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Effect of foliar spray of GA_3 and NAA on growth, yield, and quality of cabbage (*Brassica oleracea* var. *capitata* L.)

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Abstract
Present experiment entitled "Effect of foliar spray of GA_3 and NAA on growth, yield, and quality of cabbage (*Brassica oleracea* var. *capitata* L.)" was conducted during the *Rabi* season of 2022 - 23 at Agriculture Research Farm, Rama University, Mandhana, Kanpur. The experiment was laid out in Randomized Block Design (RBD) with three replications and nine treatments *viz.* T_1 =Control, T_2 =GA_3 30 mg foliar spray at 30 DAT, T_3 =GA_3 60 mg foliar spray at 30 DAT, T_4 =GA_3 90 mg foliar spray at 30 DAT, T_5 =GA_3 120 mg foliar spray at 30 DAT, T_6 =NAA 50 ppm foliar spray at 30 and 45 DAT, T_7 =NAA 75 ppm foliar spray at 30 and 45 DAT, T_8 =NAA 100 ppm foliar spray at 30 and 45 DAT, T_9 =NAA 125 ppm foliar spray at 30 and 45 DAT. The result of the study revealed that the maximum plant height (29.5cm), leaf length (28.50cm), leaf width (27.78cm), Number of open leaves (12.5) stalk length (11.40cm), minimum days of harvesting from transplanting (90.40), head diameter (50.8 cm), head weight (1.30kg) yield/ ha (35.67q/ha), TSS content (4.43 ºBrix), and acidity (2.50%) was reported in treatment T_9 (NAA 125 ppm foliar spray at 30 and 45 DAT) followed by treatment T_8 = NAA (100 ppm) foliar spray at 30 and 45 DAT. Basis on these results treatment T_9 can be suggested to the local farmer of Kanpur regions to obtain higher yield and better quality of cabbage.

Keywords: foliar spray, GA3, NAA, cabbage, *Brassica oleracea* var. *capitata* L.

Introduction
Cabbage (*Brassica oleracea* var. *capitata* L.) is a member of Cole crop which has originated from a single wild ancestor *Brassica oleracea* L. var. *oleracea* (syn. *sylvestris*) commonly known as wild cabbage, cliff cabbage, or„ Colewart", through mutation and introgress ion from wild species, human selection and adaptation. Historical evidence indicates that modern hard head white cabbages evolved in Germany are descended from wild non-heading leafy cabbage that originated in the eastern Mediterranean and Asia Minor (De Candolle, 1883) and was probably brought into western Europe by the Celts.

Cabbage is more nutritious than cauliflower and knol khol and it contains vitamin-A (2000 IU), thiamine (0.06 mg), riboflavin (0.03 mg), and vitamin C (124 mg) per 100 g edible part. It also rich in minerals like potassium (114 mg), phosphorus (44 mg), calcium (39 mg) sodium (14.1 mg) and iron (0.8 mg) per 100 g edible part. Cabbage juice is used as a remedy against poisonous mushrooms and as a gargle against harshness. Cabbage has an anti-cancer property and protects against cancer due to the presence of indole-3-carbinal. (Fageria *et al.*, 2003) [3].

India continues to produce more veggies than any other country in the world, trailing only China (11.4%) in terms of global production. The majority of people in India are vegetarians, and vegetables play a significant role in their daily diet. India consumes only 62.79 kg of veggies per person annually, compared to 115.92 kg, 114.89 kg, and 105.2 kg for Korea, China, and Japan, respectively. India's yearly vegetable consumption is quite low when compared to these nations, but it is unquestionably greater than other Asian countries. Cabbage is produced on 379.0 thousand hectares in India, with an annual yield of 8597.0 thousand tonnes and a productivity of 22.7 tonnes per hectare. With a production of 2341.87 (000) tonnes, West Bengal is the state that produces the most cabbage, followed by Orissa (1130.56 thousand tonnes), Gujarat (796.73 thousand tonnes), and Madhya Pradesh. (National Horticulture Board. 2021-22).

The present vegetable production is not sufficient to meet the requirement of the growing population and hence, there is immense scope to diversify the area under cultivation of other crops or by adopting new technology generated in respect of a right of variety and its seed, proper planting season, spacing, management practices, manuring and control of pests and diseases.

Diverse workers have suggested varying amounts of main and minor nutrients to boost cabbage output. Similar to this, using a plant growth regulator is preferable to boost vegetable output without compromising their quality. Utilizing plant growth regulators offers new ways to get beyond environmental restrictions on germination, development, shoots, roots, and ultimately production and quality. (Wadkar *et al.* 2002) [8].

Organic substances that improve, impede, or change a plant's internal processes are known as growth regulators. This increases yields and quality of produce. They promote the production of metabolites and the distribution of nutrients and metabolism into different components, which eventually promotes greater recuperation. Gibberellins and NAA are two of the few commercially accessible growth regulators that are particularly well-liked and utilized in a variety of vegetable crops. When utilized during the active (vegetable) growth stage of the plant, plant growth regulators function at very low concentrations (Mishra 2006) [5].

Among the growth promoters, GA3 and NAA play a key role in improving plant growth and vegetable harvesting. GA3 is one of the key growth factors that promote cell division and cell proliferation, thus contributing to the growth and development of many plants. GA3 controls various aspects of plant development and are known to be involved in all phases of the developmental cycle of angiosperms. Gibberellins stimulate cell elongation by altering the rheological properties of the cell wall; as a consequence, the water potential of the cell is lowered allowing for water uptake and therefore an increase in cell volume (Bista *et al*, 2022) [1]. When it is too cold, plant growth becomes stunted. Application of gibberellic acid can stimulate morphological characteristics of cabbage like plant height, number of leaves, head diameter, head thickness as well as the weight of head. Generally, the price of winter vegetable is higher in late of rabi season, in comparison with the pick season. If growth could be enhanced by applying gibberellic acid, farmers can get higher economic return by matching up the demand of off season (Jones and Kaufman, 1983) [4].

NAA affects body processes, speeds up maturation, and improves the quality of vegetables and fruits. The use of crop growth controllers to improve yields and the quality of many vegetable crops was emphasized by a few workers (Tomar *et al*. 2020) [7].

The advantage of crop growth controllers is that they increase the yield of many cabbage varieties, as some of them promote growth. Crop growth controls are helpful and available in the market but their use and focus will still be improved. Considering the above circumstances, this research work was undertaken to find out the appropriate concentration of GA3 for increasing production and maximum yield and economic return of cabbage. In India, a few research workers have studied the effects of crop growth on various vegetable crops, especially in seed treatment, seedling treatment and leaf use, but few indications are available for the use of cabbage control leaflets.

Material and Method

The experiment Effect of foliar spray of GA_3 and NAA on growth, yield, and quality of cabbage (*Brassica oleracea* var. *capitata* L.)" was conducted during the *Rabi* season of 2022-23 at Agriculture Research Farm, Rama university, Mandhana, Kanpur. The experiment was laid out in Randomized Block Design (RBD) with three replications and nine treatments *viz.* T_1 =Control, T_2 =GA_3 30 mg foliar spray at 30 DAT, T_3 =GA_3 60 mg foliar spray at 30 DAT, T_4 =GA_3 90 mg foliar spray at 30 DAT, T_5 =GA_3 120 mg foliar spray at 30 DAT, T_6 =NAA 50 ppm foliar spray at 30 and 45 DAT, T_7 =NAA 75 ppm foliar spray at 30 and 45 DAT, T_8 =NAA 100 ppm foliar spray at 30 and 45 DAT, T_9 =NAA 125 ppm foliar spray at 30 and 45

DAT. The crop was raised at spacing of 30cm x 30 cm and plot size of 60X 60 cm. Standard culture practices recommended for cabbage was followed uniformly in all experimental plots. Experimental data was subjected to statistical analysis as per the standard statistical procedure given by Gomez and Gomez (1984).

Result

Growth parameters

Results showed that plant height measured at harvest was recorded maximum (29.5cm) under the treatment T_9 (NAA 125 ppm foliar spray at 30 and 45 DAT) followed by T_8 (28.4cm) and T_7 (27.5cm) whereas minimum (25.0cm) control, (Table -1).

There was a significant response from plant growth regulators with respect to number of leaves per plant. Result indicate that maximum number of open leaves (12.5) were recorded in T_9 (NAA (125 ppm) foliar spray at 30 and 45 DAT) followed by T_8 (12.0) and T_7 (11.5) while minimum (10.0) in T_1 control, (Table-1).

It is clear from the data that maximum length of leaf (28.50 cm) were recorded in treatment T_9 (NAA (125 ppm) foliar spray at 30 and 45 DAT) and it was significantly at par with T_8 (28.00cm) and T_7 (27.5cm) whereas minimum length of leaf (22.13cm) was in control, (Table-1).

The result shows that, there was significant variation among the treatments and maximum width of leaf (27.78cm) was recorded in Treatment T_9=NAA (125 ppm) foliar spray at 30 and 45 DAT followed by T_8 (26.78cm) and T_7 (25.90cm) whereas minimum leaf width (21.0 cm) was reported in control (Table-1).

It is clear from the data that highest stalk length (11.40cm) was recorded in treatment T_9 NAA (125 ppm) foliar spray at 30 and 45 DAT. It was significantly at par with T_7 (10.56cm) and T_5 (9.30). A lowest value of stalk length (8.3cm) was recorded in control, (Table1).

It is clear from the data that maximum days of harvesting from transplanting (99.67) was reported in control whereas minimum in T_9 (90.4) = NAA (125 ppm) foliar spray at 30 and 45 DAT followed by T_8 (92.8) and T_7 (93.6), Table 1.

Yield parameters

At harvesting stage, head diameter ranges were from 40.1 cm to 50.8 cm. Highest diameter (50.8 cm)was recorded in treatment T_9 which was significantly at par with T_8 (50.1) and T_7 (49.5cm) Whereas lowest diameter (40.1cm) was noted in control, (Table 1).

The highest head weight (1.30kg) was produced by the treatment T_9=NAA (125 ppm) foliar spray at 30 and 45 DAT followed by T_8 (1.25) and T_7 (1.20) whereas the minimum head weight (0.50kg) was recorded in control, (Table 1).

The highest yield per plot was produced by the treatment NAA (125 ppm) foliar spray at 30 and 45 DAT), 17.5 kg which was at par with the treatment NAA (100 ppm) foliar spray at 30 and 45 DAT, (16.5 kg) and NAA (75 ppm) foliar

spray at 30 and 45 DAT, (16.8kg), the significantly lowest yield per plot (8.1 kg) were produced by the control treatment, (Table 2).

The result shows that, yield per hectare of cabbage was found statistically. It was influenced significantly by different growth regulators. Yield per hectare of cabbage ranged from 18.37 t/ha to 35.67 t/ha.

Quality parameters

Data presented in table clearly indicate that highest TSS content (4.43 º Brix) was estimated with the application treatment T_9 followed by T_8 (4.40º Brix) and T_7 (4.14 º Brix). While lowest (2.89) TSS content was estimated in control.

Among the different treatments, treatment T_9 (NAA (125 ppm) foliar spray at 30 and 45 DAT) produce maximum acidity (2.50%) which was significantly at par with T_8 (2.10%) and T_7 (1.96%) while lowest acidity (1. 00%) was reported in control.

It is clear from the data that highest content of Vitamin C (33.8gm) was observed with the application NAA (125 ppm) foliar spray at 30 and 45 DAT followed by T8 (33.8 mg)and T7 (32.0 mg) whereas lowest content (28.0 mg) was recorded in control.

Table 1: Growth parameters and Yield Parameters

Treatments	Growth Parameters					Yield Parameters		
	Plant Height At harvest (cm)	Number of open leaves	Stalk Length (cm)	Length of leaf (cm)	Width of leaf (cm)	Days to Harvesting	Head Diameter (cm)	Head Weight (cm)
T_1 =Control	25.0	10.0	8.3	22.13	21.0	99.67	40.1	0.50
T_2 = GA3 (30 mg) foliar spray at 30 DAT	27.7	10.1	8.75	24.13	22.5	98.9	45.0	0.70
T_3 =GA3 (60 mg) foliar spray at 30 DAT	28.0	10.3	9.00	24.0	22.5	96.5	46.9	0.80
T_4 =GA3 (90 mg) foliar spray at 30 DAT	28.9	10.2	9.15	25.00	23.00	96.9	46.1	0.90
T_5= GA3 (120 mg) foliar spray at 30 DAT	26.8	11.0	9.30	27.0	24.67	95.3	47.7	0.95
T_6 =NAA (50 ppm) foliar spray at 30 and 45 DAT	26.7	11.0	10.0	27.3	25.67	94.4	48.8	1.00
T_7= NAA (75 ppm) foliar spray at 30 and 45 DAT	27.5	11.5	10.56	27.5	25.90	93.6	49.5	1.20
T_8=NAA (100 ppm) foliar spray at 30 and 45 DAT	28.4	12.0	9.27	28.00	26.78	92.8	50.1	1.25
T_9=NAA (125 ppm) foliar spray at 30 and 45 DAT	29.5	12.5	11.40	28.50	27.78	90.4	50.8	1.30
SEm (±)	0.71	0.44	1.50	1.01	2.05	0.59	1.26	0.67
CD (5%)	2.1	NS	2.23	3.0	1.87	1.25	3.76	2.78
CV %	1.25	0.47	3.93	1.23	0.17	0.65	0.89	1.43

Table 2: Yield parameters and quality parameters

Treatments	Yield Parameters		Quality Parameters		
	Yield per plot (kg)	Yield per (q)	TSS (º Brix)	Acidity (%)	Vitamin C (mg/ 100g)
T_1 =Control	8.1	18.17	2.89	1.00	28.0
T_2 = GA3 (30 mg) foliar spray at 30 DAT	9.4	20.55	3.00	1.01	29.0
T_3 =GA3 (60 mg) foliar spray at 30 DAT	10.5	22.27	3.16	1.00	30.1
T_4 =GA3 (90 mg) foliar spray at 30 DAT	11.3	24.25	3.25	1.20	30.7
T_5= GA3 (120 mg) foliar spray at 30 DAT	11.6	26.38	3.50	1.50	31.4
T_6 =NAA (50 ppm) foliar spray at 30 and 45 DAT	13.4	28.67	3.87	1.76	31.6
T_7= NAA (75 ppm) foliar spray at 30 and 45 DAT	14.8	31.45	4.14	1.96	32.0
T_8=NAA (100 ppm) foliar spray at 30 and 45 DAT	16.5	32.13	4.40	2.10	32.8
T_9=NAA (125 ppm) foliar spray at 30 and 45 DAT	17.5	35.67	4.43	2.50	33.8
SEm (±)	2.9	2.89	1.5	0.65	1.00
CD (5%)	5.45	5.78	5.16	2.99	4.08
CV %	3.94	3.25	3.8	1.25	2.45

Conclusion

The findings of the present investigation may conclude as follows: The results of a study entitled “Effect of foliar spray of GA3 and NAA on growth, yield and quality of cabbage (*Brassica oleracea* var. *Capitata* L.)” Conducted at Agriculture Research Farm, Rama university, Mandhana, Kanpur, during the *rabi* season of the year 2022-23 confirmed the use of growth controllers to better grow and produce cabbage. The results of the current study revealed that, in general, growth regulators were successful in increasing cabbage yield. Among the various plant growth regulators, NAA (125 ppm) foliar spray at 30 and 45 DAT record high results in terms of, plant height, stem length, leaf length, leaf width, stalk size, head size, head weight per plant, yield head per plot and head yield per hectare.

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