Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(5): 1054-1057
Received: 16-07-2019
Accepted: 18-08-2019

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Effect of liquid biofertilizers and inorganic fertilizers on growth attributes of broccoli (*Brassica oleracea* L. var. *italica*)

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Abstract
The investigation was carried out at the Department of Horticulture, College of Agriculture, VNMKV, Parbhani (M.S.) during Rabi 2018-19 to study the effect of liquid biofertilizers and inorganic fertilizers on growth attributes of broccoli (*Brassica oleracea* L. var. *italica*) Cv. Green magic. Two factors were taken, the first factor was the chemical fertilizers at three levels (125%, 100% and 75% of RDF) and the second factor was the different biofertilizers (Azotobacter, PSB and Azotophos). The experimental design adopted was factorial randomized block design with 12 treatment combinations. The results revealed that the individual effect of chemical fertilizers at level 100% RDF (120:80:60 kg/ha) and biofertilizers level Azotophos showed a significant difference in growth characters compared to the other levels. The characters *viz.*, plant height (59.10 cm), Girth of main stem (20.00 cm), number of leaves (23.07 cm), length of leaves (48.78 cm), width of leaves (22.07 cm), weight of curd (650.33 g), days to curd initiation (45.35) and days to harvesting (54.42) of broccoli were recorded the highest value with application of 125% + Azotophos. The use of biofertilizers in combination with the chemical fertilizers would increase growth characters and also aid in adding steps towards sustainable crop production by conserving the soil health.

Keywords: Broccoli, biofertilizers, chemical fertilizers, azotobacter, PSB, Azotophos

Introduction
Broccoli (*Brassica oleracea* L. var. *italica*) belongs to the genus *Brassica* and family *Brassicaceae* which includes a wide range of crop plants derived from the Mediterranean Sea and modified over the years by selection and breeding (Decoteau, 2000) [2]. Broccoli is Latin word 'Brachium' meaning 'arm of branch' and also referred as 'cauliflower' or 'Italian asparagus'. It is one of the major crop plants in this genus. The curd of broccoli is formed from a compact flower head and produces a green curd that rapidly develops into a mass of fertile flower buds (Biggs, 1993) [1]. In India, its cultivation is negligible but now gaining popularity among Indian growers for the last couple of years due to its high nutritive value and increased tourist influx. It is mostly cultivated in the hilly areas of Himachal Pradesh, Uttar Pradesh, Jammu and Kashmir, Nilgiri hills and Northern plains of India. Application of liquid bio-fertilizers inoculation in vegetable crops has been of much significance as *Azotobacter* and *Azospirillium* for atmospheric nitrogen, also known for synthesis of biologically growth promoting substances whereas, PSB are important microbes in releasing and making available phosphorus by colonizing the root surface of growing plant root. They also improve the plant growth due to increase in nutrient uptake particularly phosphorus, zinc and other micro-nutrients, production of growth promoting substances and resistance to plant pathogen. These bio-fertilizers are organic in origin and thus, are absolutely safe. Therefore, it is essential to adopt a strategy of integrated nutrient management using combination of chemical fertilizers, organic manures and biofertilizers, so as to minimize the cost of production and to maintain biological productivity of soils, particularly because the farmers are reluctant to adopt recommended fertilizer doses due to the high cost and risk of crop failures on account of aberrant weather conditions. Hence, keeping all the points in view, the present study was undertaken to study the effect of liquid biofertilizers and inorganic fertilizer doses on growth, yield and quality of broccoli (*Brassica oleracea* L. var. *italica*) at department of horticulture VNMKV Parbhani.

Materials and Methods
The experiment was conducted at Department of Horticulture, College of Agriculture, VNMKV, Parbhani that comes under subtropical region and is geographically situated between 19º 16´ N latitude and 76º 47´ E longitudes. The experiment consisted of twelve

treatment combinations with three levels of inorganic (125% RDF (F_1) – 150:100:75 kg/ha, 100% RDF (F_2) – 120:80:60 kg/ha and 75% RDF (F_3) 90:60:45 kg/ha) and four level of biofertilizers (without biofertilizers (B_0), Azotophos (B_1), PSB (B_2) and Azotophos (B_3). The Factorial randomized block design was adopted with three replications. The experimental field was thoroughly ploughed to a depth of 30 cm and harrowed twice. The field was laid out at a plot size of 3 x 2.25 m. The biofertilizers (Azotobacter, PSB and Azotophos) were applied by drenching after transplanting of the seedlings. They are transplanted in ridges and furrow system at a spacing of 60 x 45 cm. Standard cultural and management practices were adopted. Observations were recorded on various growth traits i. e. plant height, number of leaves per plant, length of leaf, width of leaves, girth of main stem, weight of curd, days to curd initiation and days to harvesting of broccoli. Least significant difference at 5% level was used for finding the significant differences among the treatment means. The data obtained from selected plants were subjected to analysis of variance given by Panse and Sukhatme (1961).

Results and Discussion

The results obtained highlight the importance of the significant variation within the various levels of inorganic and biofertilizers, singly and also in combinations. The plant height of broccoli recorded highest (57.38 cm) which were applied with 100% RDF (F_2) (56.99 cm) followed by 125% RDF (F_1) and 75% RDF (F_3) (56.93 cm). Biofertilizers Azotophos (B_4) recorded the highest plant height (58.60 cm) followed by PSB (B_2) (57.90 cm) and Azotobacter (B_1) (57.13 cm). The treatment applied with 125% RDF + Azotophos (F_1B_3) combination reported maximum interaction effect and recorded highest plant height (59.10 cm) followed by 100% RDF + Azotophos (F_2B_3) (58.74 cm.) The increasing plant height could be due to the improvement of soil structure, nutrient and moisture status of the soil in favour of plant growth due to application of biofertilizers. The findings are in agreement with the Meena *et al*., (2017) [3] in broccoli.

The girth of main stem and number of leaves increased with increasing level of chemical fertilizers and recorded highest 18.22 cm and 22.97 respectively with the treatment of 100% RDF (F_2) followed by 75% RDF (F_3) and 125% RDF (F_1). Similarly, biofertilizers Azotophos (B_3) recorded the highest girth of main stem 19.64 cm and number of leaves 22.77 followed by PSB (B_2) with 18.57 cm and 21.93 respectively. It was observed that within the interaction effect of 125% RDF + Azotophos (F_1B_3) recorded the highest girth of main stem (20.00 cm) and number of leaves 20.00 cm, followed by 100%RDF + Azotophos (F_2B_3) while the lowest values were recorded in the combination of 125% RDF + without biofertilizers (F_1B_0) in both the parameters. The reason behind this maximum girth of main stem may be due to the more succulence in stem and balance C: N ratio and sufficient supply of available nutrients from soil. These findings are in agreement with Pawar and Barkule (2017) [4] in cauliflower.

The highest length of leaf (46.93 cm) and width of leaf (21.09 cm) was recorded with 100% RDF (F_2) followed by 125% RDF (F_1) and 75% RDF (F3). Among the various biofertilizers the application of Azotophos (B_3) recorded the highest length of leaf (48.35 cm) and width of leaf (21.81 cm) followed by PSB (B_2) and Azotobacter (B_1). The treatment combination at various levels of chemical fertilizers and biofertilizers recorded the highest values of length of leaf (48.78 cm) and width of leaf (22.07 cm) in the plants applied with 125% RDF + Azotophos (F_1B_3) followed by 100% RDF + Azotophos (F_2B_3) while the lowest values were recorded with combination of 125% RDF (F_1B_0). The increase in maximum length of leaves might be due to the availability of nitrogen through biological nitrogen fixation and influenced physiological activities. Similar results were reported by Singh *et al*., (2013) [5] in cabbage.

Highest weight of curd per plant (523.83 g) was recorded under 100% RDF (F_2) followed by 125% RDF (F_1) and 75% RDF (F_3). Among the biofertilizers Azotophos (B_3) recorded maximum weight of curd (621.44 g) per plant followed by PSB (B_2) and Azotobacter (B_1). The interaction of 125% RDF + Azotophos (F_1B_3) recorded maximum weight of curd (650.33 g) per plant followed by 100% RDF + Azotophos (F_2B_3) and lowest values recorded under 125% RDF (F_1B_0). This might be due to the possible role organic and inorganic fertilizers through atmospheric nitrogen fixation. Similar results were obtained by Singh *et al*., (2017) [6].

The minimum days required to curd initiation (60.99) and days required to harvesting (68.64) were recorded in 125% RDF (F_1) which were at par with 100% RDF (F_2) and maximum days recorded under 75% RDF (F_3). Among various biofertilizers Azotophos (B_3) recorded minimum days required to curd initiation (49.59) and days required to harvesting (57.85) respectively, followed by PSB (B_2) and Azotobacter (B_1). The interaction treatment of 125% RDF + Azotophos (F_1B_3) recorded minimum days required to curd initiation (45.35) and days required to harvesting (54.42) which was followed by 100% RDF + Azotophos (F_2B_3) and maximum days were recorded under 75% RDF (F_3B_0).

Table 1: Growth characters as affected by different chemical fertilizers and biofertilizers

Treatments	Plant height (cm)				Girth of main stem (cm)			
Factor - A :- Chemical Fertilizers	**15 DAT**	**30 DAT**	**45 DAT**	**60 DAT**	**15 DAT**	**30 DAT**	**45 DAT**	**60 DAT**
F_1	14.04	29.09	45.56	56.99	5.25	9.64	15.02	17.24
F_2	14.78	29.82	46.78	57.38	5.86	10.29	15.30	18.22
F_3	13.12	28.42	45.41	56.93	4.93	9.22	14.63	17.89
SE+	0.31	0.35	0.73	0.75	0.11	0.21	0.14	0.26
CD at 5% level	0.91	1.02	NS	NS	0.33	0.62	0.40	0.78
Factor – B :- Biofertilizers								
B_0	12.53	24.81	43.64	54.77	4.80	9.24	13.15	15.32
B_1	13.58	28.03	45.78	57.13	5.03	9.18	14.87	17.60
B_2	14.29	30.30	46.87	57.90	5.53	9.86	15.55	18.57
B_3	15.53	33.30	47.38	58.60	6.02	10.58	16.36	19.64
SE+	0.36	0.40	0.84	0.87	0.13	0.24	0.16	0.30
CD at 5% level	1.05	1.17	2.48	2.54	0.38	0.71	0.48	0.88

Interactions (FXB)								
$F_1 B_0$	12.82	24.57	42.82	54.07	4.36	9.02	12.96	13.33
$F_1 B_1$	12.93	26.50	44.51	56.71	4.65	8.76	14.42	16.90
$F_1 B_2$	14.39	30.87	47.01	58.07	5.64	9.94	15.71	18.73
$F_1 B_3$	16.03	34.42	47.91	59.10	6.35	10.93	16.99	20.00
$F_2 B_0$	14.83	25.08	45.65	55.16	6.30	8.20	13.50	16.17
$F_2 B_1$	14.36	29.29	46.59	57.60	5.36	9.47	15.35	18.22
$F_2 B_2$	14.45	31.58	47.09	58.00	5.63	10.07	15.72	18.78
$F_2 B_3$	15.50	33.32	47.78	58.74	6.06	10.61	16.64	19.69
$F_3 B_0$	9.93	24.78	42.45	55.07	3.68	7.68	12.99	16.45
$F_3 B_1$	13.44	28.31	45.90	57.09	5.07	9.32	14.85	17.69
$F_3 B_2$	14.04	28.45	46.50	57.61	5.32	9.57	15.22	18.20
$F_3 B_3$	15.05	32.15	46.44	57.95	5.66	10.30	15.45	19.22
SE±	0.62	0.69	0.73	1.50	0.22	0.42	0.27	0.52
CD at 5% level	1.82	2.03	NS	NS	0.66	1.24	0.79	1.53

Table 2: Growth characters as effected by different chemical fertilizers and biofertilizers

Treatments	**Number of leaves per plant (cm)**				**Length of leaves (cm)**			
Factor :– A Chemical Fertilizers	**15 DAT**	**30 DAT**	**45 DAT**	**60 DAT**	**15 DAT**	**30 DAT**	**45 DAT**	**60 DAT**
F_1	7.94	11.85	16.28	21.31	20.57	28.79	38.08	45.99
F_2	8.10	12.13	16.45	21.97	21.10	29.66	38.34	46.93
F_3	7.60	11.32	15.92	20.87	20.18	28.82	37.87	46.21
SE±	0.12	0.14	0.10	0.47	0.24	0.26	0.65	0.88
CD at 5% level	0.35	0.41	0.30	NS	0.72	0.76	NS	NS
Factor :- B Biofertilizers								
B_0	7.33	9.79	15.05	19.50	18.19	26.69	36.01	43.38
B_1	7.77	11.42	15.88	21.33	20.55	29.12	37.97	46.44
B_2	8.02	12.44	16.47	21.93	21.41	29.87	38.72	47.32
B_3	8.42	13.41	17.47	22.77	22.33	30.69	39.69	48.35
SE±	0.14	0.16	0.12	0.55	0.28	0.30	0.75	1.01
CD at 5% level	0.41	0.48	0.34	1.60	0.83	0.88	2.20	2.97
Interactions (FXB)								
$F_1 B_0$	7.42	9.64	14.94	18.60	17.25	25.11	36.00	42.02
$F_1 B_1$	7.55	10.98	15.60	21.31	20.03	29.02	37.41	45.74
$F_1 B_2$	8.00	12.90	16.77	22.25	21.60	30.04	38.90	47.40
$F_1 B_3$	8.80	13.87	17.80	23.07	23.38	31.10	40.02	48.78
$F_2 B_0$	7.36	10.43	15.35	21.40	19.19	28.42	36.42	44.66
$F_2 B_1$	7.95	12.13	16.14	21.89	21.09	29.61	38.50	47.07
$F_2 B_2$	8.75	12.76	16.85	21.86	21.56	30.01	38.80	47.65
$F_2 B_3$	8.35	13.20	17.46	22.74	22.56	30.61	39.63	48.35
$F_3 B_0$	7.20	9.29	14.85	18.50	18.12	26.53	35.60	43.47
$F_3 B_1$	7.80	11.13	15.90	20.81	20.52	28.72	38.01	46.51
$F_3 B_2$	7.30	11.67	15.77	21.67	21.06	29.56	38.45	46.92
$F_3 B_3$	8.10	13.17	17.16	22.50	21.04	30.48	39.42	47.93
SE±	0.24	0.28	0.20	0.94	0.49	0.52	1.30	1.75
CD at 5% level	0.70	0.83	0.60	NS	1.43	1.53	NS	NS

Table 3: Growth characters as effected by different chemical fertilizers and biofertilizers

Treatments	**Width of leaf (cm)**			
Factor :– A Chemical Fertilizers	**15 DAT**	**30 DAT**	**45 DAT**	**60 DAT**
F_1	9.97	12.13	16.28	20.83
F_2	10.39	12.55	16.52	21.09
F_3	9.81	11.81	16.34	20.39
SE±	0.16	0.21	0.21	0.14
CD at 5% level	0.48	0.61	NS	NS
Factor : - B Biofertilizers				
B_0	9.01	10.82	15.52	19.38
B_1	9.83	11.80	16.61	20.74
B_2	10.17	12.10	16.47	21.15
B_3	11.22	13.93	16.93	21.81
SE±	0.19	0.24	0.24	0.45
CD at 5% level	0.55	0.70	0.71	1.32
Interactions (FXB)				
$F_1 B_0$	8.18	9.73	15.64	19.53

$F_1 B_1$	9.34	11.35	15.68	20.51
$F_1 B_2$	10.37	12.53	16.63	21.22
$F_1 B_3$	12.00	14.90	17.17	22.07
$F_2 B_0$	9.80	12.07	16.01	20.21
$F_2 B_1$	10.44	12.15	16.51	21.03
$F_2 B_2$	10.30	12.00	16.64	21.29
$F_2 B_3$	11.03	13.98	16.90	21.82
$F_3 B_0$	9.06	10.65	14.90	18.41
$F_3 B_1$	9.70	11.90	17.63	20.69
$F_3 B_2$	9.85	11.77	16.13	20.92
$F_3 B_3$	10.62	12.91	16.71	21.56
SE±	0.32	0.41	0.42	0.78
CD at 5% level	0.95	1.21	1.24	2.28

Table 4: Curd parameters as effected by different chemical fertilizers and biofertilizers

Treatment	**Curd Parameters**		
Factor :– A Chemical Fertilizers	**Weight of curd (g)**	**Days to curd initiation**	**Days to harvesting**
F_1	511.67	60.99	68.64
F_2	523.83	61.11	68.83
F_3	483.50	64.42	71.49
SE±	8.84	0.92	0.80
CD at 5% level	25.93	2.71	2.35
Factor :- B Biofertilizers			
B_0	381.44	72.50	80.97
B_1	480.67	66.62	72.45
B_2	541.78	59.99	67.35
B_3	621.44	49.59	57.85
SE±	10.21	1.07	0.93
CD at 5% level	30.56	3.13	2.72
Interactions (FXB)			
$F_1 B_0$	406.33	69.44	79.20
$F_1 B_1$	437.00	70.10	74.91
$F_1 B_2$	553.00	59.08	66.05
$F_1 B_3$	650.33	45.35	54.42
$F_2 B_0$	383.33	73.04	82.33
$F_2 B_1$	524.33	62.89	69.78
$F_2 B_2$	560.67	58.22	65.03
$F_2 B_3$	627.00	50.29	58.17
$F_3 B_0$	354.67	75.01	81.38
$F_3 B_1$	480.67	66.86	72.64
$F_3 B_2$	511.67	62.68	70.97
$F_3 B_3$	587.00	53.12	60.96
SE±	17.68	1.85	1.60
CD at 5% level	51.86	5.42	4.70

Conclusion

Interaction of chemical fertilizer and biofertilizers enhanced the vegetative and reproductive growth. Therefore, amongst all the treatments interaction of 125% RDF and Azotophos can be considered as most beneficial in terms of growth. From the present investigation it is revealed that, soil application of chemical fertilizers and biofertilizers is an instant and effective way of application which significantly influenced vegetative characters of plant and physicochemical properties of curd of broccoli.

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