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Causal factor of gibberellic acid (GA_3) and nitrogen on growth and yield of cabbage

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Abstract

Different levels of GA_3 and nitrogen effect was studied on cabbage cultivar 'Atlas 70' in the Sher-e-Bangla Horticulture Farm, Dhaka during November 2015 to March 2016. The objective of this research was to find out the suitable combination of GA_3 and nitrogen for ensuring better growth and higher yield of cabbage. The experiment was set-up and considering the two-factor such as three levels of GA3; G0 = 0ppm, G1 = 60ppm and G2 = 80ppm and four levels of nitrogen; N0= 0kg/ha, N1= 210kg/ha, N2= 240kg/ha, N3= 270kg/ha. As per the result of GA_3, the highest yield (87.87t/ha) was obtained from G1 and lowest yield (74.29t/ha) was gained from G2. For nitrogen, the highest yield (85.41t/ha) was obtained from N2 and lowest yield (70.83t/ha) was obtained from N0. Among all treatments combinations G1N2 produced the highest yield (97.77t/ha) and G0N0 produced lowest yield (68.88t/ha). So, it is clearly concluded that 60ppm of GA_3 and 240kg N/ha may be used for cabbage cultivation for higher yield and better root growth. This study also supports to the different farmer in cabbage cultivation as well as economic benefited to the farmers.

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Introduction

Cabbage (*Brassica oleracea* var. *capitata* L.) belongs to the family Cruciferae and is biennial herbaceous in nature. It is one of the important vegetable crops in Bangladesh. It occupied an area of 11.33 thousand hectares of land during 1999-2000 growing season with a total production of 112 thousand metrictons in Bangladesh (BBS, 2000) and the average yield was 9.39t/ha. Growth regulators are organic compounds other than nutrients; small amount of which are capable of modifying growth (Leopold, 1963). Due to the diversified use of productive land, it is necessary to increase the food production, and GA_3 may be a contributor in achieving the desired goal. The production of cabbage can be increased by using GA_3 plant growth regulators (Islam *et al.*, 1993). Application of GA_3 stimulates morphological characters like plant height (PH), number of leaves, head diameter, thickness of head and the weight of head. Application of GA_3 with the environmental conditions play important role in modifying the growth and yield of cabbage. It has quick growth, early head formation and higher yield when treated with plant growth regulators especially GA_3 and NAA (Dhengle and Bhosale, 2008; Yadav *et al.*, 2000; Kumar *et al.*, 1996). Cabbage seedlings are transplanted from seedbed to the main field. The crop needs good maturing for producing higher yield. The optimum dose depends largely on soil type, growing conditions and environmental factors. Vegetables, like, cabbage, respond well to plant growth regulators in minimizing the transplanting shock and being encouraged to a quick growth (Chhonkar and Jha, 1963). The effects of spacing, nitrogen, phosphorus and potassium on yield and yield contributing characters of cabbage and found 240kg N/ha were good for cabbage yield (Lawande *et al.*, 1986). The research may inspire the growers to cultivate cabbage commercially as well as to improve health and economic status of peoples of Bangladesh. Our initiative was to use some elements such as GA_3 and nitrogen fertilizer by which we can improve the growth, yield and quality of cabbage. However, considering the above circumstances, the present research was undertaken with the following objectives are to investigate the optimum level of GA_3 for growth and higher yield of cabbage, to determine the optimum nitrogen fertilizer dose for growth and higher yield of cabbage and to find out the suitable combination of GA_3 and nitrogen for ensuring better growth and higher yield of cabbage.

Materials and methods

Experimental site and Soil characteristics

The experiment was conducted at the Horticulture Research farm of Sher-e-Bangla Agricultural University (SAU) which is 24.090N latitude and 90.260E longitudes during the period of November 2015 to March 2016. The research site is situated in subtropical zone and the soil texture is sandy loam in nature. The cabbage (*Brassica oleraceae* var capitata) cultivar 'Atlas-70' was used as the test crop in the present study. The seeds were collected from Siddique Bazar, Dhaka.

Materials and Field Management

The research consisted of two factors: Factor A: 3 levels of GA_3 Viz. G0 = 0 (control); G1 = 60ppm; G2 = 80ppm and Factor B: 4 levels of Nitrogen N0 = 0 (control); N1 = 210kg/ha; N2 = 240kg/ha; N3 = 270kg/ha. There were 12 treatments combination such as G0N0, G0N1, G0N2, G0N3, G1N0, G1N1, G1N2, G1N3, G2N0, G2N1, G2N2 and G2N3. The double factorial research was laid out in the Randomized Complete Block Design (RCBD) with three replications. The size of each plot was 2m×1.8m. The distance maintained between two blocks and two plots were 1.0m and 0.5m, respectively. Seedlings were transplanted on the plots with 60cmx40cm spacing. 15 seedlings were accommodated in each unit plot. Field management was followed as the normal agronomic practices.

Collection, preparation and application of growth regulator

Plant growth regulator GA_3 was collected from Hatkhola Road, Dhaka. A 1000ppm stock solution of GA_3 was prepared by dissolving 1 g in a small quantity of ethanol prior to dilution with distilled water in one litre of volumetric flask. The stock solution was used to prepare the required concentration for different treatment i.e. 60 ml of this stock solution was diluted in 1 litre of distilled water to get 60ppm GA_3 solution.

In a similar way, 80ppm stock solutions were diluted to 1 litre of distilled water to get 80ppm solution. Control solution also prepared only by adding a small quantity of ethanol with distilled water. GA_3 as per treatment were applied at three times 15, 35 and 55 days after transplanting by a mini hand sprayer.

Data collection

When the heads were fully compact, the plants were harvested at random from each unit plot. Plants were randomly selected from each plot and data were recorded according to the parameter were studied. However, for gross and marketable yield per plot, all plants of each unit plot were considered. Periodical data i.e. plant height, number of loose leaves was taken 30, 45 and 60 days after transplanting. One of them canopy was taken 60 days after transplanting whereas the rest parameters were recorded at the time of harvest.

Statistical analysis

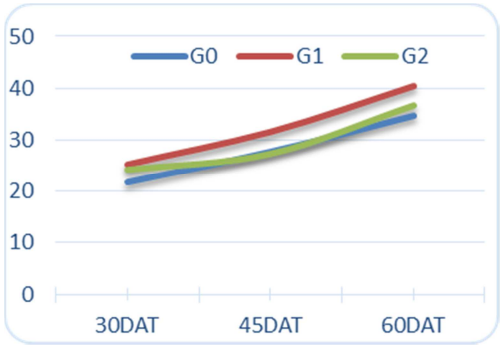
The data obtained for different characters were statistically analyzed to find out the significance of the difference for different level of GA_3 and nitrogen fertilizers on growth and yield contributing characters of cabbage. The mean values of all the recorded characters were evaluated and analysis of variance was performed by the 'F' (variance ratio) test. The significance of the difference among the treatment combinations of means was estimated by Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

Results and discussion

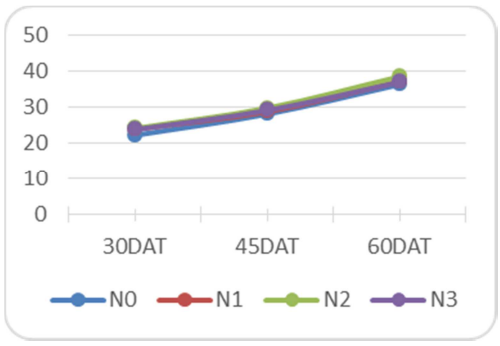
Measurement of plant height

PH is an important trait and key contributor for plant biomass. A significant variation was found at different concentrations of GA_3 on PH of cabbage applied at 30, 45 and 60 DAT (Appendix I) where the tallest plant 25.42, 31.66 and 40.48cm, respectively and it was recorded from G1 (60ppm GA3) which was followed by 24.34 and 36.90cm, respectively to G2 (80ppm GA3) at 30 DAT and 60 DAT; and 27.90cm for G0 (0ppm) at 60 DAT (Fig. 1A). The application of GA_3 increased the PH of cabbage and it was revealed that 50ppm of GA_3 produced the tallest plants (Roy, 2011). The maximum PH was obtained from 85ppm of GA_3 reported by Yadav *et al.*, (2000). The maximum PH (28.4cm) resulted from two sprays with GA_3 at 150ppm [6].

Different levels of nitrogen fertilizer showed significant variation for PH of cabbage at 30, 45 and 60 DAT (Appendix I). The tallest plant (24.23, 29.88 and 38.64cm, respectively) was recorded from N2 (240kg Urea/ha) at 30, 45 and 60 DAT. The shortest PH was observed at 22.32, 28.22 and 36.48cm, respectively from N0 (0Kg Urea) (Fig. 1B). The maximum PH was obtained from 260kg of nitrogen per hectare reported by Pramanik (2007). PH was maximum at a rate 150kg N/ha reported that [13]. Combined effect of different concentrations of GA_3 and nitrogen fertilizer showed significant differences on PH of cabbage at 30, 45 and 60 DAT (Appendix I and Table 1). The tallest plant (27.23, 33.00 and 40.00cm, respectively) at 30, 45 and 60 DAT and was obtained from G1N2 (60ppm GA_3 + 240kg urea), while the shortest plant 18.76cm from the combination G0N0 at 30 DAT; 25.63cm from the combination G0N1 at 45 DAT; and 30.97cm from the combination G2N2 at 60 DAT, respectively.



A



B

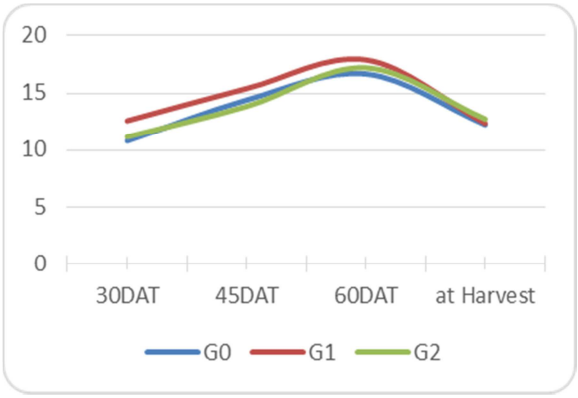
Fig. 1. Effect of different levels of A) GA_3 and B) Nitrogen on PH of cabbage at different days after transplanting.

Number of loose leaf

Significant variation was recorded on number of leaves per plant due to application of different concentrations of GA_3 at 30, 45, 60 DAT excepting at harvest (Appendix I). The maximum number of leaves per plant (12.58, 15.40 and 17.90), at 30, 45 and 60 DAT was found from G1. GA_3 concentration G2 produces the highest number of leaves per plant (12.74) at harvest (Fig. 3). The minimum number of leaves (10.81, 16.68 and 12.25) were obtained from concentration G0 at 30, 60 and at harvest, respectively. The maximum number of leaves with 50ppm GA_3 reported by [14]. The highest number of open leaves (23.6) was obtained in the treatment with two sprays of GA_3 at 100ppm reported by Lendve *et al.*, (2010).

Significant variation was observed for different levels of nitrogen fertilizer in terms of number of leaves per plant of cabbage at 30, 45, 60 DAT at harvest (Appendix I). At 30 and 60 DAT, the maximum number of leaves per plant 11.99 and 16.36) was counted from N1 which was statistically similar (11.57 and 11.42) at 30 DAT for N2 and N3 respectively; and 16.25 and 16.06 at 60 DAT for N3 and No. Highest number of leaves per plant (15.08 and 13.23) at 45 DAT and at harvest for nitrogen level N3. The minimum number (11.11 and 14.20) at 30 DAT and 45 DAT was found for No, 15.97 at 60 DAT for N2 and 11.71 at harvest for N1 respectively (Fig. 3A).

Different concentrations of GA_3 and nitrogen fertilizer showed significant differences due to their combined effect on number of leaves per plant of cabbage at 30, 45, 60 DAT and at harvest (Appendix I). At 45 and 60 DAT, the maximum number of leaves per plant (16.33 and 17.30) was recorded from G1N3; at 30 DAT, the maximum number of leaves per plant (13.00) was observed from G1N1; at harvest, the maximum number of leaves per plant (15.00) was obtained from G2N3. The minimum number of leaves per plant (10.00 and 13.60) at 30 DAT and 45DAT was found from G0N0; leaf number 15.86 at 60DAT from G0N3 and leaf number 11.90 at harvest from G0N1 (Table 1).



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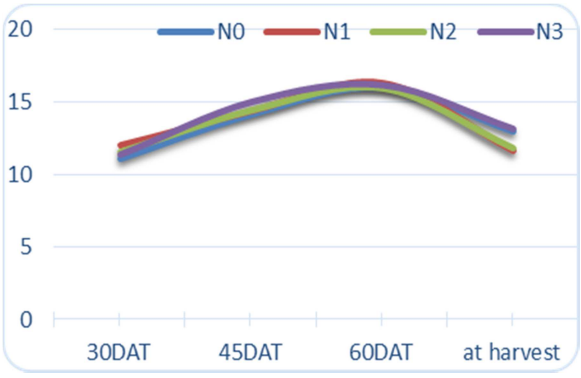

B

Fig. 2. Effect of different levels of A) GA_3 and B) Nitrogen on number of loose leaf of cabbage at different days after transplanting.

Leaf breadth

Leaf breadth (LB) varied significantly for application of different concentrations of GA_3 (Appendix I). The maximum LB (19.80 and 23.33cm) at 45 DAT and 60 DAT was obtained from G1, which was statistically similar (19.78 and 23.04cm) at same days after transplanting with G2. The minimum (18.81 and 22.72cm) at 45 DAT and 60DAT was obtained from G0 (Table 3). Different levels of nitrogen showed significant variation on LB (Appendix I). The maximum LB (20.28 and 23.15cm) at 45 DAT and 60 DAT was observed in N3 and the minimum (18.48 and 21.46cm) was obtained from No (Table 2). The increasing of Nitrogen level increases the LB of cabbage. The combined effect of GA_3 and nitrogen was significantly varied on LB (Appendix I). The maximum LB (21.60 and 24.23cm) at 45 DAT and 60 DAT was recorded from the treatment combination of G1N3 which was statistically similar to G2N2 (21.20cm) at 45 DAT and G0N1 (23.66cm) at 60 DAT.

The treatment combination of G0N0 (control) gave the minimum (17.13 and 21.06cm) LB at 45 DAT and 60 DAT (Table 2).

From the results it was found that both GA3 application and dose favored for maximum LB of plant growth.

Table 1. Combined effect of GA_3 and different levels of nitrogen on PH and number of loose leaf of cabbage at different days after transplanting.

Treatment	Plant height (cm)			Number of loose leaves			
	30 DAT	45 DAT	60 DAT	30 DAT	45 DAT	60 DAT	Harvest
G_0N_0	18.76 g	27.66 de	36.30 bcd	10.00 f	13.60 cd	16.53 abc	13.03 b
G_0N_1	20.83f g	25.63 e	33.67 defg	11.60 cd	14.66 bc	15.93 bc	11.90 c
G_0N_2	18.96 g	28.66 cd	33.97 def	11.70 bcd	15.13 abc	16.13 abc	12.10 c
G_0N_3	24.23 bcde	29.66 bcd	32.30 fg	11.00 def	14.20 bcd	15.86 bc	11.96 c
G_1N_0	25.16 abc	31.00 abc	37.97 abc	12.76 ab	15.00 abc	16.40 abc	13.20 ab
G_1N_1	23.56 cdef	32.00 ab	36.97 bc	13.00 a	14.86 abc	17.16 ab	12.23 c
G_1N_2	27.23 a	33.00 a	40.00 a	12.33 abc	15.40 ab	16.33 abc	11.33 cd
G_1N_3	24.70 abcd	30.66 abc	38.90 ab	11.83 bcd	16.33 a	17.30 a	12.73 c
G_2N_0	22.10 def	26.00 e	32.13 fg	10.26 ef	14.00 bcd	15.26 c	12.86 c
G_2N_1	26.73 ab	28.00 de	35.23 cde	11.06 def	13.80 cd	16.00 abc	11.00 d
G_2N_2	25.56 abc	29.00 cd	30.97 g	10.40 ef	12.83 d	15.46 c	12.10 c
G_2N_3	21.76 ef	27.33 de	32.97 efg	11.13 de	14.73 bc	15.60 c	15.00 a
CV%	7.71	5.15	9.72	5.79	6.73	7.75	12.31
LSD (0.05)	1.33	1.533	2.74	1.11	1.75	1.34	1.29

Table 2. Effect of GA_3 and nitrogen levels on LB of cabbage at different days after transplanting.

GA_3	Leaf breadth (cm)		Nitrogen	Leaf breadth (cm)	
	45 DAT	60 DAT		45 DAT	60 DAT
G_0	18.81 b	22.72 b	N_0	18.48 c	21.46 b
G_1	19.80 a	23.33 a	N_1	19.24 b	22.48 ab
G_2	19.78 a	23.04 ab	N_2	19.84 b	21.82 ab
CV%	10.24	6.65	N_3	20.28 a	23.15 a
LSD (0.05)	0.89	0.59	CV%	10.24	8.15
			LSD (0.05)	0.439	1.55

Canopy (cm)

Canopy varied significantly at different days after transplanting (DAT) due to application of different concentrations of GA_3 (Appendix III). At 60 DAT, the maximum plant canopy (54.13cm) obtained from G1, while the minimum (52.98cm) was recorded from Go. The effect of GA_3 application on canopy of plant was best at the concentration of 60ppm. The maximum canopy of plant was obtained from 50ppm GA_3 reported by Yadav *et al.*, (2000). The maximum plant canopy (0.187m²) resulted from two sprays with GA_3 at 150ppm [6]. Different levels of nitrogen showed insignificant variation on plant canopy at different days after transplanting (DAT) (Appendix III). The maximum plant canopy (55.60cm) was observed in N1 and the minimum (53.17cm) was found from both No and N2 at 60 DAT (Table 3).

Nitrogen upto 210kg/ha gradually increase the growth of cabbage plant. The increased plant growth from 276kg N/ha obtained by Khadir *et al.*, (1989). The maximum canopy of plant was obtained from 260kg N/ha reported that Pramanik, (2007). The variation was found for combined effect of GA3 and nitrogen on plant canopy at different DAT. The maximum plant canopy (57.06cm) was recorded from the treatment combination of G2N1 (210kg/ha N with GA_3 at 80ppm), which was statistically similar with the combination G1N1 (56.40cm), G1No (55.13cm) and G1N3 (54.93cm). The treatment combination of GoNo (control) gave the minimum (51.33cm) plant canopy (Tablev4) at 60 DAT. From the results it was found that both GA_3 and nitrogen levels influence the plant growth that means canopy.

Table 3. Effect of GA_3 and nitrogen levels on canopy of cabbage at 60 DAT.

GA_3	Canopy (cm) at 60DAT	Nitrogen	Canopy (cm) at 60DAT
Go	52.98 b	No	53.17 b
G1	54.13 a	N1	55.60 a
G2	55.06 ab	N2	53.17 b
CV%	5.19	N3	54.28 ab
LSD (0.05)	1.91	CV%	5.19
		LSD (0.05)	2.21

Table 4. Combined effect of GA_3 and nitrogen levels on LB (30 and 60 DAT) and canopy (60 DAT) of cabbage.

Combinations	Leaf breadth (cm)		Canopy (cm) (60DAT)
	45 DAT	60 DAT	
G_0N_0	17.13 c	21.06 bc	51.33 c
G_0N_1	20.33 abc	23.66 ab	53.33 abc
G_0N_2	19.20 abc	21.73 abc	52.93 bc
G_0N_3	18.60 abc	22.50 abc	54.33 abc
G_1N_0	20.20 abc	20.33 c	55.13 abc
G_1N_1	18.26 abc	21.13 bc	56.40 ab
G_1N_2	19.13 abc	22.00 abc	53.80 abc
G_1N_3	21.60 a	24.23 a	54.93 abc
G_2N_0	18.13 bc	23.00 abc	53.06 bc
G_2N_1	19.13 abc	22.66 abc	57.06 a
G_2N_2	21.20 ab	21.73 abc	52.80 bc
G_2N_3	20.66 ab	22.73 abc	53.60 abc
CV%	10.24	6.65	5.19
LSD (0.05)	3.37	2.69	2.83

Head weight

Fresh weight of head varied significantly for different concentrations of GA_3 (Appendix III). The maximum fresh weight of head (2.10kg) was obtained from G1, while the minimum (1.78kg) was recorded from G2 (Table 7). The effect of GA_3 application on fresh weight of head was optimum at the concentration of 60ppm. The maximum yield for 50ppm GA_3 same found by Chauhan and Bordia, (1971), and Badawi and EL-Sahhar, (1979). Different nitrogen levels showed significant variation on fresh weight of head (Appendix III). The maximum head weight (1.97kg) was observed from N3 and the minimum (1.89kg) was found in both No and N1 (Table 7). Nitrogen levels upto 270kg/ha gradually increase the head weight of cabbage plant. The 180kg N/ha performed the highest yield observed by Singh and Naik, (1988). The variation was found for combined effect of GA_3 and nitrogen levels on fresh weight of head. The maximum head weight (2.38kg) was recorded from the treatment combination of G1N2 which was statistically similar to G1N1, G1No and GoN3, while the treatment combination GoNo (control) gave the minimum (1.68kg) fresh weight of head (Table 8). From the results it was found that both GA_3 and nitrogen levels influence the cabbage yield which was ensured by maximum fresh weight of head. The plant fresh weight was considerably enhanced with the application of 20ppm GA_3 reported by Zee (1978).

Head diameter

Head diameter varied significantly for the application of different concentrations of GA_3 (Appendix III). The maximum head diameter (22.45cm) was obtained from G1, while the minimum (19.30cm) was recorded from Go (Table 7). The effect of GA_3 application on head diameter was the best at the concentration of 60ppm. The maximum head diameter was obtained from 50ppm GA_3 reported by Nasiruddin and Roy (2011). The maximum diameter of head was obtained from 85ppm of GA_3 observed by Moazzama (2008). Different levels of nitrogen showed significant variation on head diameter (Appendix III). The maximum head diameter (20.98cm) was observed in N3 which was followed by N1 (20.65cm) and the minimum (20.34cm) was found in No (Table 5). Nitrogen upto 270kg/ha gradually increase the head size of cabbage plant. The maximum diameter of head was obtained from 260kg of nitrogen per hectare Pramanik (2007). The maximum head diameter from 250kg N/ha observed by Hossain (1998). The head diameter increase in the levels of nitrogen up to 200kgha-1 reported by Ghanti *et al.*, (1982). The diameter of the head was maximum at a rate 150kg N/ha reported by Bhuiyan, (1996). The variation was found for combined effect of GA_3 application and nitrogen levels on head diameter. The maximum head diameter (24.00cm) was recorded from the treatment combination of G1N2 which was statistically similar to G1N1 (23.13cm) and G1N3 (22.03cm), while the treatment combination of GoN3 (18.66cm) gave the minimum head diameter which was statistically similar to G2N2 (18.80cm) (Table 6). From the findings it was revealed that both GA_3 application and nitrogen levels influence the yield which ensured by the maximum head diameter.

Table 5. Effect of GA_3 and nitrogen levels on weight of head and head diameter of cabbage.

GA_3	Weight of head (kg)	Head diameter (cm)	Nitrogen	
G_0	1.88 b	19.30 b	N_0	1.89
G_1	2.10 a	22.45 a	N_1	1.89
G_2	1.78 b	20.01 b	N_2	1.94
CV%	9.91	6.17	N_3	1.97
LSD (0.05)	0.20	1.25	CV%	11.47
			LSD (0.05)	0.028

Fresh Root Weight

Fresh weight of root was varied significantly for different concentrations of GA_3 (Appendix III).

The maximum fresh weight of root (22.66g) was obtained from G1, while the minimum (18.12g) was recorded from G0 (Table 9). The effect of GA_3 on fresh weight of root was best at the concentration of 60ppm which was followed by 80 and 0ppm. The maximum fresh weight of root was observed from 50ppm GA_3 reported by Lendve *et al.*, (2010). The maximum fresh weight of root was obtained from 85ppm GA_3 observed by [11]. Different nitrogen levels showed significant variation on fresh weight of root (Appendix I). The maximum fresh weight of root (20.52g) was observed in N2 which was statistically similar to N3 (20.40g) and the minimum (19.73g) was found from N0 (Table 9). Nitrogen upto 240kg/ha gradually increase the root growth of cabbage plant. The maximum fresh weight of root was obtained from 260kg N/ha reported by Pramanik (2007). The variation was found for the combined effect of GA_3 application and nitrogen levels on fresh weight of root. The maximum fresh weight of root (24.00g) was recorded from the treatment combination of G1N2 which was statistically similar to G1N0 (23.00g) and G1N3 (22.66g), while the treatment combination of G0N0 gave the minimum (16.86g) fresh weight of root (Table 10). From the results it was reported that both GA_3 application and nitrogen levels influence the plant growth which ensured maximum fresh weight of root.

Root length

The maximum length of root (19.55cm) was obtained from G1, while the minimum (15.42cm) was recorded from G0 (Table 6). The effect of GA_3 on length of root was best at concentration of 60ppm which was followed by 80 and 0ppm. The maximum length of root (17.15cm) was obtained from N1, while the minimum (16.23cm) was recorded from N0 (Table 6). The effect of nitrogen on length of root was best at 210kg/ha. The variation was not found for the combined effect of GA_3 and nitrogen on length of root (Appendix III). The maximum length of root (23.33cm) was recorded from the treatment combination of G1N3 which was statistically similar to G1N2 (22.23cm), G1N0 (20.05cm) and G2N3 (16.86cm), while the treatment combination of G0N0 gave minimum (16.70cm) length of root (Table 7). From the results, it was reported that both GA_3 application and nitrogen levels influenced the plant growth which ensured maximum length of root.

Table 6. Effect of GA_3 and nitrogen levels on fresh weight of root and length of root of cabbage.

GA_3	Fresh weight of root (g)	Length of root (cm)	Nitrogen	
G_0	18.12 c	15.42 b	N_0	19.73 a
G_1	22.66 a	19.55 a	N_1	20.12 a
G_2	19.79 b	16.40 b	N_2	20.52 a
CV%	8.01	9.82	N_3	20.40
LSD (0.05)	1.36	1.46	CV%	8.01
			LSD (0.05)	0.77

Table 7. Combined effect of GA_3 and nitrogen levels on A) weight of head and head diameter of cabbage B) fresh weight of root and length of root of cabbage.

Treatment	A		B	
	Weight of head (kg)	Head diameter (cm)	Fresh weight of root (g)	Root length (cm)
G_0N_0	1.68 c	19.36 d	16.86 h	16.50 f
G_0N_1	1.91 b	18.86 d	19.80 defg	18.06 def
G_0N_2	1.99 abc	20.30 cd	17.33 gh	18.23 ef
G_0N_3	2.07 abc	18.66 d	18.50 efgh	18.90 cdef
G_1N_0	2.11 ab	20.66 bcd	23.00 ab	20.05 abc
G_1N_1	2.12 ab	23.13 ab	21.00 bcde	20.73 bcd
G_1N_2	2.38 a	24.00 a	24.00 a	22.23 ab
G_1N_3	2.01 abc	22.03 abc	22.66 abc	23.33 a
G_2N_0	1.77 bc	21.00 bcd	21.33 abcd	18.00 ef
G_2N_1	1.78 bc	19.96 cd	19.56 efgh	19.56 bcde
G_2N_2	1.88 bc	18.80 d	20.23 cdef	17.50 c
G_2N_3	1.98abc	20.30 cd	18.03 fgh	10.86 abc
CV%	9.91	6.17	8.01	9.82
LSD (0.05)	0.40	2.50	2.73	2.73

Root dry matter

Significant variation was observed on dry matter content of 100g root of cabbage for different GA_3 concentration under the present study (Appendix III). The highest dry matter content of 100g root (17.20%) was found from G1, while the lowest dry matter content of 100g root (15.80%) was recorded from G0 (Table 11). The maximum dry weight of root was obtained from 50ppm GA_3 reported by Lendve *et al.* (2010). Different levels of nitrogen fertilizer showed significant variation for dry matter content of 100g root of cabbage (Appendix III). The highest dry matter content of 100g root (20.15%) was found from

N2, whereas the lowest dry matter content of 100g root (15.45%) was recorded from N0 (Table 11). The interaction effect of different concentrations of GA_3 and nitrogen fertilizer showed significant differences on dry matter content of 100g root of cabbage (Appendix III). The highest dry matter content of 100g root (20.56%) was recorded from G1N2 and the lowest dry matter content of 100g root (15.56%) was found from G0N0 (Table 12).

Leaf dry matter

Significant variation was recorded for dry matter content of 100g leaf of cabbage for different concentrations of GA_3 under the present study (Appendix III). The highest dry matter content of 100g leaf (7.22%) was recorded from G1 which was followed by G2 (6.26%), while the lowest dry matter content of 100g leaf (5.54%) was found from G0 (Table 8) same result found by Chauhan and Tandel (2009). Different nitrogen levels showed significant variation for dry matter content of 100g leaf of cabbage (Appendix III). The highest dry matter content of 100g leaf (6.56%) was found from N2 which was followed (6.17%) by both N1 and N3, whereas the lowest dry matter content of 100g leaf (6.08%) was found from N0. Significant difference was observed on dry matter content of 100g leaf of cabbage due to combined effect of different concentrations of GA_3 and nitrogen fertilizer (Appendix III). The highest dry matter content of 100g leaf (8.26%) was recorded from G1N2 and the lowest dry matter content of 100g leaf (4.53%) was found from G0N0 (Table 9).

Table 8. Effect of GA_3 and nitrogen levels on dry matter percent of root and matter percent of leaf of cabbage.

GA_3			Nitrogen		
	Dry matter percent of root	Dry matter percent of leaf		Dry matter percent of root	Dry matter percent of leaf
G_0	15.80 c	5.54 c	N_0	15.45 c	6.08
G_1	17.20 a	7.22 a	N_1	15.75 c	6.17
G_2	16,81 b	6.26 b	N_2	20.15 a	6.56
CV%	10.05	9.07	N_3	17.40 b	6.17
LSD (0.05)	0.29	0.51	CV%	10.02	9.07
			LSD (0.05)	0.41	1.82

Table 9. Combined effect of GA_3 and nitrogen levels on dry matter percent of root and matter percent of leaf of cabbage.

Combinations	Dry matter percent of root	Dry matter percent of leaf
G_0N_0	15.56 c	6.13 cde
G_0N_1	16.93 abc	5.83 de
G_0N_2	17.03 abc	4.53 f
G_0N_3	18.53 abc	5.66 e
G_1N_0	16.10 c	7.26 ab
G_1N_1	17.83 abc	6.76 bcd
G_1N_2	20.56 a	8.26 a
G_1N_3	19.56 abc	6.60 bcde
G_2N_0	17.26 bc	6.23 bcde
G_2N_1	18.23 abc	7.10 bc
G_2N_2	19.86 ab	5.73 de
G_2N_3	19.53 abc	6.00 de
CV%	10.05	9.07
LSD (0.05)	3.67	1.03

Yield (kg/plot)

Yield per plot varied significantly for application of different concentrations of GA_3 (Appendix III). 31.637kg cabbage was obtained as highest yield/plot from G1 (60ppm of GA3), while 26.750kg cabbage was found as lowest yield/plot from G2 (80ppm of GA3) (Table 10). The best effect of GA_3 application on yield per plot was obtained from the concentration of 60ppm. The plants treated with GA_3 (50ppm) showed significantly greater yield per plot than untreated controls reported by Badawi and EL-Sahhar (1979). A gradual increase in the yield per plot with 50ppm of GA_3 revealed by Chauhan and Bordia (1971). Significant variation was observed for different levels of nitrogen on yield per plot (Appendix III). Yield per plot was highest (30.75kg) in nitrogen dose N2 (240kg/ha) and it was followed by 28.65kg in N1 (210kg/ha), while the lowest yield per plot (25.50kg) was found in N0 (control) (Table 10). The best effect of nitrogen application on yield per plot was obtained from the dose of 240kg/ha. 180kg N/ha performed the highest yield reported by [18]. The combined effect of GA_3 and nitrogen was found significant variation on yield per plot. The treatment combination G1N2was produced the maximum yield/plot (35.20kg), while the treatment combination G0N0 was performed the lowest yield/plot (24.80kg) (Table 11). From the results it was found that 60ppm of GA_3 and 240kg N favored highest yield per plot.

Table 10. Effect of GA_3 and nitrogen levels on yield/plot of cabbage.

GA_3	Yield (kg/plot)	Nitrogen	Yield (kg/plot)
G_0	28.325 b	N_0	25.50 c
G_1	31.637 a	N_1	28.65 b
G_2	26.750 c	N_2	30.75 a
CV%	9.95	N_3	29.25 b
LSD (0.05)	1.341	CV%	9.95
		LSD (0.05)	1.05

Yield (t/ha)

Significant variation was observed on yield/ha (ton) for application of different concentrations of GA_3 (Appendix III). The highest yield/ha (87.876ton) was obtained from G1 (60ppm GA3), while the lowest (74.296ton) was found from G2 (80ppm) (Fig. 3). The highest yield (494.78 q/ha) was obtained in the treatment with two sprays of GA_3 at 100ppm reported by Dharmender *et al.* (1996). The high yield was observed from the treatment with 50ppm GA_3 found by Yadav *et al.* (2000).

Nitrogen showed significant variation in different levels on yield/ha (Appendix III). The highest yield/ha (85.41ton) was obtained from N2 (240kg/ha) and the lowest (70.83ton) was found from No (Control) (Fig. 6). The highest yield/ha was obtained from nitrogen doses 180kg/ha which was reported by (Singh and Naik, 1988). The higher yields was observed from application of 200kgha-1 N reported by Parmar *et al.* (1999). The highest gross yield (79.62ton/ha) was achieved by the application of 150kg N/ha compared to the lowest yield at 28.88ton/ha case of 0kg N/ha Bhuiyan (1996). The interaction of GA_3 with nitrogen was found significant on yield/ha. The maximum yield (97.77ton) was noted from the treatment combination of G1N2 (60ppm GA_3 with 240kg N/ha), while the treatment combination of GoNo (Control) gave the minimum (68.88ton) yield (Table 11). From the present findings it was revealed that 60ppm GA_3 with 200kg N/ha favored for obtaining higher yield of cabbage.

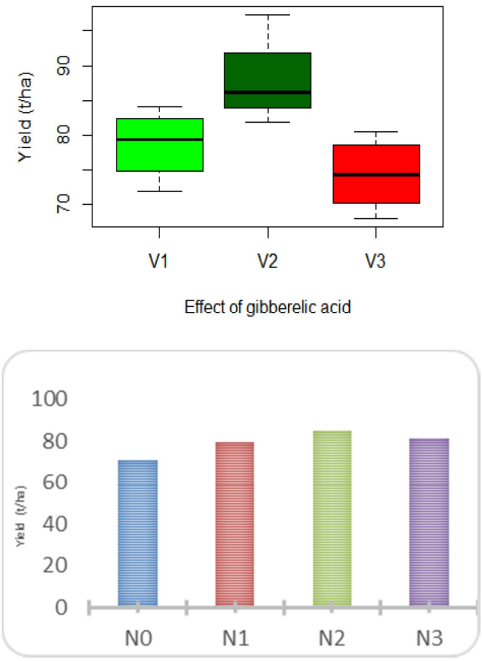

Fig. 3. Effect of A) GA_3 and B) nitrogen levels on yield (t/ha) of cabbage.

Table 11. Combined effect of GA_3 and nitrogen levels on yield (kg/plot) and yield (t/ha) of cabbage.

Combinations	Yield (kg/plot)	Yield (t/ha)	Combinations	Yield (kg/plot)	Yield (t/ha)
G_0N_0	24.80 f	68.88 f	G_1N_3	30.50 bc	84.72 b
G_0N_1	26.20 e	72.77 e	G_2N_0	27.80 d	77.22 d
G_0N_2	28.20 cd	78.33 d	G_2N_1	29.70 c	82.50 c
G_0N_3	31.25 b	86.80 b	G_2N_2	31.26 b	86.83 b
G_1N_0	26.21 de	72.80 e	G_2N_3	29.20 c	81.11 c
G_1N_1	29.30 c	81.38 c	CV%	9.95	10.12
G_1N_2	35.20 a	97.77 a	LSD (0.05)	1.21	2.43

Conclusions

Cabbage cultivation was economically profitable if the maintain the effective doses and appropriate management. It is no doubt that GA_3 and nitrogen has marvelous effect on cabbage growth and yield performance. Among the combinations of different levels of GA_3 and nitrogen fertilizer, 60ppm GA_3 and 240kg N/ha has been performed as the best use for superior growth and yield contributing characters of cabbage. Considering the situation of the present experiment, further studies in the following areas may be suggested to study the trialed in different Agra-ecological zones (AEZ) of Bangladesh for exploitation of regional adaptability and other performances.

Finally, it is clearly concluded that cabbage cultivation helps to the farmer to increase their net profit if conserve the effect of different growth promoter application and effective nitrogen fertilization.

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Appendix

Appendix I. Analysis of variance of the data on PH and number of loose leaves of cabbages influenced by different levels of GA_3 and nitrogen.

Source of variation	df	Mean square						
		Plant height(cm) at			No. of loose leaves at			
		30 DAT	45 DAT	60 DAT	30 DAT	45 DAT	60 DAT	At harvest
Replication	2	0.99	0.85	5.63	1.97	0.78	1.69	2.75
GA_3 (Factor:A)	2	28.27**	202.17**	445.42**	1.99**	7.33**	5.27**	12.45
Nitrogen (Factor:B)	3	22.12*	152.53**	403.09**	145.57**	5.58**	4.63**	8.22**
Interaction(A*B)	6	2.66**	7.84**	11.19**	76.73**	0.65*	0.82**	6.74**
Error	22	0.83	0.96	0.84	0.76	0.77	0.33	0.49
Total	35							

Appendix II. Analysis of variance of the data on LB and leaf length of cabbage as influenced by different levels of GA_3 and nitrogen.

Source of variation	df	Mean square	
		Leaf breadth (cm) at	
		45 DAT	60 DAT
Replication	2	8.22	11.84
GA_3 (Factor:A)	2	33.33**	27.17**
Nitrogen (Factor:B)	3	142.27**	133.36*
Interaction (A*B)	6	6.55**	61.19*
Error	22	1.07	0.99
Total	35		

* and ** indicates at 1% and ** 5% level of significance.

Appendix III. Analysis of variance of the data on yield contributing characters of cabbage as influenced by different levels of GA_3 and nitrogen.

Source of variation	df	Mean square								
		Canopy (cm)	Weight of head (kg)	Diameter of head (cm)	Fresh weight of root (gm)	Root length (cm)	Dry matter content of root (%)	Dry matter content of leaf (%)	Yield (kg/plot)	Yield(t/ha)
Replication	2	3.63	9.29	6.73	8.92	10.11	9.06	7.45	7.87	8.03
GA_3 (Factor:A)	2	4.47**	21.23*	38.12**	41.49**	62.73*	45.77**	55.42*	74.73*	65.78*
Nitrogen (Factor:B)	3	8.77	27.13*	31.42**	47.43**	190.23**	35.35*	61.95**	81.84**	85.82**
Interaction (A*B)	6	3.09	10.16*	18.17**	30.29**	42.46**	21.24**	25.52**	46.69**	53.76**
Error	22	0.69	0.82	0.93	0.75	0.98	0.97	0.91	0.85	0.89
Total	35									

* and ** indicates at 1% and ** 5% level of significance.