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Effect of Gibberellic acid and nitrogen on yield and marketability of cabbage (*Brassica oleracea* var. *capitata* L.) cv. pride of India

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Abstract
The present investigation entitled "Effect of Gibberellic acid and Nitrogen on yield and marketability of cabbage (*Brassica oleracea* var. *capitata* L.) cv. Pride of India" was conducted at Rampur Farm and (PG) Laboratory of Doon (PG) College of Agriculture Science & Technology, Selaqui, Dehradun during the Rabi season (2016) in India. The recorded data were analysed with Factorial Randomized Complete Block Design having sixteen treatments combining two factors (four each) like N_0G_0, N_0G_1, N_0G_2, N_0G_3, N_1G_0, N_1G_1, N_1G_2, N_1G_3, N_2G_0, N_2G_1, N_2G_2, N_2G_3, N_3G_0, N_3G_1, N_3G_2 and N_3G_3 which were replicated three times. The data were recorded for pre harvest parameters like Plant height, number of leaves per plant and plant canopy while post harvest observations like fresh weight of the whole plant, fresh weight of heads, diameter of head, thickness of head and yield of head and economic of production. The significantly superior results were observed with the treatment N_1G_3 (8Kg Nitrogen and 20ppm GA_3 respectively) while minimum with control (N_0G_0).

Keywords: Cabbage, Nitrogen and gibberellic acid

1. Introduction
Cabbage (*Brassica oleracae var. capitata* L.) belongs to Cruciferae family and is biennial herbacious in nature. India is the second largest producer of cabbage in the world, next to China, accounting for 16.55 per cent of the world area and 12.79 per cent of the world production. Countrywide, it is grown in an area of 4.00 lakh hectare with an annual production of 9.03 million tonnes and productivity of 22.6 t/ha, ranking second to cauliflower in area but topping in production among cole crops (NHB, 2015). Cabbage can grow easily under wide range of environmental condition in both temperate and tropical, but cool moist climate is most suitable (Kibar *et al*., 2014) [3]. In tropical and sub-tropical countries, cabbage is grown during winter (Rabi season) In India. The particular flavour in the cabbage head is due to the glycoside 'sinigrin' which contains sulphur also.
Nasiruddin and Roy 2011[7], reported that due to the diversified use of productive land, it is necessary to increase the food production, and gibberellic acid (GA_3) and nitrogen may be a contributor in achieving the desired goal. The production and marketability of cabbage can be increased by using growth regulator and nutrient. Cabbage was found to show a quick growth when treated with plant growth regulators. Application of GA_3 stimulates morpho-physiological, and yield and yield contributing characters of cabbage. Further, the less is the input cost, the greater is the margin of profit when yield remains the same. Despite, many reports of reduce wastage of nitrogen by foliar application for increased production with lesser quantity, little attention has been paid to its use in case of cabbage. Cabbage being a leafy vegetable is a heavy feeder of Nitrogen, phosphorus and Potassium (NPK). The supply of nutrition may be enhanced when its application is supplemented by using growth regulators like Gibberellic acid.
In case of cabbage production, a few reports on increase of yield by increasing the size of the leave with the increase number of outer and inner leaves, diameter of heads, percentage of head formation and shortened duration of head formation and malnutrition by application of Gibberellic acid and Nitrogen on growth and yield of cabbage, especially in Dehradun (Uttarakhand) conditions are available. Therefore, the present study was undertaken to assess the effect and interaction of application of Gibberellic acid and Nitrogen on growth and yield of cabbage and economic feasibility of different treatment combination at farmer's field.

Materials and Methods
The present investigation was conducted at Rampur Farm and (PG) Laboratory of Doon (PG) College of Agriculture Science & Technology, Selaqui, Dehradun during the Rabi season

(2016) in India. The experimental site is located at 71.52E longitude and 30.21N latitude at an elevation of 516 m above the mean sea level. The seed of cabbage "Pride of India" was sown in nursery beds containing mixture of clean garden soil and clean sand in 3:2 ratio. Three to four weeks old Seedlings were transplanted there were altogether 21 plants in each sub-plot having three rows with 7 plants in each row. Each plot was separated by 0.5 m and each replication by 0.6 m. The recorded data were analysed with Factorial Randomized Complete Block Design having sixteen treatments combining two factors (four each). The two factors first nitrogen N_0-Control, N_1-8kg, N_2-16kg, N_3-24kg like while second Gibberellic acid G_0-Control, G_1-10ppm, G_2-15ppm and G_3-20ppm each factors were combined as N_0G_0, N_0G_1, N_0G_2, N_0G_3, N_1G_0, N_1G_1, N_1G_2, N_1G_3, N_2G_0, N_2G_1, N_2G_2, N_2G_3, N_3G_0, N_3G_1, N_3G_2 and N_3G_3 which were replicated three times. The data were recorded for pre harvest parameters like Plant height, number of leaves per plant and plant canopy while post harvest observations like fresh weight of the whole plant, fresh weight of heads, diameter of head, thickness of head and yield of head and economic of production. Since the population of plants was large it was very difficult to take the record of the observation on each and every plant, the technique of representative samples was adopted for recording the observation on various morphological characters of the cabbage plant. Observations were recorded from 7 randomly selected plants under each treatment at 30, 50, 70, 90 Days after planting (DAT) from each plot. Cost of cultivation for each treatment was worked out separately. Gross return (Rs. /ha) was obtained by converting the harvest into monetary terms at the prevailing market rate during the course of investigation. Net return was obtained by deducting cost of cultivation from gross return. The benefit-cost ratio (BCR) was calculated with the help of following formula

$$\text{Benefit: cost ratio (B: C)} = \frac{Net\ return\ (Rs.)}{Total\ cost\ of\ cultivation\ (Rs.)}$$

Result and Discussion

The results are beneficial for cabbage production. In general, foliar application of Gibberellic acid and nitrogen produced better significant effect when applied in small doses but higher doses have negative effects. The data on plant height recorded at 30, 50, 70 and 90 days after transplanting (DAT) and at harvest are presented in table 4.1. At 90 DAT and at harvest significant differences among different treatments of N, GA_3 and their interactions were observed. The tallest plants were observed by the treatment N_1G_3 (25.25 cm and 26.76 cm respectively) and the minimum with control (19.13 cm and 19.76 cm respectively). Among the main effects of treatments of N and GA_3, the treatment N_1 was found to produce tallest plant at both stages (23.72 cm and 25.08 cm respectively) among the treatment of N, while this was obtained by G_1 at 90 DAT (23.18 cm) and (24.52 cm) at harvest among the treatment of GA_3 produced significantly taller plants than control, no significant differences were observed among the different doses of GA_3 at all stages. In case of plant height, upto 70 DAT no significant interaction effects of GA_3 and nitrogen were observed but at 90 DAT and at harvest, N_1G_3 (26.76 cm) produced tallest plant. Similar observations were made by Islam (1993) [2] in cabbage, Mishra and Singh (1986) [5] in Cauliflower, Thapa *et al.* (2013) [11] in broccoli.

The data presented in the table 4.2, the highest number of leaves was obtained by N_1G_3 (12.33) at 50 DAT, N_2G_1 (13.74) at 70 and N_2G_1 (14.49) at 90 DAT while the lowest was recorded with control. Among the main effects of nitrogen, though highest number of leaves at 70 DAT was recorded by N_1 (12.98), this was recorded with N_2 (13.21) at 90 DAT. This might be due to increased leaf area thereby enabling to assimilate more nitrogen by the leaves as plant went on increasing in size. In respect of GA_3, although all doses of GA_3 produced more number of leaves, the highest number was produced by 15 ppm GA_3, G_2 (13.12) at 90 DAT. The increase in leaf number might be due to invigoration of physiological process of plants and stimulatory effects with GA_3 to form new leaves at faster rates and thus increased vegetative growth. The finding herewith was in agreement with those of Reddy (1989) [10] in Cauliflower, Patil and Patil (1989) [9], Moyazzama (2008) [6] in cabbage.

The effect of GA_3 and N affect significantly at 30 days while at 50 days it is found that the interaction between N and GA_3 can only affect significantly other than N and GA_3 in table 4.3. However, from 70 DAT onwards, significant differences in the plant canopy were observed in all treatments of GA_3, N and their interaction. At 90 DAT, the highest plant canopy (1194.37 cm^2) was recorded from N_1G_3 and the minimum was with control (666.06 cm^2). At this stage also, all the effect of GA_3, N and their interaction were significant. In respect of main effect of GA_3 and N separately, the highest plant canopy was observed in G_2 (1001.20 cm^2) in case of GA_3 and N_1 (1030.07 cm^2) regarding the application of N alone. In this case also, the moderate dose of nitrogen combined with 20 ppm GA_3 produced the best effect on plant growth and development in cabbage among the different treatments studied. This finding was corroborated with the findings of Mishra and Singh (1986) [5] in cauliflower, Patil *et al.* (1987) [8] in cabbage, Thapa *et al.* (2013) [11] in broccoli.

The fresh weight of cabbage plant under different treatments of GA_3 and N ranged from 801.32 g to 1089.92 g and it is presented in table 4.4. The minimum weight (801.32 g) was associated with control while the maximum weight (1089.92 g) was associated with the treatment N_2G_1. The mean data on fresh weight of head of cabbage at harvest are shown in table 4.4. It was observed that maximum fresh weight of head at harvest was recorded in the treatment N_1G_3 (905.35 g). The minimum fresh weight of head at harvest was observed with control (584.08 g). This was due to increase in the number outer leaves by the application of the higher doses of N along with lower dose of GA_3. The increase in fresh weight of cabbage with increase concentration of GA_3 might be due to more leaf area produced or their persistent stimulatory effect till harvest and thus keeping the plant physiologically more active. The increase in fresh weight of cabbage head might be due to the increase in the number of inner leaves in the head as reported by Makwana, J.J., (2005) [4] in cabbage.

In table 4.5, the maximum diameter of cabbage head at harvest was observed with the treatment N_1G_3 (14.03 cm) and the minimum with control (10.00 cm). The analysis of variance indicated that the effect of GA_3 and N significantly differed in the diameter of head and though their interaction effect was not significant. Among the main treatment effects of N and GA_3, the maximum diameter was observed with N_1 (12.91 cm) and with G_3 (12.90 cm) in case of treatment of N and GA_3 respectively. The data on the average thickness of cabbage head at harvest are presented in table 4.5. The maximum thickness of head (15.57 cm) was observed in the treatment N_1G_2 while the minimum (12.08 cm) was recorded with control. The results obtained in the investigation largely display the possibilities of significantly increasing the size of cabbage head with foliar application of nitrogen and GA_3 at

proper doses and their interactions. Application of GA_3 and nitrogen increased the diameter and thickness of head and this increase in the size of head closely related with the weight of the head. The maximum diameter of head were obtained from N_1G_3 (16 kg N per ha and 20 ppm GA_3) i.e. (14.03 cm), and thickness of head were obtained N_1G_2 (15.57 cm) i.e. 8 kg N per ha and 15 ppm GA_3, while the minimum of both characters were recorded from control. In case of main effects of nitrogen, both diameter and thickness were found maximum at N_1 (8 kg N per ha) but the effect of GA_3 on both the diameter and thickness were found maximum at G_3 (20 ppm GA_3) and G_2 (15 ppm) respectively. This indicated that all the application of GA_3 and nitrogen and their interaction increased the size of the head of cabbage. The increase in head size might be due to the combined effect of GA_3 and nitrogen, enhancing vegetative growth with foliar application of nitrogen and increase cell division and cell enlargement by GA_3 application which subsequently helped in the rapid and vigorous growth and production of new leaves at faster rates. These findings were in line with the findings of Reddy (1989) [10] in cauliflower, Thapa *et al.* (2013) [11] in broccoli, Patil and patil (1989) [9] in cabbage.

From table 4.6, the yield of cabbage head per hectare under different treatments of GA_3, N and their combinations ranged from 21.36 tonnes per hectare in control to 33.00 tonnes per ha in the treatment N_2G_1 which was closely followed by N_1G_3 (32.87 tonnes per ha). Analysis of variance revealed significant differences on the effect of these treatments on yield. Among the main effect of different treatments of N, highest yield 28.88 tonnes per ha was associated with N_1 which was significantly higher than other treatments. In case of main effect of individual treatments of GA_3, a maximum yield of 28.41 tonnes per ha was observed with G_3 (20 ppm GA_3) which was significantly higher than other treatments with a minimum of G_0 (25.14 tonnes per ha. Data on yield revealed significant difference among the different treatments of N, GA_3 and their interactions. The highest yield was obtained with N_2G_1 (33.00 tonnes per ha), while the lowest was recorded with control. Regarding the main effects of nitrogen and Gibberellic acid, higher yields were obtained by N_1 (8 kg N per ha) i.e. 28.88 tonnes per ha, and G_3 (20 ppm GA_3) i.e. 28.41 tonnes per ha as compared to other treatments of nitrogen and GA_3 respectively. The higher yield in this case might be due to increased head weight and head size by increasing different plant characters like number of leaves, plant height which caused increased photosynthetic area and vegetative growth of the plant since N_2G_1 (16 kg N per ha along with 10 ppm GA_3) induced increased head weight, head size and other yield attributing to the high resume of carbohydrate and large leaf area for better exposure to available sun light. Possible increase rate of water use per unit area accounts for invigoration of the photosynthetic activity leading to carbohydrate manufacture. These were in accordance with the findings of Chauhan and Bordia (1971) [1] in cabbage, Nasiruddin K.M. and Nasiruddin and Roy (2011) [7] also reported a great influence of GA_3 on the production of cabbage.

The details of material utilized, operation carried out and labour engaged were recorded. The cost of cultivation of cabbage per hectare and the costs of cultivation of each treatment per hectare are presented in Appendix. Further, the values of return per hectare and cost benefit ratio are furnished in table 4.8. The lowest cost of production per hectare (Rs. 45806.07) and lowest net return (Rs. 103741.93) was with the control and the maximum cost of production was recorded from the treatment N_3G_3 (Rs. 4,7140.90) with a net return of Rs. 1,24,084.70. The maximum net return of Rs. 1, 84,339.74 was observed from the treatment N_2G_1 (16 kg per ha with 10 ppm GA_3) with a maximum cost benefit ratio of 3.95:1 which is closely followed by N_1G_3 (8 kg N per ha with 20 ppm GA_3) with a maximum net return of Rs.1, 83,014.39 and cost benefit ratio of 3.89:1. The observation on the economics of cabbage production under the different treatments of present study indicated highest cost benefit ratio from the treatment N_2G_1 (16 kg N per ha with 10 ppm GA_3) which was closely followed by N_1G_3 (8 kg N per ha with 20 ppm GA_3). The highest cost benefit ratio by the former although higher gross return was obtained by the later might be due to lower cost of production by the former as compare to the later. Similar trend of highest cost benefit ratio was obtained by Nandeshwa *et al.* (2013). Higher net return from the lower cost of production from foliar application of nitrogen thereby reducing the losses of nitrogen through leaching, fixation and violation.

From the present investigation, it could be concluded that foliar application of GA_3 and nitrogen either alone or in combination on cabbage var. Pride of India was beneficial in increasing the growth and yield of cabbage. Among the treatments, the highest yield and benefit cost ratio was obtained with the foliar application of nitrogen at the rate of 16 kg N per ha along with 20 ppm GA_3 and found to be most economic among the different treatments. Thus to increase the yield and economies the cost of production of cabbage, foliar application of 16 kg N per ha along with 10 ppm GA_3 can be recommended. Hence, the technique of foliar application of cabbage with nitrogen and GA_3 appears to be full of promise and can be used with advantage in augmenting not only the yield and economic return from cabbage crop but also affecting saving in fertilizer use.

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