum value was observed in the treatment T_0 (control). Similar study was also reported by Bambal *et al*. (1998) who found that *Azotobacter* + *Azosprillium* + 100% nitrogen resulted maximum leaf area (643.58cm^2 plant^{-1}) in on cauliflower cv. Snowball-16.

Table 3: Effects of bio-organic nutrition on quality of curds of broccoli

Treatments	Curd diameter (cm)	Vitamin C(mg $100g^{-1}$)	T.S.S. (^{0}Brix)	Total sugars (%)	Reducing sugar (%)	Non-reducing sugar (%)	Acidity (%)	TSS: Acid ratio
T_0	12.88	85.91	7.77	2.61	2.00	0.45	0.32	24.28
T_1	14.61	86.89	8.70	3.96	2.99	0.73	0.36	24.16
T_2	14.37	87.23	8.40	2.98	2.23	0.57	0.40	21.00
T_3	14.67	86.34	8.23	3.10	2.56	0.47	0.42	19.59
T_4	15.48	93.31	9.23	4.20	3.26	0.90	0.44	20.97
T_5	14.46	92.77	8.60	2.98	2.29	0.66	0.39	22.05
T_6	13.70	88.18	7.70	3.50	2.74	0.68	0.41	18.78
T_7	14.73	88.15	8.33	3.45	2.79	0.61	0.34	24.50
T_8	14.49	89.15	8.57	3.32	2.53	0.70	0.37	23.16
T_9	15.29	87.82	7.90	3.07	2.48	0.49	0.40	19.75
SEm (±)	**0.32**	**1.25**	**0.29**	**0.29**	**0.27**	**0.26**	**0.038**	**0.281**
LSD (0.05)	**0.96**	**3.74**	**0.88**	**0.88**	**0.09**	**0.77**	**0.11**	**0.982**

Weight of curd with guard leaves and without guard leaves were recorded maximum under T_4 (*Azospirillum*) and minimum recorded under control (T_0). It was clearly seen that there was no statistical differences among T_1 (RDF) and T_4 (*Azospirillum*). Similarly, the curd yield (kg $plot^{-1}$ and q ha^{-1}) was also maximum (2.59 kg $plot^{-1}$ and 183.92 q ha^{-1}) under treatment T_4 followed by T_1 (RDF). The effect of *Azospirillum*, *Azotobacter*, phosphate solubilizing bacteria (PSB) and vesicular arbuscular mycorrhiza (VAM) inoculation on the yield of cauliflower was studied and it obtained the maximum yield of cauliflower with the application of *Azospirillum* (213.25 and 219.95 q ha^{-1}), followed by *Azospirillum* + 75% dose of N which was also in accordance the finding of Singh *et al.* (2014) in improvement of yield and quality of broccoli.

In respect of quality of curd, it was observed that application of inoculants *Azospirillum* (T_4) significantly increased the curd size (15.48 cm diameter). Vitamin-C and Total Soluble Solids (TSS) were found maximum under T_4 (*Azospirillum*) (93.31 mg $100g^{-1}$ and 9.23 0 Brix, respectively) and minimum observed in T_0 (control) and T_6 (VAM) followed by T_1.

Similar observation in reducing sugars, non-reducing sugars and titratable acidity was recorded maximum in T_4 (*Azospirillum*) and minimum was recorded T_0 (control) but total sugars was recorded maximum in T_1 (RDF) and minimum was observed in T_0 (control). The increase of acidity due to *Azospirillum* (T_4) is not clear. However, it may be due to the fact that *Azospirillum* or other biofertilizers might increase the mineral (Nitrogen) availability which may increase acidity (Maji *et al.*, 2015). However, overall TSS: Acid ratio is higher in T_4 and T_1.

It also observed that increase of ascorbic acid, carbohydrate and crude protein contents when treated with 100% NPK + FYM + A*zospirillum* + Phosphobacteria, whereas, Kumarswamy and Madalageri (1990) concluded from their study on tomato that *Azotobacter* in combination with 30Kg N ha^{-1} recorded a high marketable yield of tomato fruits and also found to improve quality in ber (Kundu *et al*., 2015).

On the basis of present investigation it may be concluded that the use of biofertilizers improved the performance of broccoli in general, in terms of yield and quality of curd as compared to untreated control. Among the all treatment under study application of *Azospirillum* can be recommended to broccoli growers for obtaining better growth, marketable curd yield and quality improvement of broccoli cv. KTS-1 under Lucknow condition to reduce the use of chemical fertilizers.

REFERENCES

Amirthalingam, S. 1988. Studies on the effect and *Azospirillum*, Nitrogen and NAA on growth and yield of Chilli cv. K-1. *South Indian Hort.*, **36**:218.

AOAC 2000. *Official Methods of Analysis* (6th Ed.). In: Association of Official Agricultural Chemists, Washington, D.C. Bambal, A. S. 1998. *Orissa J. Hort*., **26**:14-17.

Beecher, C. 1994. Cancer preventative properties of varieties of *Brassica oleracea*: a review. *American Soc. Clin. Nutri.*, **59**:1166-70.

Cecagno, R., Fritsch, T. F. and Schrank, I. S. 2015. The plant growth-promoting bacteria, *Azospirillum amazonense*, genomic versatility and phytohormone pathway. *Bio Med Res. Int*. pp.7. http://dx.doi.org/10.1155/2015/898592

Chattoo, M. A., Gandroo, M. Y. and Zargar, M. Y. 1997. Effect of *Azospirillum* and *Azotobacter* on growth, yield and quality of Knol-khol (*Brassica oleracea* var. *gongylodes* L.). *Veg. Sci.*, **24:**16-19.

Edwards, C. A. 1998. *Use of earthworms in break down and management of organic wastes*: Earthworm ecology. CRC Press LLC, Boca Raton, Florida, pp. 327-54.

Ghosh, N. 2004. Promoting Biofertilisers in Indian Agriculture, *Eco. Pol. Weekly*, **39**: 5617-25.

Gupta, A. K. and Samnotra, R.K. 2004. Effect of biofertilizers and nitrogen on growth, quality and yield of cabbage. cv. Golden Acre. *Env. Eco.*, **22** : 551-53.

Kloepper, J. W. and Schroth, M. N. 1978. *Plant growth promoting Rhizobacteria and plant growth under Gnotobiotic condition*. Department of Plant Pathology, University of California. **71** : 642-44.

Kumarswamy, D. and Madalageri, B. B. 1990. Effect of *Azotobacter* on tomato. *South Indian Hort*., **38** : 345-46.

Kundu, S., Chakraborty, S., Roy, D., Ghosh, B. and Dutta, P. 2015. Studies on organic nutrition in improving yield and quality of ber cv. BAU Kul-1. *J. Crop Weed*, **11**:14-18.

Maji, S., Das, B. C. and Sarkar, S. K. 2015. Efficacy of some chemicals on crop regulation of Sardar guava. *Sci. Hort*., **188**: 66-70.

Ray, M., Haldar, P., Saha, S., Chatterjee, S., Adhikary, S. and Mukhopadhyay, S.K. 2017. Effect of balanced nutrition on productivity, economics and soil fertility of rice (*Oryza sativa* L.) – greengram [*Vigna radiata* (L.) Wilczek] cropping system under coastal West Bengal. *J. Crop Weed*, **13**:89-92.

Sahu, P. K. and Das, A. K. 2014. Agriculture and Applied Statistics. 2nd Edition, Kalyani Pub., pp.163-208.

Sau, S., Mandal, P., Sarkar, T., Das, K. and Datta, P. 2017. Influence of bio-fertilizer and liquid organic manures on growth, fruit quality and leaf mineral content of mango cv. Himsagar. *J. Crop Weed*, **13**: 132-36.

Singh, A., Maji, S. and Kumar, S. 2014. Effect of Biofertilizers on Yield and Biomolecules of Anti-cancerous Vegetable Broccoli. *Int. J. Bio-res. Stress Managmnt.*, **5**:262-68.

Sunda, N. R. 2011. *A Competitive Book of Agricultutre.* Published by Surahee publication.

Vessey, J. K. 2003. Plant growth promoting *rhizobacteria* as biofertilizers. *Pl. Soil*, **255**:571-86.