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Effect of Various PGR and Micronutrients on Growth and Yield of Cabbage in Eastern Region of Uttar Pradesh, India

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ABSTRACT

The experiment comprising three treatments of plant growth regulators (BA @ 15ppm, GA_3 @ 50 ppm and NAA @ 100 ppm),three treatments of micronutrients ($ZnSO_4$ @ 5%, $FeSO_4$ @ 0.5% and boric acid @ 0.2%) and one untreated control plot thus, seven treatments were tested in randomized block design with three replications. Results showed that application of GA_3 @ 50 ppm recorded maximum and significantly superior plant height (18.85 cm), number of leaves per plant (13.31), leaf area at harvest (1027 cm^2) and maximum average weight of head (532.93 g), head yield per plot (25.51kg), head yield (270.90 q/ha) and $ZnSO_4$ @5% record maximum plant spread (638.05 cm^2). However, foliar application of NAA @ 100 ppm was found statistically at par with GA3 @ 50 ppm. The results of the study further, revealed that application of GA_3 @ 50 ppm to the cabbage crop recorded significantly highest plant height (18.85 cm), number of leaves per plant (13.31), leaf area, took minimum days for head initiation & head maturity, maximum average weight of head (532.93 g/plant), yield per plot & total head yield (25.51 kg/plot and 270.90 q/ha).

Key words: *Cabbage, PGR, Micronutrients, Eastern Uttar Pradesh, Yield and growth parameters*

Introduction

Brassicaceae is the family name for the biennial herbaceous vegetable crop known as cabbage (*Brassica oleracea* var. *capitata* L.). Cabbage originated in Western Europe and along the northern coastlines of the Mediterranean Sea (Chauhan, 1986). It is grown successfully in both tropical and subtropical climates. It is marked as a winter vegetable in India and is grown throughout the year in various regions. The nutrients and minerals in cabbage are abundant. The head of cabbage is consumed raw, boiled, and cooked used in pickles, curries, and vegetable dehydrators.

According to reports, 100 g of cabbage's green edible component provides 92% water, 24 kcal of dietary energy, 1.5 g of protein, 4.8 g of carbohydrate, and 40,60 mg of vitamin C, 0.05 mg of riboflavin, 0.3 mg of niacin, 0.6 mg of iron, 600 IU of carotene, and mg of calcium (Rashid, 1993). It restores appetite and digestion and balances acidity (Katyal and Chadha, 1985). The "sinigrin" glucoside is what gives cabbage its flavour. (Singh *et al*., 2004). Throughout the temperate, tropical, and subtropical regions of the world, cabbage is widely grown. South Korea, Indonesia, Japan, South India, China, the Russian Federation, and countries that grow kale. In terms of both output and area, India is just behind China. In India, the states of Orissa, West Bengal, U.P., Bihar, Karnataka, Maharashtra, Gujrat, Punjab, and Himachal Pradesh produce the majority of the country's cabbage. Fageria *et al*. (2003). with

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an annual production of roughly 9.270 million tons, cabbage is grown over an area of about 0.397 million hectares in India (Anonymous, 2019-20). A small number of substances, aside from nutrition, can alter development (Leopold, 1963). Throughout the many stages of development, from germination to harvest and post-harvest presentation, PGRs are employed to adjust crop growth rate and growth model. When treated with plant growth regulators, particularly GA_3 and NAA, cabbage was found to exhibit fast growth, early head formation, and increased yield (Dhengle and Bhosale, 2008). Many commercial plant roots horticulture treatments include naphthalene acetic acid (NAA), a synthetic plant hormone in the auxin family. NAA significantly influences the numerous horticultural and vegetable crops, as well as fruit retention, have been shown to significantly increase productivity (Younis and Tigani, 1977). Using GA_3, it is possible to boost cabbage yield (Islam *et al.*, 1993). Benzyl adenine (6-benzylaminopurine) stimulates plant growth and development by establishing blooms and increasing fruit richnesspromoting the division of cells.Using micronutrients helps increase the translocation of carbohydrates from the site of synthesis to the storage organ and also contributes to improving cabbage quality and production (Jenny *et al*., 2008). The right and judicious application of nutrients and management techniques is one of the most crucial elements that may guarantee financial returns from the cultivation of cabbage. In light of these facts, the current study makes use of foliar applications of zinc, iron, and boron as micronutrients as well as naphthalene acetic acid, gibberellic acid, and benzol adenine as plant growth regulators to assess their effect on growth and yield of cabbage. Zinc is essential for maintaining the structure and form of protein molecules, and it is fundamental to their function as enzymes or structural proteins. Diverse physiological processes, including cell replication, are impacted by zinc deficiency.

Materials and Methods

The present study was carried out in Horticulture Research Farm, Deeksha Bhawan, Department of Horticulture, Institute of Agriculture & Natural Science, Deen Dayal Upadhyay Gorakhpur University, Gorakhpur during the *Rabi* season of the year 2022-23 with Randomized block design (RBD) with three replications. With the variety *Pusa Mukta.* The size of each plot was 3 x 3.15 m with a spacing of 60 x 45 cm counting 35 plants per plot. The gap between the plots was 50 cm and between the replications was 1 m. A total of seven treatments were their including the untreated control were selected for the investigation in which there were three micronutrients ($ZnSO_4$@ 0.5%, $FeSO_4$ @ 0.5% and Boric acid @ 0.2% and three plant growth regulators (BA @ 15 ppm, GA_3 @ 50 ppm and NAA @ 100 ppm) and an untreated control plot. Plants in untreated control plots had no spray. With recommended fertilizer N: P: K dose at the rate of 130:80:60 kg/ha at the time of transplanting was applied. The data were taken from randomly selected five plants from each plot on various characters *viz*., plant height(cm), plant spread (cm^2), leaf yield (q/ha) and head yield (q/ha).

Results and Discussion

Plant height (cm)

The data presented in Table 1 revealed that the application of plant growth regulators significantly influenced the plant height of cabbage. The maximum and significantly superior plant height (18.85 cm) at 45 days after transplanting was observed at GA_3 @ 50 ppm treatment which was significantly higher than the rest of the treatments except NAA @ 100 ppm. Data further indicated that foliar application of different micronutrients also had a significant effect on plant height during experimentation. Foliar application of $ZnSO_4$ @ 0.5% recorded a maximum plant height of 16.74 cm. Minimum plant height was observed in control.

Number of leaves per plant

The analysis of data in Table 1 indicated that plant growth regulators significantly affected the number of leaves per plant of cabbage. It is apparent from the data that foliar spray of GA_3 @ 50 ppm recorded a significantly higher number of leaves (13.31). Similarly, the application of various micronutrients significantly influenced the number of leaves per plant. The maximum number of leaves per plant (12.16) was recorded with application of ZnSO4 @ 0.5%. But while the minimum number of leaves per plant was observed treatments were in control.

Plant spread (cm^2)

It is apparent from the data in Table 1 that plant spread was significantly affected by foliar spray of

plant growth regulators. The maximum and significantly better plant spread (636.29 cm^2) at 45 DAT was recorded under treatment (GA_3 @ 50 ppm) over the rest of the plant growth regulators treatments**.** Data given in Table 1 further indicated that the application of micronutrients had significantly increased the plant spread of cabbage. Significantly higher plant spread (638.05 cm2) at 45 DAT was recorded with application of $ZnSO_4$ @ 0.5 % micronutrients.

Leaf area (cm^2)

A critical analysis of data in Table 1 indicated that leaf area had a significant effect with foliar spray of plant growth regulators. The maximum leaf area (1027.54cm^2) was recorded at harvest under treatment GA3 @ 50 ppm which was found significantly higher than the rest of the treatments. Data mentioned in the same table further indicated that the application of different micronutrients significantly affected the leaf area of cabbage at harvest. Application of $ZnSO_4$ @ 0.5% recorded significantly higher leaf area of (1019.32cm^2) at harvest over control and Boric acid @ 0.2%, but statistically at par to FeSO4 @ 0.5%. But minimum leaf area was recorded in control. The results of the interaction were found insignificant and therefore, are not being discussed here.

The results of the investigation indicated that different plant growth regulators significantly affected the plant height, number of leaves, plant spread, leaf area as well as chlorophyll content, Application of GA_3 @ 50 ppm increased the plant height, number of leaves, plant spread, leaf area as well as chlorophyll content over control and BA @ 15 ppm, but statistically at par to NAA @ 100 ppm. These findings indicated that PGRs played a significant role in enhancing the growth of cabbage. The marked increase in all these growth parameters might be due to the effect of plant growth regulators on cell division and cell enlargement which resulted in the higher production of biomass. The possible reasons for the increase in growth characteristics of cabbage plants may be the increased osmotic uptake of water and nutrients under the influence of gibberellic acid which would have maintained a constant swelling force against softening of cell walls (Feucht and Watson, 1958). Salah and Abd (1989) reported that the application of gibberellic acid is also helpful for cell enlargement, cell division and stimulation of growth and expansion of cells through increasing the wall plasticity of cells in plants. Gibberellic acid and NAA both are responsible for promoting the vegetative growth of plants. The increase in plant height, number of leaves per plant, spread of plant and leaf area per plant might be due to the activity of gibberellic acid at the apical meristem resulting in the synthesis of more nucleo-protein which is responsible for increasing leaf initiation and expansion (Simao *et al.,* 1960). The other possible reasons may be the increased rate of photosynthesis and rapid translocation of photosynthates onwards the head by gibberellic acid treatment (Alvin, 1960). These results are in conformity with Kaur and Mal (2018), Meena *et al.* (2018) and Ahamed *et al.* (2019) in cauliflower, Chanwala *et al.* (2019) in broccoli and Rishabhdev *et al.* (2020) in cabbage.

Yield attributes

Days taken to head initiation

The data presented in Table 1 reveals that the appli-

Table 1. Data related to the plant height (cm), Plant speared (cm), No. of leaves per plant,Leaf area (cm^2), Days taken to head initiation, Days taken to Head Maturity

Treatments Symbol	Treatments	Plant height (cm)	No. of leaves per plant	Plant speared (cm^2)	Leaf area (cm^2)	Days taken to head initiation	Days taken to head maturity
T_1	Control	14.10	10.23	529.88	836.69	53.64	78.06
T_2	BA @ 15 ppm	15.41	11.55	587.78	944.66	49.24	72.55
T_3	GA_3 @ 50 ppm	18.85	13.31	636.29	1027.54	47.62	71.31
T_4	NAA @ 100 ppm	15.93	11.86	624.87	1006.35	48.79	71.85
T_5	$ZnSO_4$ @ 5%	16.74	12.16	638.05	1019.32	47.67	71.80
T_6	$FeSO_4$ @ 0.5 %	16.13	11.78	621.78	981.42	48.77	71.87
T_7	Boric acid @ 0.2 %	15.32	11.23	576.12	928.57	49.19	73.34
CD 5%	1.947	1.498	NA	N/A	1.502	N/A	
SEm (±)	0.625	0.481	25.38	39.959	0.482	1.67	
CV (%)	6.735	7.1	7.30	7.183	1.695	3.96	

cation of plant growth regulators had induced an earliness to the head initiation of cabbage. Application of GA_3 @ 50 ppm took a minimum of days (47.62) to head initiation which was significantly early over control. Application of $ZnSO_4$ @ 0.5 % among all the micronutrients took a minimum of days (47.67) to head initiation of cabbage. However, maximum days (53.64) to head initiation were recorded under control. The results of the interaction were found insignificant and therefore, are being discussed below.

Days taken to head maturity

It is apparent from data Table 1 that application of plant growth regulators significantly affected the days taken to head maturity. Application of GA_3 @ 50 ppm took minimum days (71.31) to head maturity which was significantly earlier than control. Data from the table that the application various of micronutrients also had a significant effect on days taken to head maturity. Application of $ZnSO_4$ @ 0.5 % among all the micronutrients took minimum days (71.79) to head maturity of cabbage. However, maximum days (78.05) to head maturity were recorded under control. The results of the interaction were found insignificant and therefore, are being discussed below.

The average weight of the head (g)

The data about the average weight of the head presented in Table 2 indicated that foliar spray of plant growth regulators had a significant effect on the average weight of the head. Application of GA_3 @ 50 ppm recorded maximum average weight of head (532.92 g). Data given in the same table further revealed that the application of different micronutrients had significantly influenced the average weight of the cabbage head. The maximum and significantly higher average weight of the cabbage head (523.38 g) was recorded with the application of ZnSO4 @ 0.5%. The minimum average fruit weight of the head is recorded in control. The results of the interaction were found insignificant and therefore, are being discussed below.

Yield per plot (kg)

It is apparent from data in Table 2 that yield per plot of cabbage was significantly increased with foliar spray of plant growth regulators. The maximum and significantly higher yield per plot (25.51 kg) was recorded under treatment. Data presented in the same table further revealed that the application of various micronutrients also had a significant effect on yield per plot. Application of $ZnSO_4$ @ 0.5% recorded maximum and significantly higher yield per plot (25.39 kg). Minimum Total head yield per plot (kg) observed in control. The results of the interaction were found insignificant and therefore, are being discussed below.

Total yield (q/ha)

It is apparent from data in Table 2 that yield per plot of cabbage was significantly increased with foliar spray of plant growth regulators. The maximum and significantly higher yield per hectare (270.90q) was recorded under treatment GA_3 @ 50 ppm. Data presented in the same table further revealed that the application of various micronutrients also had a significant effect on yield per ha. Application of $ZnSO_4$ @ 0.5% recorded maximum and significantly higher yield per ha. (267.72q). Minimum Total head yield per hectare(q) observed in control. The results of the

Table 2. Data related to the Average weight of the head (g), total head yield per plot(kg), and total yield per hac. (q/ha)

Treatments Symbol	Treatments	Average fruit weight of the head (g)	Total head yield per plot(kg)	Yield of head (q/ha)
T_1	Control	457.42	22.03	233.42
T_2	BA @ 15 ppm	493.57	23.78	251.09
T_3	GA_3 @ 50 ppm	532.93	25.51	270.90
T_4	NAA @ 100 ppm	504.67	24.13	255.77
T_5	$ZnSO_4$ @ 5%	523.38	25.39	267.72
T_6	$FeSO_4$ @ 0.5 %	511.11	24.72	262.25
T_7	Boric acid @ 0.2 %	482.36	23.41	247.64
CD 5%	7.84	1.235	8.388	
SEm (±)	2.51	0.396	2.692	
CV (%)	0.87	2.844	1.825	

interaction were found insignificant and therefore, are being discussed here. It was observed that yield attributes *i.e.,* days taken to head initiation, days to head maturity, the average weight of head, the yield of head per plot and per hectare were significantly higher in the treatments of gibberellic acid as compared to control and benzyl adenine but statically at par to NAA. The reduction in time taken for head initiation and head maturity by application of GA_3 treatment may be due to accelerated nutrient transport from the root to the aerial parts of the plant (Denisova and Lupinovich, 1962). The beneficial effect of GA_3 on yield attributes and yield might be due to an enhanced supply of macro and micronutrients during the entire growing season. Significant increase in yield under the influence of plant growth regulators was largely a function of improved growth and the consequent increase in different yield attributes and yield as mentioned above. The reason for this result pattern might be due to the exogenous application of growth regulators, which enhanced and activated the enzymatic activities of plants for various physiological processes and metabolic activities *viz.*, vegetative growth, photosynthetic area and leaf pigments to maximize yield of the crop. These results were by the findings of Sawant *et al.* (2010) in cabbage. The increase in head weight by GA_3 application may be due to the profound effect of gibberellic acid on cell division, cell elongation and cambial activity. The next possible explanation for the increased head weight of cabbage with foliar application of gibberellic acid is due to a larger accumulation of carbohydrates owing to better photosynthesis by the plant. A larger leaf area also supported better exposure of the leaves to the available light which increased the stem extension and possible increased rates of water use per unit leaf area. This might also be increased due to the application of gibberellic acid accounts for the invigoration of the photosynthetic activity and leads to carbohydrate manufacture. The increase in head weight was ultimately responsible for a greater yield of heads per hectare. These findings are in close conformity with Yadav *et al.* (2000), Rishabhdev *et al.* (2020) in cabbage, Kumar and Ray (2000) in cauliflower and Reza *et al*. (2017) in broccoli.

Conclusion

Based on results that have emerged from the one-year field experiment it can be concluded that: 1. Depending upon the ease of availability of gibberellic acid or Naphthalene acetic acid, application of either of these plant growth regulators i.e., GA_3 @ 50 ppm or NAA @ 100 ppm is recommended as both of them fetched comparable head yield and net return of cabbage, which was significantly higher than control and BA @ 15 ppm. Similarly, foliar application of either $ZnSO_4$ @ 0.5% or $FeSO_4$ @ 0.5% is also recommended as both of these produced equally and significantly better head yield and net return of cabbage as compared with control and foliar application of boric acid @ 0.2%.

Conflicts of interest

The authors have no conflicts of interest.

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References

Ahamed, N., Waheed, A., Hamid, F.S., Ahmed, I., Khan, M.A., Aslam, S., Younis, Ali, S., Khan, N. and Bashir, M. 2019. Response of cabbage cultivars to different concentration of gibberellic acid. *Pakistan Journal of Agriculture Research*. 32(9): 562-565.

Alvin, P. 1960. Net assimilation rate and growth behaviour of leaves as affected by gibberellic acid, urea and sugar. *Plant Physiology*. 35: 285-288.

Anonymous, 2019-20. Estimate of Area and Production of Horticulture Crops (2019-20) 3rd Advance. Ministry of Agriculture and Farmers Walfare, Government of India 85, Institutional Area, Sector-8, Gurgaon, Harayana. pp. 230-260.

Chanwala, P., Soni, A.K., Sharma, D. and Choudhary, G. 2019. Effect of foliar spray of plant growth regulators on growth and quality of sprouting Broccoli (*Brassica oleracea var. italica* L.). *International Journal of Current Microbilogy and Apllied Sciences*. 8(8): 1846-1852.

Chauhan, 1986. *Vegetable Production in India*. Ram Prasad and sons, pp. 131-140.

Denisova, A.Z. and Lupinovich, I.S. 1962. The effect of mineral nutrition of plant. Soil Science. Ins BSSR Agril Minsk. *U.S.S.R.* 8 (4): 360-364.

Dhengle, R.P. and Bhosale, A.M. 2008. Effect of plant growth regulators on yield of cabbage (*Brassica oleracea* var. *capitata* L.). *International Journal of Plant Sciences*. 3(2): 376-378.

Fageria, M.S., Choudhary, B.R. and Dhaka, R.S. 2003. *Vegetable Crop Production Technology,* Kalyani Publication. 2(1): 75-92.

Feucht, J.R. and Watson, D.P. 1958. The effect of gibberellins on intermodal tissues of cow pea (*Phaseohus vulgaris* L.). *Amer Journa of Bototan.* 45: 520-522.

Islam, M.A., Siddiqui, A. and Kashem, M.A. 1993. Effect of growth regulators on the growth, yield and ascorbic acid content of cabbage. *Bangladesh Journal of Agriculture Science.* 20(1): 21-27.

Jenny, M.N., Sarker, C., Mazumdar, M.A. and Shikder, M.F. 2008. Effect of storageconditions on quality and shelf life of selected winter vegetables. *Journal of Bangladesh Agriculture University.* 6(2): 391- 400.

Katyal, S.L. and Chadha, K.L. 1985. *Vegetable Growing in India.* Second Edition, Oxford and IBM Publication, New Delhi. pp. 174-179.

Kaur, P. and and Mal, D. 2018. Effect of foliar spray of NAA and GA_3 on the growth, curd formation and yield of cauliflower (*Brassica oleracea* var. *botrytis* L.). *Journal of Pharmacognosy and Phytochemistry.* 7(3): 2805-2807.

Kumar, V. and Ray, N. 2000. Effect of plant growth regulators on cauliflower cv. Pant Subhra. *Orissa Journal of Horticulture.* 28(1): 65-67.

Leopold, A.C. 1963. Auxins and Plant Growth, Berkeley and Los Angeles, University of California p.p.5 Lindsay, W.I. and Norwell, W.A. 1978. Development of DTPA-soil test for Zn, Fe, Mn and Cu. *Soil Science Society of American Journal.* 42: 421-428.

Li, X., Liu, K., He, X., Chen, Y., Tan, J., Jiang, H. and Liu, H. 2023. Mutual Effects of Zinc Concentration and Ratio of Red-Blue Light on Growth and Nutritional Quality of Flowering Chinese Cabbage Sprouts. *Horticulturae.* 9(2): 226.

Makwana, J.J. 2005. *Effect of plant growth regulators on growth, yield and quality of cabbage (Brassica oleracea var. capitata L.) cv. Golden Acre.* M.Sc. Thesis submitted to N.A.U, Navsari.

Meena, M.K., Kavita, A.A., Dhayal, M., Singh, J. and Meena, S.L. 2018. Effect of biofertilizers and growth regulators on growth attributes of cauliflower (*Brassicae oleracea* var. *botrytis* L.). *International Journal of Current Microbiology and Applied Sciences.* 8(7): 885-890.

Rashid, M.M. 1993. *Sabjibigyan*.1st edition Bangla academy, Dhaka, Bangladesh. pp.189-196.

Reza, M., Islam, M., Hoque, A., sikder, R.K. and Mehraj, H. 2017. Growth and yield response of(*Brassica oleracea* var. *italica*) to different GA_3 application time. *Bio Accent Online Journal of Biotechnology.* 3: 0-24.

Rishabhdev, Singh, V.K., Shani, R. and Shukla, K.C. 2020. Effect of plant growth regulators on growth and yield of cabbage (*Brassica oleracea* var. *capitata* L.). *Journal of Pharmacognosy and Phytochemistry.* 9(3): 1024-1026.

Salah, M.M.S. and D.J. Abd, 1989. Effect of gibberellic acid and naphthalene acetic acid on growth, yield and quality of onion. *Dirsat.* 16: 39-51.

Sawant, V.P., Naike, N.B., Barkule, S.R., Bhosale, A.M. and Sinde, S.B. 2010. Effect of foliar application of plant growth regulators on growth, yield and quality of cabbage cv. *Golden Acre. The Asian Journal of Horticulture*. 5(2): 495-497

Simao, S., Serzedello, A. and Yamamura, A. 1960. The effect of gibberellic acid on lettuce. *Journal of Agriculture Research. Piracicoba.* 35: 193-197.

Singh, N.P., Bhardway, A.K., Kumar, A. And Singh, K.M. 2004. *Modern Technology on Vegetable Production*. International Book District coorporation. Chaman Studio Building, 2nd Floor, Charbag Lucknow, India. pp. 135-138.

Yadav, R.L., Dhaka, R.S., and Fageria, M.S. 2000. Effect of GA_3, NAA and succinic acid on growth and yield of cabbage cv. Golden Acre. Haryana *Journal of Horticulture Science*. 29 (3&4): 269-270.

Younis, M.E. and Tigani, L.S.E. 1977. Comparative effects of growth substances on the growth, flowering and fruiting of tomato (*Lycoperscion esculentum* Mill.) plants. *Acta Agronomia Academiae Scientia rumientiarum Nungaricae*. 6(1): 89-103.