Agriways 7(1): 44-49. June 2019

ISSN: 2321-8614 (Print)
ISSN: 2454-2318 (Online)

Research Article

INFLUENCE OF PLANT GROWTH REGULATORS AND BIOFERTILIZERS ON GROWTH AND YIELD OF BROCCOLI (*BRASSICA OLERACEA* L. VAR. *ITALICA*) UNDER CENTRAL REGION OF PUNJAB

Kamlesh Kumari, S. K. Singh*, Vishavjot Mehmi, Umesh Kumar and Kirandeep Kaur
Department of Agriculture, Mata gujri College, Fatehgarh Sahib, Punjab-140406
*Email.: sandeephort0233@gmail.com

Received: 25 April 2019/Accepted: 28 May 2019

Abstract The present investigation were carried out at Experimental Farm of the Department of Agriculture, Mata Gujri College, Sri Fatehgarh Sahib, Punjab, India during the year 2019. The experiment comprised three treatments of plant growth regulators, (G0 = No growth regulator, G1= GA3 @ 50 ppm, G2= NAA @ 100 ppm) and four treatments of biofertilizers (B0= No biofertilizer, B1= Azotobacter @ 5 kg ha-1, B2= PSB @ 5 kg ha-1, B3= KSB @ 5 kg ha-1). Thus there were 12 treatment combinations replicated thrice in factorial randomized block design. Among plant growth regulators, maximum growth and yield parameters were observed in GA3 @ 50 ppm. Among the biofertilizers, B1= Azotobacter @ 5 kg ha-1 were recorded to be the best regarding growth and yield parameters. Maximum fruit yield was obtained in treatment combinations of G1 B1 - GA3 @ 50 ppm + Azotobacter @ 5 kg ha-1.
Key words: Broccoli, GA_3, NAA, *Azotobacter*, PSB and KSB

Introduction

Broccoli (*Brassica oleracea* L. var. *italica*), is a member of cole group originates from the Mediterranean region commonly known as Hari ghobi in hindi. The term cole has originated from the word "*Colewart''* which means wild cabbage. It is biennial and herbaceous winter vegetable crop of Brassicacae family and is considered as commercial crop in India (Hossain *et al*., 2011). Broccoli is related to cabbage, kale, cauliflower, and Brussels sprouts. *Brassica* vegetables possess both antioxidant and anti carcinogenic properties. Broccoli is known as the "Crown of Jewel Nutrition" as it is rich in vitamins and minerals. Eating large portion may also have additional benefits, since broccoli is also a rich source of many vitamins and minerals such as vitamin A and C, carotenoides, fiber, calcium and folic acid**.** It has about 130 times more vitamin A contents than cauliflower and 22 times than cabbage (Meena *et al*., 2017). Among the cole crops, the sprouting broccoli is highly nutritious as compared to others. It contains carbohydrates (5.5 %), protein (3.3 %), Vitamin-A (3500 IU), Vitamin-C (137 mg), calcium (0.80 mg) and phosphorus (0.79 mg) and 0.12 mg in Vitamin-B_2 (Hazra and Som, 1999).

Plant growth regulators (PGR's) are organic compounds, other than nutrients that modify the plant physiological processes. They normally are active in low concentrations in plants (Bisht *et al*., 2018). GA_3 exhibited beneficial effect in several cole crops by stimulating cell division or cell enlargement or both and foliar application of GA_3 provide more yield (Reza *et al*., 2015). The application to NAA affected the physiological processes particularly respiration and photosynthesis, which ultimately lead to accumulation of dry matter, minerals and carbohydrates (Vishwakarma *et al*., 2017). Biofertilizers can serve as alternative to mineral fertilizers for improving soil structure and microbial biomass for sustainable increased production. *Azotobacter* and Phosphorus Solubilizing Bacteria (PSB) are the biofertilizers which nourish the crops and soil by liberating the growth promoting substances and vitamins. *Azotobacter* fixes atmospheric nitrogen in the root zone of the plants, where as PSB solubilises unsoluble fixed phosphates already present in the soils. These biofertilizers are organic and thus absolutely safe, provide mechanical support, vigor and health to the seedlings (Chand *et al*., 2017).

Methods and Materials

The present investigation entitled "Effect of plant growth regulators and biofertilizers on growth and yield of broccoli (*Brassica oleracea* L. var. *italica*)" was conducted during 2018-19 at the Experimental Farm, Mata Gujri College, Sri Fatehgarh Sahib, Punjab, India. Broccoli (*Brassica oleracea* L. var. *italica*) cv. 'Palam Samridhi' was used for present study. Raised nursery beds of 3 x 1 m size were prepared by mixing well rotten FYM in the soil @ 20 kg per bed. The seeds were sown 5 cm apart in rows. The complete dose of phosphorus and potassium and 1/3 dose of nitrogen was applied at the time of field preparation as basal dose. However the rest of nitrogen was applied in two equal doses viz one and two months after

transplanting. FYM was applied @ 25 tonnes/ha before transplanting. One month seedlings were transplanted at 45 cm × 45 cm accommodating 25 plants in 7.20 square meter beds.

Transplanting was done on 18 Oct., 2018 followed by light irrigation for 3-4 days. Biofertilizers (*Azotobacter* and PSB) application was done through soil application @ 5 kg per hectare thoroughly mixed with FYM. The biofertilizers were applied at the time of first earthing up i.e 30 days after transplanting. The experiment was laid out in a factorial randomized block design with three replication and twelve treatments. The treatments consisted of T_1 (G_0B_0): Control, T_2 (G0B1): *Azotobacter* @ 5 kg ha^{-1}, T_3 (G_0B_2): PSB @ 5 kg ha^{-1}, T_4 (G_0B_3): KSB @ 5 kg ha^{-1}, T_5 (G_1B_0): GA_3 @ 50 ppm, T_6 (G_1B_1): GA_3 @ 50 ppm + *Azotobacter* @ 5 kg ha^{-1} , T_7 (G_1B_2): GA_3 @ 50 ppm + PSB @ 5 kg ha^{-1}, T_8 (G_1B_3): GA_3 @ 50 ppm + KSB @ 5 kg ha^{-1}, T_9 (G_2B_0): NAA @ 100 ppm T_{10} (G_2B_1): NAA @ 100 ppm + *Azotobacter* @ 5 kg ha^{-1}, T_{11} (G_2B_2): NAA @ 100 ppm + PSB @ 5 kg ha^{-1} and T_{12} (G_2B_3): NAA @ 100 ppm + KSB @ 5 kg ha^{-1}. Observations were recorded on randomly selected plants with different characters *i.e*. plant height (cm), plant spread (cm), number of leaves $plant^{-1}$, leaf length (cm), leaf width (cm), stalk length (cm), days taken to head initiation, head yield $plant^{-1}$(g), head yield $plot^{-1}$ (kg), head yield ha^{-1} (q) and biological yield. The data was analyzed as per design of the experiment.

Result and Discussion

Growth parameters

The analysis of variance revealed significant differences among the treatments for all the plant growth attributes under study.

Plant height (cm)

The data recorded on the effect of plant growth regulators and biofertilizers on various growth attributes of broccoli cv. Palam Samridhi presented in Table 1. Maximum plant height (55.43 cm) was obtained when GA_3 was applied at the rate of 50 ppm. Dhengle and Bhosle (2007) supported the results as increases in plant height may be due to GA_3 which increase the cell division and cell elongation in sub apical meristem. In case of biofertilizers maximum plant height (55.70 cm) was obtained when *Azotobacter* was applied at the rate of 5 Kg/ha.The possible reason may be that application of *Azotobacter* improved nitrogen status of the soil because this is free nitrogen fixer. Similar results have been reported by Badawy and Imam (1976), Chattoo *et al*. (1997), Jayathilake *et al.* (2002).

Plant spread (cm)

Maximum plant spread (55.45 cm) was obtained when GA_3 was applied at the rate of 50 ppm. The possible reason for increase in the plant spread was due to the physiological effects of auxins and gibberellins on growth parameters of plants e.g. cell elongation and cell division, increase in photosynthetic activity and better food accumulation The similar trend was also reported by Yadav *et al*. (2000) in cabbage, Patil *et al*. (2003) in Knol-khol and Manjit *et al*. (2011) in cabbage. In case of biofertilizers maximum plant spread (56.68 cm) was obtained when *Azotobacter* was applied at the rate of 5 Kg ha^{-1}. *Azotobacter* has the ability to produce vitamins like thiamine and riboflavin and plant hormones viz., indole acetic acid, gibberellins, siderophores and cytokinins (Pandey and Kumar 1989).

Number of leaves/plant

Maximum number of leaves/plant (18.11) was obtained when GA_3 was applied at the rate of 50 ppm. Dhengle and Bhosle (2007) supported the results as increases in number of leaves may be due to activity of GA_3 at the apical meristem resulting in more nucleo - protein synthesis responsible for increasing leaf initiation. In case of biofertilizers maximum number of leaves $plant^{-1}$ (18.33) was obtained when *Azotobacter* was applied at the rate of 5 Kg ha^{-1}. The possible reason may be that application of *Azotobacter* improved nitrogen status of the soil because this is free nitrogen fixer. Application of efficient and healthy strain of *Azotobacter* in rhizosphere have resulted in greater fixation of atmospheric nitrogen for use by the plant resulting in vigorous growth of plant. Similar results have been reported by Badawy and Imam (1976), Chattoo *et al*. (1997), Jayathilake *et al.* (2002).

Maximum leaf length (cm)

Maximum leaf length (44.30 cm) was obtained when GA_3 was applied at the rate of 50 ppm. Paleg (1965) had concluded that the mechanism of gibberellins action in the apex of the responsive plant result in increased protein synthesis, cell division, auxin production and cell expansion. All these in combination have lead to increase in various growth attributes of broccoli. These results are in close proximity of Davis *et al*. (2000), Chao and Lovatt (2006) and Rahman *et al.* (2015). In case of biofertilizers maximum leaf length (45.42 cm) was obtained when *Azotobacter* was applied at the rate of 5 Kg/ha. According to Abbas *et al*. (1993) increase in leaf length was observed due to inoculation of *Azotobacter* over control. Thus, efficient and healthy strains of *Azotobacter* in the rhizosphere, which in turn have resulted in greater fixation of atmospheric nitrogen and consequently for use of by the plant resulting in vigorous growth of plant.

Table: 1. Effect of plant growth regulators and biofertilizers on growth attributes of broccoli cv. Palam Samridhi.

Treatment	Plant height (cm)	Plant spread (cm)	Number of leaves plant^{-1}	Leaf length (cm)	Leaf width (cm)
Factor A					
G_0 (No growth regulator)	49.71	49.76	16.11	37.74	19.38
G_1 (GA_3 @ 50 ppm)	55.43	55.45	18.11	44.30	21.16
G_2 (NAA @ 100 ppm)	54.88	54.71	17.79	43.43	20.93
SEm±	0.50	0.74	0.23	0.54	0.18
$CD_{0.05}$	1.05	1.54	0.48	1.12	0.37
Factor B					
B_0(No biofertilizer)	49.61	48.38	16.06	36.91	19.18
B_1(*Azotobacter*@ 5 Kg/ha)	55.70	56.68	18.33	45.42	21.50
B_2(PSB @ 5Kg/ha)	55.29	55.41	17.97	44.46	21.28
B_3(KSB @ 5 Kg/ha)	52.74	52.76	16.99	40.50	20.00
SEm±	0.58	0.86	0.26	0.62	0.21
$CD_{0.05}$	1.21	1.78	0.55	1.30	0.43
Interaction (GxB)					
G_0B_0 (Control)	46.87	45.57	14.80	34.77	18.70
G_0B_1 (*Azotobacter* @ 5 Kg/ha)	52.67	54.77	17.43	41.07	20.10
G_0B_2 (PSB @ 5Kg/ha)	51.90	51.73	17.13	40.10	19.80
G_0B_3 (KSB @ 5 Kg/ha)	47.40	46.97	15.07	35.03	18.93
G_1B_0 (GA_3 @ 50 ppm)	51.03	50.40	16.80	38.27	19.47
G_1B_1 (GA_3 @ 50 ppm + *Azotobacter* @ 5 Kg/ha)	57.53	57.83	18.93	47.93	22.27
G_1B_2 (GA3 @ 50 ppm + PSB @ 5Kg ha^{-1})	57.43	57.57	18.67	47.40	22.20
G_1B_3 (GA3 @ 50 ppm + KSB @ 5 Kg ha^{1})	55.70	56.00	18.03	43.60	20.70
G_2B_0 (NAA @ 100 ppm)	50.93	49.17	16.57	37.70	19.37
G_2B_1 (NAA @ 100 ppm + *Azotobacter* @ 5 Kg ha^{-1})	56.90	57.43	18.63	47.27	22.13
G_2B_2 (NAA @ 100 ppm + PSB @ 5Kg ha^{-1})	56.53	56.93	18.10	45.87	21.83
G_2B_3 (NAA @ 100 ppm + KSB @ 5 Kg ha^{-1})	55.13	55.30	17.87	42.87	20.37
$CD_{0.05}$	NS	NS	NS	NS	NS

Table: 2. Effect of plant growth regulators and biofertilizers on yield attributes of broccoli cv. Palam Samridhi.

Treatment	Head yield (g) /plant	Head yield (kg)/ plot	Head yield (q)/ha
Factor A			
G_0 (No growth regulator)	231.43	5.79	114.20
G_1 (GA_3 @ 50 ppm)	297.58	7.44	148.94
G_2 (NAA @ 100 ppm)	292.74	7.32	146.56
SEm±	2.60	0.06	1.10
CD $_{0.05}$	5.40	0.13	2.29
Factor B			
B_0(No biofertilizer)	229.76	5.74	112.57
B_1(*Azotobacter*@ 5 Kg ha^{-1})	303.57	7.59	152.63
B_2(PSB @ 5Kg ha^{-1})	298.72	7.47	150.31
B_3(KSB @ 5 Kg ha^{-1})	263.62	6.59	130.76
SEm±	3.01	0.07	1.27
CD $_{0.05}$	6.24	0.15	2.65
Interaction (GxB)			
G_0B_0 (Control)	199.20	4.98	97.88
G_0B_1 (*Azotobacter* @ 5 Kg ha^{-1})	258.30	6.46	127.98
G_0B_2 (PSB @ 5Kg ha^{-1})	250.13	6.25	123.99
G_0B_3 (KSB @ 5 Kg ha^{1})	218.10	5.45	106.93
G_1B_0 (GA_3 @ 50 ppm)	248.83	6.22	121.80
G_1B_1 (GA_3 @ 50 ppm + *Azotobacter* @ 5 Kg ha^{-1})	327.37	8.18	165.51
G_1B_2 (GA3 @ 50 ppm + PSB @ 5Kg ha^{-1})	326.60	8.17	165.12
G_1B_3 (GA3 @ 50 ppm + KSB @ 5 Kg ha^{1})	287.50	7.19	143.34
G_2B_0 (NAA @ 100 ppm)	241.23	6.03	118.02
G_2B_1 (NAA @ 100 ppm + *Azotobacter* @ 5 Kg ha^{-1})	325.03	8.13	164.39
G_2B_2 (NAA @ 100 ppm + PSB @ 5Kg ha^{-1})	319.43	7.99	161.81
G_2B_3 (NAA @ 100 ppm + KSB @ 5 Kg ha^{-1})	285.27	7.13	142.02
SEm±	5.21	0.13	2.21
CD $_{0.05}$	10.80	0.27	4.59

Maximum leaf width (cm)

Maximum leaf width (21.16 cm) was obtained when GA_3 was applied at the rate of 50 ppm. Paleg (1965) had concluded that the mechanism of gibberellins action in the apex of the responsive plant result in increased protein synthesis, cell division, auxin production and cell expansion. All these in combination have lead to increase in various growth attributes of broccoli. These results are in close proximity of Davis *et al*. (2000), Chao and Lovatt (2006) and Rahman *et al.* (2015). In case of biofertilizers maximum leaf width (21.50 cm) was obtained when *Azotobacter* was applied at the rate of 5 Kg ha^{-1}. According to Abbas *et al*. (1993) increase in leaf width was observed due to inoculation of *Azotobacter* over control. Thus, efficient and healthy strains of *Azotobacter* in the rhizosphere, which in turn have resulted in greater fixation of atmospheric nitrogen and consequently for use of by the plant resulting in vigorous growth of plant.

Yield parameters

Head yield/plant, head yield/plot and yield/ha

The data recorded on the effect of plant growth regulators and biofertilizers on various growth attributes of broccoli cv. Palam Samridhi presented in Table 2. In plant growth regulator application the higher head yield /plant, head yield/plot and yield/ha was noticed (297.58 g, 7.44 Kg and 148.94 q) in G_1 (GA_3-50 ppm) over without growth regulator application (231.43 g, 5.79 kg and 114.20 q) in G_0. In biofertilizers application the higher head yield $plant^{-1}$ head yield per plot and yield ha^{-1} was noticed (303.57 g, 5.74 Kg and 152.63 q) in B_1 (*Azotobacter* @ 5 kg ha^{-1}) over without biofertilizers application (229.76 g, 5.74 Kg and 112.57 q). Among the interaction, significantly higher head yield/plant, head yield/plot and yield/ha was observed in the interaction of plant growth regulator and biofertilizers (327.37 g, 8.18 kg and 165.5 q) in G_1B_1 (GA_3 50ppm + *Azotobacter* @ 5 kg ha^{-1}) as compare to control (199.20 g , 4.98 kg and 97.90 q). The increase in yield by application of GA_3 due to the accumulation of carbohydrates owing to grater photosynthesis, higher food accumulation and better plant growth because the economic part of cabbage is head and which is formed by thick overlapping of leaves. The another probable reason for increasing yield attributes might be due to the increasing growth characters by cell division, cell elongation and cell expansion that might have ultimately increased in the yield. Similar trend was also observed by Yadav *et al*. (2000), Sawant *et al*. (2010), Lendve *et al*. (2010) in cabbage and Thapa *et al*. (2013) in sprouting broccoli. According to Tanwar *et al*. (2003) yield increase might be due to the fact that *Azotobacter* is known to produce antifungal, antimicrobial substances that inhibit varieties of soil borne fungal diseases. It can also synthesise the thiamin, riboflavin, pyridoxin, cyanocobalamine, nicotinic acid, pentathenic acid, indole acetic acid and gibberellins or gibberellins like substances resulting in vigorous plant growth and dry matter production which in turn resulted in better head development and ultimately the higher yield. Similar results have also been reported by Wange *et al*., Chattoo *et al.*, and Mohapatra *et al. Azotobacter* inoculation helped in increasing nitrogen availability because it is a micro acrophillic nitrogen fixer.

Conclusion

Based on the results experimentation it seems quite logical to conclude that application of plant growth regulator G_1 (GA_3 @ 50 ppm) observed maximum growth and yield. Among the biofertilizers B_1(*Azotobacter*@ 5 Kg ha^{-1}) were recorded to be the best regarding the growth and yield of broccoli. In case of interaction maximum head yield was recorded in G_1B_1 (GA_3 50ppm + *Azotobacter* @ 5 kg ha^{-1}).

References

Abbas Z and Okon Y. 1993. Plant growth promotion by Azotobacter paspali in the rhizosphere. Soil Biology and Biochemistry 25 (8): 1075-1083.

Badaway FH and Imam MK. 1976. Effect of seed inoculation with Azotobacter and soaking in trace element solution on the growth and yield of some vegetable crops. Libyan Journal of Agriculture 4: 69-78.

Bisht TS, Rawat L, Chakraborty B and Yadav V. 2018. A recent advances in use of Plant Growth Regulators (PGRs) in fruit crops - A Review International Journal of Current Microbiology and Applied Sciences 7(5):1307-1336.

Chao CT and Lovatt CJ. 2006. Effect of concentrations and application time of GA3 and urea on yield, fruit size distribution and crop value of clementline mandarin in California. Acta Horticulture 727 : 227-238.

Chand P, Mukherjee S and Kumar V. 2017. Effect of fertigation and bio-fertilizers on growth and yield attributes of sprouting broccoli (Brassica oleracea var. italica) cv Fiesta. International Journal of Pure and Applied Bio Science 5(4): 144-149.

Chattoo MA, Gandroo MY and Zarger MY. 1997. Effect of Azospirillium and Azotobacter on growth, yield and quality of knol-khol (Brassica oleracea var. gongylodes L.). Vegetable Science 34(1): 16-19.

Davis RMD, Davis RH and Nunez 2000. Influence of gibberelic acid on carrot growth and severity of Alternaria leaf blight. University of California. Plant Disease 84: 555-558.

Dhengle RP and Bhosale AM. 2007. Effect of NAA and GA3 along with urea on certain quality attributes of cabbage (Brassica oleracea L. var. capitata). The Asian Journal of Horticulture 70 (2): 30-32.

Hazra P and Som MG. 1999. Technology for vegetable production and improvement of nutritive value of different vegetables. Naya Prakash, Calcutta, 31 p.

Hossain MF, Ara N, Uddin MR, Dey S and Islam MR. 2011. Effect of time of sowing and plant spacing on broccoli production. Tropical Agricultural and Extension 14(4): 90-92.

Jayathilake PKS, Reddy IP, Shrihari D, Neeraja G and Reddy R. 2002. Effect of nutrient management on growth yield and yield attributes of rabi onion (Allium cepa). Vegetable Science 29(2): 184-185.

Lendve VH, Chawan SD, Barkule SR and Bhosale AM. 2010. Effect of foliar application of growth regulators on growth and yield of cabbage cv. Pride of India. Asian Journal of Horticulture. 5(2): 475- 478.

Manjit, Rana DK, Rawat JMS and Rawat SS. 2011. Effect of GA3 and kinetin on growth, yield and quality of sprouting broccoli (Brassica oleracea var. italica). Journal of Horticulture and Forestry. 3(9): 282- 285.

Meena K, Ram RB, Meena ML, Meena JK and Meena DC. 2017. Effect of organic manures and bio-fertilizers on growth, yield and quality of broccoli (Brassica oleracea var. italica Plenck) cv. KTS-1. Chemical Science Review 6(24): 2153-2158.

Mohapatra SK, Munsi PS, Mohapatra PN. 2013. Effect of Integrated Nutrient Management on growth, yield and economics of broccoli (Brassica oleracea var. italica Plenck). Vegetable Science 40(1):69-72.

Paleg LC. 1965. Physiological effects of gibberellins. Annals of Plant physiology 16: 291-322.

Pandey A and Kumar SJ. 1989. Soil beneficial bacterial and their role in plant growth promotion. Science Indian Research 48: 134-144.

Patil SS, Patil BS and Ingle VG. 2003. Effect of foliar application of growth regulators on growth and yield of knol-khol cv. White Vienna. Annals of Plant physiology 17(1): 56-59.

Rahman MS, Haque MA and Mostofa MG. 2015. Effect of GA3 on biochemical attributes and yield of summer tomato. Journal of Bioscience and Agriculture Research 3(2): 73-78.

Reza M, Islam M, Hoque A, Sikder RK, Mehraj H and Uddin AFMJ. 2015. Influence of different GA3 concentration on growth and yield of broccoli. American-Eurasian Journal of Scientific Research 10(5): 332-335.

Sawant VP, Naik DM, Barkule SR, Bhosale AM and Shinde SB. 2010. Effect of foliar application of growth regulators on growth, yield and quality of cabbage cv. Golden Acre. Asian Journal of Horticulture 5(2): 495-497.

Tanwar SPS, Sharma GL and Chahar MS. 2003. Effect of phosphorus and bio-fetilizer on yield, nutrient concentration and uptake by blackgram (Vigna mungo L. Hepper). Legume Research 26 (1): 39-41.

Thapa U, Das R, Mandal AR and Debanath S. 2013. Influence of GA3 and NAA on growth, yield and quality attributing characters of sprouting broccoli [Brassica oleracea (L.) var. Italica Plenk]. Crop Research (Hisar). 46(1/3): 192-195.

Vishwakarma S, Bala S, Kumar P, Prakash N, Kumar V, Singh SS and Singh SK. 2017. Effect of nitrogen, naphthalene acetic acid and gibberellic acid on growth, yield and quality of broccoli (Brassica oleracea var italica L.) cv. Sante. Journal of Pharmacognosy and Phytochemistry 1: 188-194

Wange SS, Patil PL, Mehar BB and Karkeli MS. 1995. Response of cabbage to microbial inoculants and increasing levels of nitrogen. Journal of Maharashtra Agriculture University 20(3): 429-30.

Yadav RL, Dhaka RS and Fageria MS. 2000. Effect of GA3, NAA and succinic acid on growth and yield of cabbage cv. Golden acre. Haryana Journal of Horticultural Sciences 29(3/4): 269-270.