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Effect of application of GA_3 and NAA on yield, quality and economics of broccoli (*Brassica oleracea var. italica*) var. Pusa KTS-1

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Abstract
The present investigation was carried out on "Effect of application of GA_3 and NAA on yield, quality and economics of broccoli (*Brassica oleracea var. italica*) var. Pusa KTS -1" at Horticultural Research Farm, Department of Horticulture, B. A. College of Agriculture, Anand Agricultural University, Anand during *Rabi* season of the year 2019-20. The experiment was laid out in Randomized Block Design replicated thrice with nine treatments. Among all the different treatments foliar application of GA_3 50 mg/l recorded significantly, highest yield 671.67 g/plant, 19.31 kg/plot and 22.35 t/ha. The highest chlorophyll content (0.20 mg/100g) and the maximum shelf life (3.83 days) was also recorded in treatment T_3 (GA_3 50 mg/l). The highest net realization (263760 ₹/ha) and benefit cost ratio (3.6) was observed in foliar application of GA_3 50 mg/l.

Keywords: Broccoli, GA_3, NAA, yield, quality and economics

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) [4]. 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) [6-7]. 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-B2 (Hazra and Som, 1999) [3]. In India, Cauliflower and Broccoli is cultivated in an area of 5.69 lakh ha with an annual production of 70.60 MT and productivity of 19.05 t ha^{-1} (FAO, 2018) [2].
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) [1]. 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) [9-10]. 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) [14].

Methods and Materials
The present investigation was carried out on "Effect of application of GA_3 and NAA on yield, quality and economics of broccoli (*Brassica oleracea var. italica*) var. Pusa KTS -1" at Horticultural Research Farm, Department of Horticulture, B. A. College of Agriculture, Anand Agricultural University, Anand during *Rabi* season of the year 2019-20. The broccoli seeds were sown in raised bed should be prepared by addition of well rotten farmyard manure or

vermicompost @ 10 kg/m^2. The field was ploughed thoroughly and then rotavated until the soil was friable and free from perennial weeds. Well-rotten farm yard manure @15-20 t ha^{-1} was incorporated at the time of final ploughing. Plots measuring 37.4 m x 18.5 m were laid out. Healthy seedlings of 30 days old were transplanted in evening hours as per the treatments. After transplanting basal dose of half of the nitrogen @ 50 kg ha^{-1}, full dose of phosphorous @ 50 kg ha^{-1} and potash @ 50 kg ha^{-1} was applied at the time of land preparation. The remaining dose of nitrogen was top dressed in two equal splits, one at 30 days after transplanting and other at curd initiation stage. Hand weeding was done at 15, 30 and 45 days after transplanting.

The experiment was laid out in Randomized Block Design replicated thrice with nine treatments *viz.*, T_1 - Absolute control, T_2 - GA_3 25 mg/l, T_3 - GA_3 50 mg/l, T_4 - GA_3 75 mg/l, T_5 – NAA 60 mg/l, T_6 – NAA 120 mg/l, T_7 – NAA 180 mg/l, T_8 – GA_3 25 mg/l + NAA 60 mg/l, T_9 - GA_3 50 mg/l + NAA 120 mg/l. Five plants were tagged randomly in each treatment of respective replication for recording data on various traits *i.e.*, curd yield per plant (g), curd yield per plot (kg), curd yield per hectare (t), chlorophyll content in curd (mg/100g) and shelf life of curd (days). The data pertaining to all the characters studied were subjected to the statistical analysis of variance technique as described by Panse and Sukhatma (1985) [8].

Result and Discussion

Effect on yield parameters

Curd yield (g/plant)

The curd yield per plant was significantly affected by foliar application of GA_3 and NAA. The highest curd yield (671.67 g/plant) was found in treatment T_3 (GA_3 50 mg/l) which was statistically at par with treatment T_4 *i.e.* GA_3 75 mg/l (595.31 g), whereas minimum curd yield per plant (235.35 g) was recorded in absolute control. The above results were in accordance with the findings of Roy and Nasiruddin (2011) [11] in cabbage, Reza *et al*. (2015) [9-10] in broccoli and Kaur and Mal (2018) [5] in cauliflower.

Curd yield (kg/plot)

The curd yield per plot was significantly affected by foliar application GA_3 and NAA treatment. The maximum curd yield (19.31 kg/plot) was found in treatment T_3 (GA_3 50 mg/l) which was statistically at par with treatment T_4 (GA_3 75 mg/l) *i.e.* (18.29 kg/plot). Whereas the least curd yield (13.20 kg/plot) was recorded in absolute control.

Curd yield (t/ha)

The curd yield per hectare as significantly affected by foliar application GA_3 and NAA. The highest curd yield (22.35 t/ha) was found in treatment T_3 (GA_3 50 mg/l), which turned superior over rest of the treatments. Which was statistically at par with treatment T_4 (21.17 t/ha), whereas minimum curd yield (15.28 t/ha) was recorded in absolute control. The above results were in accordance with the findings of Roy and Nasiruddin (2011) [11] in cabbage, Reza *et al*. (2015) [9-10] in broccoli and Kaur and Mal (2018) [5] in cauliflower.

Effect on quality parameters

Chlorophyll content in curd (mg/100g)

The chlorophyll content of curd was significantly affected by foliar application of GA_3 and NAA. The highest chlorophyll content (0.20 mg/100g) was found in treatment T_3 *i.e.* GA_3 50 mg/l as compared to rest of the treatments, whereas minimum chlorophyll content (0.13 mg/100g) was recorded in absolute control. The above results were also in accordance with the findings of Reza *et al*. (2015) [9-10] in broccoli; Kumar *et al.* (2017) [6] in cauliflower and Kaur and Mal (2018) [5] in cauliflower.

Shelf life of curd (days)

The shelf life was significantly affected by an application of GA_3 and NAA through foliar. The maximum shelf life (3.83 days) was recorded in treatment GA_3 50 mg/l which was statistically at par with treatment T_4 *i.e.* GA_3 75 mg/l (3.77 days). Whereas, minimum shelf life of curd (1.13 days) was recorded in absolute control. The above result was in accordance with the finding of Verma *et al.* (2018) [13] in broccoli.

Effect on economics of treatments

Studies on the economics of the treatments application are very important as they are of farmers primary concerned to monetary returns and profitability by crop recommendation and adaption of any package of practice by the farmer depends upon economics viability of the treatments hence, it becomes necessary to work out economics of different treatments of the experiment conducted for determining the best treatment. Data related to economics are present in Table 2.

Total cost of cultivation

Total expenditure of each treatment was divided into two parts *viz*., fixed expenditure and treatments wise extra cost. Fixed expenditure includes cost of field preparation seed, sowing expenses, transplanting expanses, fertilizers application, weeding and use of insecticide spraying, watching, irrigation, harvesting and general expenses. The cost of cultivation of Rs 60291 was common for all the treatments but the cost of different treatments of plant growth regulators varied from treatment to treatment. The highest total cost of cultivation (Rs 73809 /ha) was incurred in GA_3 @ 75 mg/l (T_4) against the total cost of Rs 64691/ha involved in control (T_1).

Gross income

Data embodied in Table 2 revealed that the maximum gross income of Rs 335250/ha was obtained with the GA_3 @ 50 mg/l (T_3) followed by in order resulting are T_4 (317550), T_6 (Rs 286800), T_5 (Rs 280650) against T_1 control (Rs 229200)**.**

Net income

The net return obtained by foliar application of GA_3 and NAA treatment to broccoli crop was ranging from Rs 164507 to Rs 263750 per hectare, maximum net return of 263750/ha was obtained with treatment T_3 followed by T_4 (Rs 243741), T_5 (Rs 219740), T_6 (219533) against T_1 (Rs 164507).

Benefit cost ratio

The B:C ratio for foliar application of nine GA_3 and NAA treatment to broccoli crop was ranging from 2.5 to 3.6 while maximum benefit: cost ratio obtained with T_3 (3.6) followed by T_4 (3.3), T_5 (3.2), T_6 (3.2) against T_1 (2.5). Similar results were reported by (Singh, B.K. 2015) in cabbage.

Table 1: Effect of foliar application of GA_3 and NAA on yield parameters

Sr. No.	Treatment	Curd yield (g/plant)	Curd yield (kg/plot)	Curd yield (t/ha)	Chlorophyll content (mg/100g)	Shelf life (days)
T_1	Absolute control	235.35	13.20	15.28	0.13	1.13
T_2	GA_3 25 mg/l	426.69	14.32	16.57	0.14	1.60
T_3	GA_3 50 mg/l	671.67	19.31	22.35	0.20	3.83
T_4	GA_3 75 mg/l	595.31	18.29	21.17	0.17	3.77
T_5	NAA 60 mg/l	578.45	16.16	18.71	0.15	2.80
T_6	NAA 120 mg/l	474.76	16.52	19.12	0.16	1.45
T_7	NAA 180 mg/l	389.17	14.45	16.72	0.16	2.53
T_8	GA_3 25 mg/l + NAA 60 mg/l	428.56	14.04	16.25	0.15	2.00
T_9	GA_3 50 mg/l + NAA 120 mg/l	350.75	15.21	17.60	0.17	1.27
	S. Em.±	27.6	0.74	0.86	0.005	0.12
	C.D. at 5%	82.7	2.22	2.57	0.014	0.35
	C.V.%	10.4	8.3	8.2	4.96	8.8

Table 2: Economics of broccoli as influenced by different treatments

Treatment	Treatment detail	Fixed costs	Curd Yield (t/ha)	Gross realization (₹/ha)	Total cost of cultivation (₹/ha)	Net realization (₹/ha)	BCR
T_1	Absolute control	60291	15.28	229200	64693	164507	2.5
T_2	GA_3 25 mg/l	60291	16.57	244050	69172	174878	2.5
T_3	GA_3 50 mg/l	60291	22.35	335250	71490	263760	3.6
T_4	GA_3 75 mg/l	60291	21.17	317550	73809	243741	3.3
T_5	NAA 60 mg/l	60291	18.71	280650	67060	219740	3.2
T_6	NAA 120 mg/l	60291	19.12	286800	67267	219533	3.2
T_7	NAA 180 mg/l	60291	16.72	250800	67470	183330	2.7
T_8	GA_3 25 mg/l + NAA 60 mg/l	60291	16.25	243750	69379	174371	2.5
T_9	GA_3 50 mg/l + NAA 120 mg/l	60291	17.60	264000	71874	192126	2.6

Selling price of curd: - 15 `/kg

Conclusion

On the basis of the *Rabi* season experiment it can be concluded that foliar application of GA_3 50 mg/l treatment at 20 and 40 days after transplanting found most effective treatment with regards to yield and quality parameters as well as economics in broccoli cv. Pusa KTS -1.

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