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Effect of Foliar Application of Plant Growth Regulators on Quality and Economics of Broccoli Production under Walk-In-Tunnel

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ABSTRACT

An experiment was conducted at "Center of Excellence on Protected Cultivation, College of Agriculture, IGKV, Raipur (CG)" to find out the possible effect of foliar application of plant growth regulators with different concentration levels on yield of broccoli. The experiment was laid out in Randomized Block Design (RBD) with three replications. It was consisted of ten treatments including T_0: Control (without spray of PGRs), T_1: GA_3 @ 40 ppm, T_2: GA_3 @ 60 ppm, T_3: GA_3 @ 80 ppm, T_4: NAA @ 60 ppm, T_5: NAA @ 120 ppm, T_6: NAA @ 180 ppm, T_7: GA_3 @ 40 ppm + NAA @ 60 ppm, T_8: GA_3 @ 60 ppm + NAA @ 120 ppm and T_9: GA_3 @ 80 ppm + NAA @ 180 ppm". Two foliar applications were performed at 20 days after transplanting and 40 days after transplanting. The important parameters encompassed in the study were gurd diameter (cm), primary curd weight (g), secondary curd weight (g), curd yield per plant, curd yield per plot and curd yield per hectare. Data was recorded three times during investigation that is 30 DAT, 60 DAT and at the time of harvest. Although all treatments showed a positive effect on yield among all the treatments, T_9 was showed better performance which may be due to the elongation of cells and cell division, increased dry matter accumulation in plants. Therefore, foliar application of GA_3 80 ppm + NAA 180 was optimum among all treatments for getting higher yield in broccoli crop.

Keywords Broccoli, GA_3, NAA, Quality, Economics.

INTRODUCTION

Broccoli (*Brassica oleracea* var. *italica* L.) is originated in Mediterranean region and belonging to the family Cruciferae. Broccoli is 2 types- heading type and sprouting type. Heading types of forms curds like Cauliflower, while the sprouting type contains a group of green, immature buds and thick fleshy flower stock forming a head. Generally green type broccoli is being cultivated in India which knowns as 'Calabrese'. Comparatively green types are more nutritive than white, yellow and purple types. Broccoli has 22 times more than cabbage and 130 times more

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vitamin A than cauliflower. It contains protein (3.3 g), Vitamin A (3500 IU), 0.14 mg Vitamin-B_1, 0.3 mg B_2, 1.2 mg niacin, Vitamin-C 137 mg, Calcium (0.80 mg) and Iron (205 mg) per 100 g. It has antioxidant and anticarcinogenic properties due to the presence of "sulphoraphane" which helps to fight against breast and lung cancer. In India, cultivation of broccoli is negligible in so many areas but mostly cultivated in hilly areas of Himachal Pradesh, Uttar Pradesh, Jammu and Kashmir, Nilgiri hills and northern plains of India. Purple types are hardier and withstand extremely low temperatures. Its consumption is more in hotels in cities like Mumbai, Calcutta, Delhi and Chennai.

Plant growth regulators natural chemicals biosynthesized in plants that influence various physiological processes in plants. Now a days, growth and development of plants is hampered due to the gradual changes in the climate. Both biotic and abiotic stresses are the main reasons to decline of economic and biological yield. However, plant growth regulators play an important role in plant responses to various abiotic stress. Now-a-days farmers are much interested in production of quality produce and earning profits by using plant growth regulators during crop cultivation. Plant growth regulators are two types: Natural and synthetic. Among all the growth regulators, auxins and gibberellins play important role in cell division and cell enlargement or both. Gibberellic acid (GA_3) and Naphthalene acetic acid (NAA) showed beneficial effect in several vegetable crops. NAA is a synthetic plant hormone in auxin family. It will be used as a rooting agent in vegetative propagation of plants to induce roots for stem and leaf cuttings. Generally, it can be used to induce flowering, preventing shedding of flower buds and immature fruits. It helps in enlargement of size, to increasing the yield and quality improvement of the produce. Gibberellins are essential in regulating major aspects of plant growth and developmental processes like seed germination (by breaking of dormancy), stem elongation, leaf expansion, trichome development, pollen maturation, induction of flowering.

Vishwakarma *et al*. (2017) conducted an experiment to find out the best concentration of PGRs in relation to growth, yield and quality of broccoli. The concentrations of PGRs they used was Nitrogen 0, 1 and 2%, NAA 60 ppm and 120 ppm, Gibberellic acid 0, 50 and 100 ppm. They found that application of nitrogen at 2.0 %, NAA @ 120 ppm, GA_3 @ 100 ppm was found significant growth, yield and quality of broccoli. Meena *et al.* (2018) conducted an experiment on effect of bio fertilizers and plant growth regulators (control, NAA @ 50 ppm, NAA @ 100 ppm, GA_3 @ 50 ppm and GA_3 @ 100 ppm) on cauliflower. In the individual application of PGRs, maximum plant height (64.58 cm), number of leaves per plant (24.05), length of stem (9.39 cm), minimum days taken to 50% flowering curd initiation (32.48), days taken to 50% of marketable curd size (58.32) and maximum chlorophyll content in leaves (0.45 mg/g).

MATERIALS AND METHODS

The research was conducted at Center of Excellence on Protected Cultivation and Precision Farming, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur (CG) during *rabi*, 2020-21. The experiment was performed in a "Randomized Block Design" with three replications comprising of ten treatments viz., T_0: Control (without any spray), T_1: GA_3 40 ppm, GA_3T_2: 60 ppm, T_3: GA_3 80 ppm, T_4: NAA 60 ppm, T_5: NAA 120 ppm, T_6: NAA 180 ppm, T_7: GA_3 40 ppm + NAA 60 ppm, T_8: GA_3 60 ppm + NAA 120 ppm and T_9: GA_3 80 ppm + NAA 180 ppm. Green Magic (F1 hybrid) seeds of broccoli were sown in the pro trays and monitored regularly by keeping them in nursery. Four weeks (28-30 days) old healthy seedlings having 12-15 cm height and 3-4 leaves were transplanted in beds having drip irrigation system which covered with mulch under the walk-in-tunnel. The area of walk-in-tunnel (Covered with polythene) was 696 sq m (72.5 Length X 9.6 Breadth) which fixed with an exhaust fan to maintain optimum temperature and relative humidity. 10 kgs FYM was applied to each bed. Water soluble fertilizers were given to the crop in the form of drenching and fertigation for fertilizer use efficiency.

Preparation of GA_3 solutions

To prepare 40 ppm, 60 ppm and 80 ppm of GA_3 solutions, 40 mg, 60 mg and 80 mg was measured by using electrical balance and taken into a glass

container (100 ml) individually. The containers were mixed with 99% ethyl alcohol (10-15 ml) for dilution of GA_3; and continuously stirred with glass rod for proper dilution. Then the solution was transferred into a volumetric flask (1000 ml) and make up the solution to 1 liter by adding normal water. The containers which contain solution was kept away from the light as GA_3 is photosensitive.

Preparation of NAA solutions

Plano fix 4.5 SL was taken as a source of Naphthalene acetic acid to prepare different doses of NAA solution. Plano fix will be containing 4.5 % of active ingredient (Alpha napthyl acetic acid). So, 1 ml of Plano fix should be dilute in 4.5 liters of water to prepare 10 ppm of NAA solution. In the similar way 60 ppm, 120 ppm and 180 ppm were prepared.

Preparation combined solutions of GA_3 and NAA

To prepare the combinations of GA_3 and NAA solutions, first required quantity of GA_3 was diluted in 99 % ethyl alcohol (10-15 ml) and made up to 500 ml by adding water. In other hand NAA solutions (according to the requirement) also prepared in 500 ml. Finally, these two solutions were mixed to make a uniform combined solution of GA_3 and NAA. The fresh solution was prepared each time of foliar application.

Two foliar applications were performed at 20 days after transplanting and 40 days after transplanting only in the morning or evening hours. The uniform spraying was carried out with the help of knapsack sprayer carefully to ensure that the leaves on both sides were completely wet with the spray solution.

The important parameters encompassed in the study were plant height (cm), no. of leaves/plant, leaf area (cm^2), canopy spread (cm^2), days to curd initiation, days to harvest, curd yield per plant, curd yield per plot and curd yield per hectare. The data were collected from five randomly selected plants for parameters mentioned above. The data was subjected to analysis of variance technique (ANOVA) and least significance difference test was applied to separate different treatment means (Panse and Sukhatme 1967).

RESULTS AND DISCUSSION

Quality parameters

The results clearly indicated that ascorbic acid, chlorophyll content and TSS of the curd were significantly influenced by the foliar application of GA_3 and NAA. Table 1 revealed that highest ascorbic acid content (138.7 mg) was obtained with the treatment T_9: GA_3 80 ppm + NAA 180 ppm which was at par with T_8: GA_3 60 ppm + NAA 120 ppm (131.6 mg) followed by T_7: GA_3 40 ppm + NAA 80 ppm (124.3 mg) and T_6: NAA 180 ppm (118.7 mg). While the lowest ascorbic acid content (84.233 mg) per hectare was recorded in the treatment T_0: control. It might be due to the physiological influence of NAA on activity of number of enzymes and due to more energy and food material available to the curds due to strong vegetative growth. These findings are in close conformity with Chanwala *et al.* (2019) in broccoli, Jakhar *et al*. (2018). Similarly, the highest chlorophyll content (79.3) was observed in the treatment T_9: GA_3 80 ppm + NAA 180 ppm which was at par with T_8: GA_3 60 ppm + NAA 120 ppm (75.49) and T_7: GA_3 40 ppm + NAA 80 ppm (73.5) followed by T_6: NAA 180 ppm (69.9), T_5: NAA 120 ppm (67.8). While the lowest chlorophyll content (44.2) was obtained from T_0: Control. Similar findings are reported by Jakhar *et al*. (2018), Meena *et al.* (2018) in cauliflower, Moniruzzaman *et al.* (2019) in cabbage. The data given in the Table 1 clearly showed that the highest TSS (6.5) was observed in the treatment T_9: GA_3 80 ppm + NAA 180 ppm which was at par with T_8: GA_3 60 ppm + NAA 120 ppm (6.3) and T_7: GA_3 40 ppm + NAA 80 ppm (6.0) followed by T_6: NAA 180 ppm (5.6), T_5: NAA 120 ppm (5.4). While the lowest chlorophyll content (4.6) was obtained from T_0: Control. The increase in TSS may be accounted to the hydrolysis of polysaccharides. Conversion of organic acids in to be soluble sugars and enhanced soluble of insoluble starch and pectin present in the cell wall and middle lamella. These results are in consequence with the findings of Chanwala *et al*. (2019) in broccoli. Dixit *et al*. (2020) reported that application of NAA @ 120 ppm increased TSS content in cauliflower. Analysis of variance doesn't show significant differences among the treatments for the shelf life of the curd. The data which is recorded was clearly revealed that there

Table 1. Effect plant growth regulators on ascorbic acid content (mg/100 g), chlorophyll content (SPAD value), TSS (%) and shelf life of the curd (days) in broccoli.

T. No.	Treatments	Ascorbic acid content in the curd (mg/100g)	Chlorophyll content in the curd (SPAD value)	TSS of the curd (%)	Shelf life of the curd (days)
T_0	Control	84.23	44.20	4.6	3
T_1	GA_3 40 ppm	97.50	52.70	4.8	3
T_2	GA_3 60 ppm	99.80	55.60	5.0	3
T_3	GA_3 80 ppm	102.40	59.80	5.1	3
T_4	NAA 60 ppm	106.30	62.40	5.2	3
T_5	NAA 120 ppm	112.40	67.80	5.4	3
T_6	NAA 180 ppm	118.70	69.90	5.6	3
T_7	GA_3 40 ppm + NAA 80 ppm	124.30	73.50	6.0	3
T_8	GA_3 60 ppm + NAA 120 ppm	131.60	75.49	6.3	3
T_9	GA_3 80 ppm + NAA 180 ppm	138.70	79.30	6.5	3
	SE (m) ±	4.727	2.848	0.196	0.211
	CD at 5%	14.043	8.461	0.582	0.626

no effect of foliar application of GA_3 and NAA on broccoli which is shown in Table 1.

Economics

Studies on the economics of the treatments are very important as they are of farmer's primary concerned to monetary returns and profitability by crop recommendation and adaptation of any package of practice by the farmer depends upon economics viability of the treatments hence, it becomes necessary to workout economics of different treatments of the experiment conducted for determining the best treatment. The details of cost of cultivation, gross income, net income and B: C ratio for individual treatment worked out and presented in Table 2. Total cost of cultivation was calculated by adding the common cost and treatment cost for each treatment. Common cost includes the cost of field preparation, bed preparation, cost of seeds, sowing and transplanting expenses, expenditure kept for manures, fertilizers and chemicals for plant protection, depreciation cost for drip irrigation

Table 2. Effect of plant growth regulators on economics of broccoli production.

Treatments	Common cost (Rs/ha)	Treatment cost (Rs/ha)	Total cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	B:C ratio
T_0	1,67,900	0	1,67,900	2,75,150	1,07,250	1.63
T_1	1,67,900	4050	1,71,950	4,18,700	2,46,750	2.43
T_2	1,67,900	6075	1,73,975	4,36,650	2,62,675	2.50
T_3	1,67,900	8100	1,76,000	4,52,750	2,76,750	2.57
T_4	1,67,900	1300	1,69,200	4,78,100	3,08,900	2.82
T_5	1,67,900	2600	1,70,500	4,88,850	3,18,350	2.86
T_6	1,67,900	3900	1,71,800	5,10,750	3,38,950	2.97
T_7	1,67,900	5350	1,73,250	5,25,650	3,52,400	3.03
T_8	1,67,900	8675	1,76,575	5,56,000	3,79,425	3.14
T_9	1,67,900	12000	1,79,900	5,93,200	4,13,300	3.29

system and overhead net tunnel, expenses of intercultural operations like weeding, spraying. The common cost is same for all the treatments. While the treatment cost was varied with each other as it depended upon the amount of plant growth regulators used for each treatment. The perusal of data (Table 2) showed that maximum benefit cost ratio (3.29) reported in T_9: GA_3 80 ppm + NAA 180 ppm, which is due to highest yield and maximum returns obtained per hectare. In contrast, lowest benefit cost ratio (1.64) was obtained with T_0: Control due to lowest yield and minimum returns obtained per hectare. Hence, it can be concluded that, combined use of GA_3 and NAA resulted in maximum yield, gross returns, net returns and B: C ratio. Similar results were obtained by Mazumdar (2013), Sultana (2015), Dixit *et al*. (2020), Dev *et al*. (2020) in cabbage, Chanwala *et al*. (2019) in broccoli.

CONCLUSION

The results of the study entitled "Studies on the effect of foliar application of GA_3 and NAA on growth, yield and quality of broccoli (*Brassica oleracea* var. *italica* L.) under Walk-in-tunnel." Confirmed the use of plant growth regulators for getting high yields with high quality. The results of the current study revealed that, foliar application of GA_3 and NAA in broccoli produced higher yield and performed better with respect to growth and quality characters. Among all the treatments, the plants sprayed with GA_3 80 ppm + NAA 180 ppm found to be superior in quality and yield attributing characters which is at par with T_8: GA_3 60 ppm + NAA 120 ppm. The highest benefit: Cost ratio was also recorded with GA_3 80 ppm + NAA 180. Based on all the results obtained from this investigation concluding that GA_3 80 ppm + NAA 180 was optimum dosage for getting higher yield in broccoli crop.

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