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Effect of Inorganic Fertilizers, Azotobacter and GA_3 on Growth, Yield and Quality of Sprouting Broccoli (*Brassica oleracea* L. *var. italica* Plenck) under Subtropical Conditions of Garhwal Himalaya

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ABSTRACT

The present research was accomplished on Sprouting Broccoli to investigate the effect of Inorganic, *Azotobacter* and GA_3 on Growth and Yield Parameters of sprouting broccoli. The experiment was conducted in Randomized Block Design (RBD) and replicated 3 times with 16 treatments. The significant increase in plant height (35.20cm) and number of leaves (9.18) at 30 DAT was recorded in T_{14} in (NPK 75% + GA_3 50ppm + *Azotobacter*). The minimum (38.75 days) days taken to primary head formation was recorded in T_{15} (NPK 50%+ GA_3 50 ppm+ *Azotobacter)* followed by 40.43 days in T_4 (*Azotobacter)* and T_2 (NPK 75%). While The minimum (58.43 days) days taken to secondary head formation was recorded in treatment T_{14} (NPK 75% + GA_3 50 ppm+ *Azotobacter)* followed by 58.50 in T_2 (NPK 75%) and 40.43 in T_4 (*Azotobacter)* whereas the maximum days taken to secondary head formation (72.21 days) was noticed in treatment control (T_{16}). The maximum (325.51g) weight of primary head and secondary head (166.31 g) was recorded in T_{14} (NPK 75% + GA_3 50ppm + *Azotobacter*); maximum head diameter and maximum (10.10) number of secondary heads per plant (10.10) also recorded in same treatment. Furthermore, the maximum yield per plant (491.11 g), maximum yield per plot (4.91 kg/plot) and maximum yield per hectare (122.95 q/ha) was recorded in treatment T_{14} (NPK 75%+ GA_3 50 ppm + *Azotobacter)*. While the minimum yield (69.80 q/ ha) was found in treatment control T_{16}.

Key words : *Randomized Block Design, Sprouting Broccoli, Plant Height, Primary Head Formation, Secondary Head Formation and Yield.*

Introduction

Vegetables are comprised up of several, largely annual plants, of which varied edible portions, including leaves, stems, flower buds, flowers, fruits, and roots, can be eaten. They are crucial components of a balanced diet since they are nutrient-rich. Broccoli (*Brassica oleracea* L. *var. Italica*) is a winter season crop which belongs to the family Brassicaceae with chromosome number 2n =2x =16. Broccoli is commonly known as Hari gobhi in Hindi. In India, the cultivation of sprouting broccoli is popular in

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Himachal Pradesh. It is mostly cultivated in the hilly area of Himachal Pradesh, Uttarakhand, Jammu and Kashmir, Nilgiri hills and Northern plains of India. It contains moisture (89.1%), carbohydrates (5.5 %), protein (3.3 %), vitamin A (2500 IU), vitamin C (113 mg), vitamin B_1 (0.10 mg), vitamin B_2 (0.23 mg), calcium (103 mg) and phosphorus (0.78 mg) in 100g of edible portion. (Thamburaj and Singh, 2001). The edible part of broccoli is immature flower buds and fleshy stem. It is also used in sauces and salads of all the methods of preparation; steaming causes the least loss of nutrients (Dhaliwal, 2007). It is also a rich source of sulphoraphane, a compound associated with reducing cancer. Fertilizer is a chemical substance which is manufactured artificially. Fertilizer is a rich source of nutrient and applied in crop production to supply a particular nutrient in which soil is deficient. Nutrients are used through a chain of reactions for energetic purposes called metabolic processes. Nitrogen favors the transformation of carbohydrates into proteins and promotes the formation of protoplasm. An adequate supply of nitrogen is associated with vigorous vegetative growth and more efficient use of available inputs which leads to higher productivity (Patel *et al.,* 1992 and Sharma, 1992). Phosphorus is needed for the transfer of energy within the plant system and has the beneficial effect on early root development, plant growth and quality of produce (Brady, 1974). Potassium also plays a vital role in crop productivity and role in proving disease resistance to plant. Among plant bio regulators, GA_3 facilitates cell elongation in different organs and tissues throughout plant growth and development. The bio-fertilizers or microbial inoculants are the products containing living cells of different types of microorganism which have an ability to mobilize nutritionally important elements from non-usable to usable form through biological process. Within biofertilizers, Azotobacter has the ability forfixing the atmospheric nitrogen under the free-living condition and promote plant growth activities like phosphate and role for nitrogen synthesis. Presently the application of organic and inorganic fertilizers has maintained long-term soil fertility and sustained the higher level of productivity (Pillai *et al.,* 1985). The aim of our study isto examine the effect of inorganic fertilizers, GA_3 and bio-fertilizer with their combinations on growth, yield and quality traits of broccoli under subtropical conditions of Garhwal Himalaya.

Materials and Methods

The experiment was conducted at Horticultural Research Centre, Chauras Campus, Department of Horticulture, H.N.B. Garhwal University, Srinagar (Garhwal), Uttarakhand. The climate of Horticultural Research Centre is humid sub-tropical with minimum and maximum temperature ranging between 7.5 ^{0}C to 25.8 ^{0}C and 17.7 ^{0}C to 40 ^{0}C, respectively during experimentation. The present experiment comprised of 16 treatments (Table 1) consisting of inorganic fertilizers, bio-fertilizer and GA_3*viz.,* RDF 100% (NPK), RDF 75% (NPK), RDF 50% (NPK), *azotobactor,* GA_3 and their combination. During the experiment, the Palam Samridhi variety developed by CSK Himachal Pradesh Krishi Vishwa Vidyalaya, Palampur. The characteristic of cultivar comprising compact green head which free from yellow eyes and bracts, average head weight is 300-400g. The crop is ready for harvest in 85-90 days after transplanting. The cultivar recommended for subtropical conditions. The seed of *cv.* Palam Samrddhi was sown in a well-prepared nursery bed. The transplanting of the crop was done at the spacing 60x45 cm in 1.20m×1.70m plot size. The entire dose of FYM @ 20 tones/ha was applied 15 days before transplanting of seedling, the recommended dose of NPK@ urea 80 kg/ha, phosphate and potash dose 100 kg/ha each were applied before transplanting according to Chadha (2007). The half dose of nitrogen and full dose of phosphorus and potassium were applied as basal dressing before transplanting as per the experimental plan. The remaining half dose of nitrogen was top dress in split doses at 25 and 45 days after transplanting. A working solution of GA_3 (50 ppm) was prepared by dissolving 50 mg of gibberellic acid by addition ethanol and then the volume was made up to 1 liter with distilled water. For application of *azotobacter,* 2.0 gis mixed in a liter of water then seedlings are dipped in the solution for 20 minutes before transplanting. During the experiment, various growth, yield and parameters were recorded. Five plants under each treatment per replication were randomly selected and tagged for recording the observations. During the trail, plant height (cm) at 30 and 60 DAT, number of leaves per plant at 30 and 60 DAT, days taken to central head formation, weight of central head (g), diameter of central dead (cm), days taken to secondary head formation, weight of secondary heads per plant (g), weight of central head per plot (kg),

weight of secondary head per plot (g), harvesting duration, yield per plot (kg) and yield per hectare (q/ha.). After working out the mean of all the observation recorded, the data were analyzed according to the procedure of analysis of randomized block design with three replications (Snedecor and Cochran, 1961). The significance of variation among the treatments was observed by applying analysis of variance (ANOVA) and critical difference (C.D.) at 5% level of significance for each character was worked out.

Results and Discussion

Effect on Vegetative Traits

The result revealed that the treatments and their combinations significantly varystatistically at par P 0.05 degree of level significant on the growth and yield of broccoli. The result which is presented in Table 2 exhibited that,the maximum plant height at 30 DAT & 60 DAT and number of leaves at 30 DAT & 60 DAT (35.20cm&63.05 cm and 9.18, 19.23 respectively) was recorded in T_{14}[NPK (75%) + GA_3 (50ppm) + Azotobacter]. Where the minimum (29.39 cm, 52. 29 cm) plant height at 30 DAT and 60 DAT respectively and the minimum (7.86, 15.52) number of leaves at 30 DAT and 60 DAT wasobserved in control treatment (T_{16}). This may be due to solubilization effect of plant nutrients by *Azotobacter* as evidenced by the increase in uptake of N, P and K (Subbiah *et al.*, 1996) and also due to its favorable effect on several physical properties of the soil. Under the present investigation, GA_3 significantly influenced the number of leaves. It is evident from the result that GA_3 treatment increases the height. Gonzalez *et al.* (2007) also reported that the $GA_3$was the best for plant height in cauliflower.

Table 1. Treatments and their combination

Treatment	Concentration	Notation
NPK(RDF)	100 %	T_1
NPK(RDF)	75%	T_2
NPK(RDF)	50%	T_3
Azotobacter	2kg/ha	T_4
GA_3	50 ppm	T_5
NPK+ *Azotobacter*	100% +2kg/ha	T_6
NPK+GA_3	100%+50 ppm	T_7
NPK+ *Azotobacter*	75%+2kg/ha	T_8
NPK+GA_3	75%+50 ppm	T_9
NPK+ *Azotobacter*	50 %+2kg/ha	T_{10}
NPK+GA_3	50%+50 ppm	T_{11}
GA_3+*Azotobacter*	50ppm +2kg/ha	T_{12}
NPK+GA_3+*Azotobacter*	100%+50 ppm +2kg/ha	T_{13}
NPK+GA_3+*Azotobacter*	75%+50 ppm +2kg/ha	T_{14}
NPK+GA_3+*Azotobacter*	50%+50 ppm +2kg/ha	T_{15}
Control	0ppm	T_{16}

Effect on Yield

Yield, being the polygenic traits, is most important trait to decide the popularity and acceptance of cultivars among farmers. various trait which directly influenced the yield are diameter of primary head, number of secondary heads/ plants, weight of primary and secondary heads/ plant as well as per plot. Result presented in Table 3 revealed that, the minimum (38.75) days taken to primary head formation was recorded in T_{15} which was found to be significantly higher over other treatments, whereas the maximum days taken to primary head formation (55.09 days) was recorded in treatment T_6.Similar findings have also been reported by Chattoo *et al.* (1997) and Bhusan *et al.* (2010) in Knol-khol. According to Chauhan and Singh (1970), the treatment of GA_3 reduced the days to central head formations. The minimum (58.43) days taken to secondary head formation was recorded in treatment T_{14} whereas the maximum days taken to secondary head formation (72.21 days) was noticed in treatment control (T_{16}). Similar findings have also been reported by Khan *et al.* (2009) and Mal *et al.* (2015) in sprouting broccoli. The result presented in Table 4 revealed that, the maximum (169.92 mm) diameter of primary head was found in T_{14}, whereas the minimum (93. 59 mm) was recorded in treatment control (T_{16}). The head diameter of sprouting broccoli is increases with the increases in nutrients uptake, that results the increasing head diameter. Similar findings have also been concluded by Khan *et al.* (2009) and Kumar *et al.* (2013) in sprouting broccoli. Kumar and Ray (2000) also reported that the GA_3 treatment influenced the head size as compared to control. The maximum (10.10) number of secondary heads per plant was recorded in treatment T_{14} which was found significantly superior over all the treatments, while the minimum (5.87) was found in control (T_{16}). All the plots receiving different concentrations exerted significant variation in respect of number of secondary heads. Present results were also agreed with the findings of Singh and Gulshan (2001) with respect to number of secondary heads. The maximum weight of primary and secondary head (325.51g and 166.31 g) was found in T_{14} respectively,

whereas the minimum (169. 84 g and 86. 98 g., respectively) was observed in T_{16}. The maximum (4.91 kg) yield per plot was recorded in treatment T_{14} which was found to be significantly superior over other treatments but statistically at par with T_{15} treatment. On the other hand, the minimum (2.79 kg) yield per plot was found in treatment control T_{16}. The weight of central head and secondary heads per plot in sprouting broccoli cv. Palam Samridhi was significantly influenced by GA_3. Above findings are accordancewith the reports of Patil *et al.* (1987) in cabbage. The findings of Chauhan and Tandel (2009) indicated that GA_3 increased the yield as compared to absolute control in cabbage. The maximum (122.95 q) yield per hectare was recorded in T_{14}, while the minimum (69.80 q) was found in treat-

Table 2. Plant height (cm) and number of leaves at 30 DAT and 60 DAT

Treatment	Plant height (cm)		No. of leaves	
	30 DAT	60 DAT	30 DAT	60 DAS
NPK (100%)	33.36	61.2	8.1	17.62
NPK (75%)	30.93	58.02	8.15	17.03
NPK (50%)	33.4	58.93	8.43	17.84
Azotobacter	30.73	57.8	8.18	16.4
GA_3 (50 ppm)	33.43	59.26	8.38	16.61
NPK (100%) + Azotobacter	30.38	52	8.12	15.61
NPK (100%) + GA_3 (50 ppm)	33.73	61.07	8.83	19.2
NPK (75%)+ Azotobacter	31.2	60.33	8.06	17.12
NPK (75%) + GA_3 (50 ppm)	33.23	61.35	8.38	18.06
NPK (50%+ Azotobacter	32.23	59.13	8.01	17.26
NPK (50%) + GA_3 (50 ppm)	30.15	53.89	8.45	17.13
GA_3 (50ppm)	29.71	52.63	7.22	16.33
NPK (100%)+ GA_3(50 ppm)+ Azotobacter	31.61	61.55	8.33	17.64
NPK(75%)+ GA_3(50 ppm)+ Azotobacter	35.2	63.05	9.18	19.23
NPK(50%)+ GA_3(50 ppm)+ Azotobacter	32.5	58.63	8.43	17.86
Control	29.39	52.29	7.86	15.52
SEm±	0.95	1.79	0.13	0.43
CD (P = 0.05)	2.77	5.2	0.38	1.26

Table 3. Days taken to primary and secondary head formation and Weight of primary and secondary head/plant

Treatment	Days taken to primary head formation	Days taken to secondary head formation	Weight of primary head/plant (g.)	Weight of secondary head/plant (g.)
NPK (100%)	44.6	71.63	184.91	121.27
NPK (75%)	41.53	58.5	213.89	118.7
NPK (50%)	48.46	67.32	186.16	122.21
Azotobacter	40.43	59.11	204.4	115.27
GA_3 (50 ppm)	47.37	66.72	176.05	103.15
NPK (100%) + *Azotobacter*	55.09	65.09	195.22	132.3
NPK (100%)+ GA_3 (50ppm)	49.67	64.17	292.22	110.17
NPK (75%) + *Azotobacter*	49.34	68.85	275.19	148.17
NPK (75%) + GA_3 (50 ppm)	52.85	70.37	266.49	125.07
NPK (50%) +*Azotobacter*	48.24	66.9	296.77	151.29
NPK (50%) + GA_3 (50 ppm)	47.13	63.82	240.82	123.19
GA_3 (50 ppm)	46.25	72.12	264.66	127.34
NPK (100%) + GA_3 (50 ppm) +*Azotobacter*	47.82	63.37	276	147.02
NPK (75%) + GA_3 (50 ppm) +*Azotobacter*	44.02	58.43	325.51	166.31
NPK (50%) + GA_3 (50 ppm)+*Azotobacter*	38.75	66.31	300.96	164
Control	42.86	72.21	169.84	86.98
SEm±	2.96	1.54	4	5.03
CD (P = 0.05)	8.6	4.49	11.62	14.6

Table 4. Performance of Head diameter, number of secondary head/plant and yield

Treatments	Head diameter (cm.)	Number of secondary heads /plants	Yield/ plant (g.)	Yield/ plots (kg.)	Yield/ha. (q.)
NPK (100%)	124.75	7.69	304.49	3.06	76.54
NPK (75%)	117.67	7.4	342.66	3.32	83.15
NPK (50%)	115.78	7.1	308.62	3.08	77.09
Azotobacter	124.27	7.29	313.54	3.19	79.92
GA_3 (50 ppm)	94.8	7	281.04	2.98	74.5
NPK (100%) + *Azotobacter*	93.59	6.59	326.3	3.27	81.88
NPK (100%)+ GA_3 (50 ppm)	158.26	9.9	403.8	4.02	100.59
NPK (75%) + *Azotobacter*	125.85	8.8	419.31	4.23	105.84
NPK (75%) + GA_3 (50 ppm)	123.94	9.67	388.52	3.91	97.89
NPK (50%+ *Azotobacter*	156.54	9.3	447.67	4.48	112.01
NPK (50%)+ GA_3 (50ppm)	121.8	8.9	366.03	3.64	91
GA_3 (50 ppm)	151.4	7	398.23	3.92	98
NPK (100%)+ GA_3 (50 ppm)+ *Azotobacter*	118.53	9.4	423.16	4.23	105.75
NPK (75%)+ GA_3 (50 ppm)+ *Azotobacter*	169.92	10.1	491.11	4.91	122.95
NPK (50%)+ GA_3 (50 ppm)+ *Azotobacter*	164.73	10	461.74	4.65	116.24
Control	114.07	5.87	263.43	2.79	69.8
SEm±	3.59	0.54	4.45	0.2	4.18
CD (P = 0.05)	10.44	1.56	12.93	0.59	12.15

ment control (T_{16}). The stimulative effect of *azotobacter* might be attributed to its efficiency in supplying the growing plants with biologically fixed nitrogen, and produced phytohormones as well as photosynthesis process which subsequently increased plant growth and yield (Hewedy, 1999). These findings was also supported by Nowak (1980) that GA_3 gave highest yield in capsicum.

Conclusion

On the basis of obtained results from the present investigation, it may beconcluded that,the integrated use of chemical fertilizer, biofertilizers and plant growth hormones significantly showed impacts on quantitively characteristics of sprouting broccoli. Hence, the treatment T_{14} [NPK(75%)+ GA_3(50ppm)+ *Azotobacter*) could be used to enhance the production of sprouting broccoli under subtropical condition of Garhwal Himalaya.

Conflict of Interest- None

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