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Gibberellic Acid and Planting Time Influence on the Growth and Yield of Cabbage (*Brassica oleracea var. capitata L.*)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The experiment was conducted at the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka during the period from October 2018 to March 2019. The goal of this study was to determine when to sow cabbage and how much gibberellic acid to use in order to maximize growth and yield. The experiment consisted of two factors: Factor A: Planting time (three different times) as - T1= 05 November; T2= 20 November and T3= 05 December and Factor B: Gibberellic acid (four levels) as- G0= 0 ppm (control); G1= 75 ppm; G2= 95 ppm and G3= 115 ppm GA3, respectively. The two factors experiment was laid out in Randomized Complete Block Design with three replications. Due to the combined effect of Gibberellic acid and planting time, the maximum thickness of head (14.5 cm) and the highest marketable yield (59.4 t/ha) was found from T2G2 whereas the minimum thickness of head (10.8 cm) and the lowest marketable yield (37.1 t/ha) was found from T3G0. The

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economic analysis revealed that T2G2 gave the maximum benefit cost ratio (2.57). That's why we can consider that 20thNovember planting time along with 95 ppm GA3 was the best combination for growth and yield of cabbage.

Keywords: Gibberellic acid; planting time; growth; yield; cabbage.

1. INTRODUCTION

Cabbage (*Brassica oleracea* var. *capitata* L.) is a popular winter vegetable in Bangladesh. It is a member of the Brassicaceae family. It is a short-season crop grown for its compact head. This one-of-a-kind vegetable is widely grown in both tropical and temperate climates around the world [1]. It has been recognized as a vital vegetable for farmers worldwide in terms of income and nutrition [2].

Cabbage is high in vitamin C and tryptophan, an essential amino acid for humans [3]. According to FAO, at least 5% of total calories should have come from vegetables and fruits, which may satisfy human vitamin and mineral requirements. It has been reported that 100 g of edible cabbage contains 92% water, 24 calories of food energy, 1.5 g of protein, 9.8 g of carbohydrate, 40 mg of Ca, 0.6 mg of Fe, 600 IU of Carotene, 0.05 mg of thiamine, 0.05 mg of riboflavin, 0.3 mg of niacin, and 60 mg of vitamin E [3].

Quality seeds, high-yielding varieties, sowing time, fertilizer management, growth hormones, disease and insect infestation, and irrigation facilities are all factors that influence cabbage yield. Plant growth regulators and planting time, among other factors, can play an important role in increasing cabbage production in Bangladesh [4].

The planting season has a significant impact on crop yield. Cabbage requires a cool environment to grow and form heads. When compared to late planting, early planting produced the largest head and the highest yield. Late sowing reduced head development, according to [5]. According to [6], cabbage cultivation is more profitable in the pre-rabi period and least profitable in the late-rabi period in the Jessore area.

Organic substances known as plant growth regulators (PGRs) are able to alter a specific physiological plant process when present in small amounts. It is crucial to many facets of plant growth and development [7]. The most notable effect of these chemicals, which have now been used to treat a wide range of plant organs in various ways, has been discovered to be a significant enhancement in stem elongation. Exposure to a small amount of gibberellic acid was seen in numerous plants (GA_3). Cabbage grew quickly after being treated with plant growth regulators [8]. The application of GA3 stimulates morphological characteristics such as plant height, number of leaves, head diameter, head thickness, and head weight [9]. The interactions of these chemicals with the environmental conditions have a significant impact on the growth and yield components of cabbage. In light of the aforementioned considerations, the current study was conducted to determine the impact of various planting times and GA_3 concentrations on the vegetative growth, yield, and economic return of cabbage.

2. MATERIALS AND METHODS

2.1 Experimental Site

The experiment was carried out at the Horticulture Research Farm of Sher-e-Bangla Agricultural University (SAU). It is located in $23^0 74'$N latitude and $90^0 35'$E longitudes. According to data from Bangladesh Metrological Department, Agargaon, Dhaka-1207, the location is 8.2 meters above sea level. The maximum temperature, Relative and rainfall were 28.5^0C, 71.6% and 3.0mm whereas the minimum temperature, Relative and rainfall were 13.5^0C, 60% and 2.0mm in this experiment.

2.2 Soil and Climate

The experimental site is located in the Modhupur Tract (UNDP, 1988) under AEZ No. 28. The chosen plot of land was medium-high in nature, had adequate irrigation facilities, and had been fallow during the previous season. The soil texture used in the experiment was sandy loam. Soil P^H 6.4, Total N (0.07 %), Available P (18.49µ gm/gm), Exchangeable K (0.07meq), Available S (20.82µ gm/gm), Available Fe (229µ gm/gm), Available Zn (4.48µ gm/gm), Available Mg (0.825µ gm/gm), Available Na (0.32µ gm/gm), Available B (0.94µ gm/gm) and Organic matter (1.4 %). The experimental area is located in a subtropical climate zone, which has heavy rainfall from April to September and little rainfall the rest of the year.

2.3 Planting Materials

The cabbage variety "Atlas-70" seed was used as a planting material in the experiment.

2.4 Treatment of the Experiment

The experiment consisted of two factors: Factor A: Planting time (three levels of planting time) such as T_1 : 5th November, T_2 : 20th November, T_3 : 5th December and Factor B: Gibberellic acid-GA_3 (four levels) such as G_0 : 0 ppm GA_3 (control), G_1 : 75 ppm GA_3, G_2 : 95 ppm GA_3, and G_3 : 115 ppm GA_3. There were 12 (3×4) treatments combination such as T_1G_0, T_1G_1, T_1G_2, T_1G_3, T_2G_0, T_2G_1, T_2G_2, T_2G_3, T_3G_0, T_3G_1, T_3G_2 and T_3G_3.The two factorial experiments were laid out in the Randomized Complete Block Design (RCBD) with three replications. The total area was divided into three equal blocks. Each block was divided into 12 plots where 12 treatments combination were allotted at random. There were 36 unit plots altogether in the experiment. The size of the each plot was 1.8 m × 1.6 m and spacing was 60 cm × 40 cm. The distance maintained between two blocks and two plots were 1.0 m and 0.5 m, respectively.

2.5 Main Field Preparation

The selected plot of the experiment was opened with a power tiller, and left exposed to the sun for a week. Subsequently cross ploughing was done five times with a country plough followed by laddering to make the land suitable for transplanting the seedlings. All weeds, stubbles and residues were eliminated from the field. Finally, a good tilth was achieved. The soil was treated with insecticides (Cinocarb 3G @ 4 kg/ha) at the time of final land preparation to protect young plants from the attack of soil inhibiting insects such as cutworm and mole cricket. The experimental plot was partitioned into the unit plots in accordance to the experimental design.

2.6 Manures and Fertilizer Application

Manures and fertilizers were applied to the experimental plot considering the recommended fertilizer doses of BARI (2018) such as cowdung 10 t ha^{-1}, Urea 300 kg ha^{-1}, TSP 250 kg ha^{-1} and MoP 200 kg ha^{-1}. The total amount of cowdung, TSP and MOP was applied as basal dose at the time of land preparation. The total amount of urea was applied in three installments at 10, 30 and 50 days after transplanting (DAT).

2.7 Preparation and Application of Gibberelic Acid

A 1000 ppm stock solution of GA_3 was prepared by dissolving 1 g of it in a small quantity of ethanol prior to dilution with distilled water in one liter of volumetric flask. The stock solution was used to prepare the required concentration for different treatment i.e. 75 ml of this stock solution was diluted in 1 litre of distilled water to get 75 ppm GA_3 solution. In a similar way, 95 ml stock solutions were diluted to 1 litre of distilled water to get 95 ppm solution and 115 ml stock solutions were diluted to 1 litre of distilled water to get 115 ppm 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 30, 45 and 60 DAT by a mini hand sprayer.

2.8 Raising of Seedlings

The seedlings were raised at the Horticultural Farm, SAU, Dhaka under special care in a 3 m × 1 m size seed bed. The soil of the seed bed was well ploughed with a spade and prepared into loose friable dried masses and to obtain good tilth to provide a favorable condition for the vigorous growth of young seedlings. Ten (10) grams of seeds were sown in seedbed. The 1st, 2nd and 3rd seed sowing on seed bed were done on 5th October, 20th October and 5th November, respectively. After sowing, the seeds were covered with finished light soil. At the end of germination shading was done by bamboo mat (chatai) over the seedbed to protect the young seedlings from scorching sunshine and heavy rainfall.

2.9 Transplanting

Healthy and uniform 30 days old seedlings were transplanted in the experimental plots. The 1st, 2nd and 3rd transplanting in the main field was done on 5 November, 20 November and 5 December, respectively.

2.10 Intercultural Operation

After raising seedlings, various intercultural operations such as gap filling, weeding, earthing up, irrigation pest and disease control etc. were accomplished for better growth and development of the cabbage seedlings.

2.11 Harvesting

Harvesting of the cabbage was not possible on a certain or particular date because the head

initiation as well as head maturation period in plants were not similar. Only the compact marketable heads were harvested with fleshy stalk by using sharp knife. Before harvesting of the cabbage head, compactness of the head was tested by pressing with thumbs.

2.12 Economic Analysis

The cost of production was analyzed in order to find out the most economic combination for different level of planting time and GA_3 application. All input cost included the cost for lease of land and interests on running capital in computing the cost of production. The interests were calculated @ 9% in simple rate. The market price of cabbage was considered for estimating the cost and return. Analyses were done according to the procedure of [10].

2.13 Statistical Analysis

The data obtained for different characters were statistically analyzed to find out the significance of the difference for different level of planting time and GA_3 application 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) and mean separation was done by LSD at 5% level of significance [11].

3. RESULTS AND DISCUSSION

3.1 Days to Head Formation of Cabbage

The treatment combination of gibberellic acid and planting time showed significant differences for days to head formation of cabbage (Table 1). The highest days to head formation of cabbage (40.37 days) was obtained from T_3G_0 which was statistically similar to T_2G_3 (40.04). The lowest days to head formation of cabbage (32.16 days) was provided by T_2G_2 which was statistically similar to T_2G_0 (32.34 days). Similar trends results were found by [12] and they reported that head formation was 13 days earlier with 50 ppm GA_3 compared to the control plot. The Authors [13] also showed the minimum number of days to head formation (43.54 days) and maturity (69.95 days) with 50 ppm GA_3.

3.2 Fresh Weight of Stem

Combined effect of different concentrations of gibberellic acid and planting time showed significant differences for fresh weight of stem of cabbage (Table 1). The highest fresh weight of stem of cabbage (65.90 g) was obtained from T_2G_3 which was statistically identical to T_3G_3 (64.73g) and T_1G_3 (64.55g). The lowest fresh weight of stem of cabbage (51.03 g) was obtained from T_1G_0 which was statistically similar to T_3G_0 (51.43 g) and T_2G_0 (52.91 g).Similar trend results were also found by [15]. They noticed that GA_3 60 ppm significantly increased the fresh plant weight than control.

3.3 Dry Weight of Stem

Combined effect of different concentrations of gibberellic acid and planting time showed significant differences for dry weight of stem of cabbage (Table 1). The highest dry weight of stem of cabbage (9.08 g) was obtained from T_2G_3 which was statistically similar toT_1G_3 (8.92 g), T_2G_2 (8.72 g), T_1G_2 (8.52 g). T_2G_3 (8.94 g), and T_3G_2 (8.62 g). The lowest dry weight of stem of cabbage (7.27 g) was obtained from T_1G_0 which was statistically similar to T_3G_0 (7.31g) and T_2G_0 (7.56 g). The Authors [14] got the similar trend of findings in their observation.

3.3.1 Thickness of head

Combined effect of different concentrations of gibberellic acid and planting time showed significant differences on thickness of head of cabbage (Table 2). The highest thickness of head of cabbage (14.55 cm) was obtained from T_2G_2 which was statistically identical toT_1G_2 (14.14 cm) and T_3G_2 (13.95 cm). The lowest thickness of head of cabbage (10.81 cm) was obtained from T_3G_0 which was statistically similar to T_1G_0 (11.57 cm) and T_2G_0 (11.89 cm).The present finding was conformity with the results of [15], they stated that the thickness of head on cabbage increase with the application of certain levels of GA_3.

3.3.2 Diameter of head

Combined effect of different concentrations of planting time and gibberellic acid showed significant differences for diameter of head of cabbage (Table 2). The highest diameter of head of cabbage (13.44 cm) was obtained from T_2G_2 followed by T_1G_2 and T_3G_2 where the lowest diameter of head of cabbage (10.14 cm) was recorded fromT_3G_0 whereas statistically similar with T_1G_0 (10.50 cm) and T_2G_0 (10.80 cm). An earlier another experiment, The Authors [12] were noticed the maximum head diameter with GA_3 at 50 ppm. The Authors [13] obtained the highest diameter (23.81 cm) of cabbage head with the application of 50 ppm GA_3 where the lowest diameter (17.89 cm) of cabbage head was

found in control (0 ppm GA_3)(Table 2). Similar trend results were also found by [16]. They noticed that GA_3 60 ppm significantly increased the head diameter (18.88 cm) than control.

3.3.3 Dry matter content of head

Combined effect of different concentrations of gibberellic acid and planting time showed significant differences for dry matter content of head of cabbage (Table 2). The highest dry matter content of head of cabbage (12.16 %) was obtained from T_2G_2 which was statistically similar with T_1G_2 (11.99 %), T_1G_1 (11.93 %) and T_3G_1 (11.69 %). The lowest dry matter content of head of cabbage (9.79 %) was recorded from T_3G_0 which was statistically similar withT_1G_0 (10.00 %) and T_2G_0 (10.16 %). The Authors [17] agreed to the findings of the present study.

Table 1. Effect of planting time and gibberellic acid (GA_3) on days from transplanting to head formation, fresh weight of stem and dry weight of stem

Treatment	Days from transplanting to head formation	Fresh weight of stem (g)	Dry weight of stem (g)
T_1G_0	36.48 bc	51.03 f	7.27 e
T_1G_1	34.27 d	56.03 e	7.88 cd
T_1G_2	37.64 b	61.07 c	8.52 ab
T_1G_3	39.52 a	64.55 ab	8.92 a
T_2G_0	32.34 e	52.91 f	7.56 de
T_2G_1	34.64 d	58.87 d	8.24 bc
T_2G_2	32.16 e	62.69 bc	8.72 ab
T_2G_3	40.04 a	65.90 a	9.08 a
T_3G_0	40.37 a	51.43 f	7.31 e
T_3G_1	36.20 c	56.69 e	7.95 cd
T_3G_2	37.61 b	61.87 c	8.62 ab
T_3G_3	33.60 d	64.73 a	8.94 a
$LSD_{0.05}$	1.128	1.863	0.5052
CV (%)	8.37	10.26	11.39

T_1= 5 November *T_2= 20 November* *T_3= 5 December*
G_0= Control *G_1= 75 ppm GA_3* *G_2= 95 ppm GA_3* *G_3= 115 ppm GA_3*

Table 2. Effect of planting time and gibberellic acid (GA_3) on thickness of head, diameter of head and dry matter content of head

Treatment	Thickness of head (cm)	Diameter of head (cm)	Dry matter content of head (%)
T_1G_0	11.57 g	10.50 ij	10.00 fg
T_1G_1	13.51 bc	12.13 de	11.93 ab
T_1G_2	14.14 ab	12.96 b	11.99 ab
T_1G_3	12.71 de	11.40 fg	10.89 de
T_2G_0	11.89 fg	10.80 hi	10.16 fg
T_2G_1	13.81 b	12.30 cd	11.17 cd
T_2G_2	14.55 a	13.44 a	12.16 a
T_2G_3	12.95 c-e	11.68 ef	11.19 cd
T_3G_0	10.81 h	10.14 j	9.79 g
T_3G_1	13.09 cd	11.94 de	11.69 ab
T_3G_2	13.95 ab	12.66 bc	11.53 bc
T_3G_3	12.39 ef	11.09 gh	10.49 ef
$LSD_{0.05}$	0.6082	0.4759	0.4699
CV (%)	8.54	7.83	9.28

T_1= 5 November *T_2= 20 November* *T_3= 5 December*
G_0= Control *G_1= 75 ppm GA_3* *G_2= 95 ppm GA_3* *G_3= 115 ppm GA_3*

3.3.4 Gross weight of head plant^{-1}

Due to combined effect of different concentrations of gibberellic acid and planting time showed significant differences on gross weight of head plant^{-1} of cabbage (Table 3). The highest gross weight of head plant^{-1} of cabbage (1713.00 g) was obtained from T_2G_2.The lowest gross weight of head plant^{-1} 1281.00 g) was recorded from T_3G_0 followed by T_1G_0 (1301.00 g) and T_2G_0 (1349.00 g). The Authors [18] recorded the highest yield per plant from earlier plantation. The Authors [19] also found different transplanting dates showed significant influence on the yield and yield contributing characters of broccoli. They observed that weight of curd plant^{-1} (319.11 g), were decreased with delay in transplanting. Similar results was also found by [16]. They noticed that GA_3 60 ppm significantly increased the whole plant weight (2.44 kg) than control.

3.3.5 Gross yield plot^{-1}

Combined effect of different concentrations of gibberellic acid and planting time showed significant differences for gross yield plot^{-1} of cabbage (Table 3). The highest gross yield plot^{-1} of cabbage (19.78 kg) was obtained from T_2G_2 which was statistically identical to T_1G_2 (19.16 kg).The lowest gross yield plot^{-1} of cabbage (14.60 kg) was recorded from T_3G_0 which was statistically similar to T_1G_0 (14.84 kg). The Authors [20] recorded the highest yield per plot over later date of planting. The Authors [19] also found different transplanting dates showed significant influence on the yield and they observed that curd yield plot^{-1} (7.83 kg) and were decreased with delay in transplanting. Similar results was also found by [16]. They noticed that GA_3 60 ppm significantly increased the head yield (51.26 t/ha) than control.

3.3.6 Gross yield ha^{-1}

Combined effect of different concentrations of gibberellic acid and planting time showed significant differences for gross yield ha^{-1} of cabbage (Table 3). The highest gross yield ha^{-1} of cabbage (68.68 t/ha) was obtained fromT_2G_2). The lowest gross yield ha^{-1} of cabbage (50.52 t/ha) was recorded from T_3G_0 which was statistically similar to T_1G_0 (51.68 t/ha). THE Authors [20] observed that head yield decreased with delayed planting. [19] also found different transplanting dates showed significant influence on the yield and yield contributing characters of broccoli. They observed that curd yield ha^{-1} (13.04 t/ha) was decreased with delay in transplanting. The Authors [4] observed the highest yield (494.78 q/ha) with 2 sprays of gibberellic acid at 100 ppm.

3.3.6 Marketable yield plant^{-1}

Combined effect of different concentrations of gibberellic acid and planting time showed significant differences on marketable yield plant^{-1} of cabbage (Table 3). The highest marketable yield plant^{-1}of cabbage (1363.00 g) was obtained from T_2G_2.The lowest marketable yield plant^{-1} (966.00 g) was found from T_3G_0. The Authors [20] recorded the highest yield per plant from earlier plantation. The Authors [19] also found different transplanting dates showed significant influence on the yield and yield contributing characters of broccoli. They observed that weight of curd plant^{-1} (319.11g), were decreased with delay in transplanting. Similar results were also found by [16]. They noticed that GA_3 60 ppm significantly increased the head weight (1.73 kg) than control.

3.3.7 Marketable yield plot^{-1}

Combined effect of different concentrations of gibberellic acid and planting time showed significant differences on marketable yield plot^{-1} of cabbage (Table 3). The highest marketable yield plot^{-1} of cabbage (17.10 kg) was obtained from T_2G_2 which was statistically identical to T_1G_2 (15.80 kg). The lowest marketable yield plot^{-1} of cabbage (10.69 kg) was recorded from T_3G_0 which was statistically similar to T_1G_0 (10.90 kg). The Authors [20] recorded the highest yield per plot over later date of planting. The Authors [19] also found different transplanting dates showed significant influence on the yield and they observed that curd yield plot^{-1} (7.83 kg) and were decreased with delay in transplanting. Similar trends results were found by [16]. They noticed that GA_3 60 ppm significantly increased the head yield (51.26 t/ha) than control.

3.3.8 Marketable yield ha^{-1}

Due to combined effect of different levels of planting time and GA_3 showed significant differences on marketable yield ha^{-1} of cabbage. The highest marketable yield ha^{-1} of cabbage (59.35 t/ha) was found from T_2G_2 whereas the lowest marketable yield ha^{-1} of cabbage (37.12 t/ha) was found from T_3G_0 (Fig.1). The Authors [5] reported that late sowing reduced the head development. The Authors [6] revealed that cabbage cultivation is more profitable in pre-rabi

period and least profitable (actually negative profitable) in the late-rabi period. The Authors [20] observed that head yield decreased with delayed planting. The Authors [17] also found different transplanting dates showed significant influence on the yield and yield contributing characters of broccoli. They observed that curd yield ha^{-1} (13.04 ton) was decreased with delay in transplanting. Similar results were also found by [16]. They noticed that GA_3 60 ppm significantly increased the head yield (51.26 t/ha) than control.

Table 3. Effect of planting time and gibberellic acid (GA_3) on yield of cabbage.

Treatment	Gross weight of head plant^{-1} (g)	Gross yield plot^{-1} (kg)	Gross yield ha^{-1} (ton)	Marketable yield plant^{-1} (g)	Marketable yield plot^{-1} (kg)
T_1G_0	1301.00 k	14.84 g	51.68 h	981.00 k	10.90 ij
T_1G_1	1523.00 e	17.50 d	60.77 d	1176.00 e	14.11 de
T_1G_2	1662.00 b	19.16 ab	66.52 b	1317.00 b	15.80 b
T_1G_3	1409.00 h	16.13 ef	56.02 ef	1070.00 h	12.84 hi
T_2G_0	1349.00 j	15.41 fg	53.52 g	1019.00 j	11.08 i
T_2G_1	1584.00 d	18.23 cd	63.31 c	1232.00 d	14.78 cd
T_2G_2	1713.00 a	19.78 a	68.68 a	1363.00 a	17.10 a
T_2G_3	1443.00 g	16.54 e	57.43 e	1099.00 g	13.19 fg
T_3G_0	1281.00 *l*	14.60 g	50.52 h	966.00 *l*	10.69 j
T_3G_1	1494.00 f	16.14 ef	59.52 d	1138.00 f	13.66 ef
T_3G_2	1611.00 c	18.56 bc	64.43 c	1263.00 c	15.16 bc
T_3G_3	1379.00 i	15.77 ef	54.77 fg	1043.00 i	12.96 gh
$LSD_{0.05}$	4.540	0.8450	1.732	4.892	0.5767
CV (%)	8.33	10.27	9.67	9.74	12.32

T_1= 5 November *T_2= 20 November* *T_3= 5 December*
G_0= Control *G_1= 75 ppm GA_3* *G_2= 95 ppm GA_3* *G_3= 115 ppm GA_3*

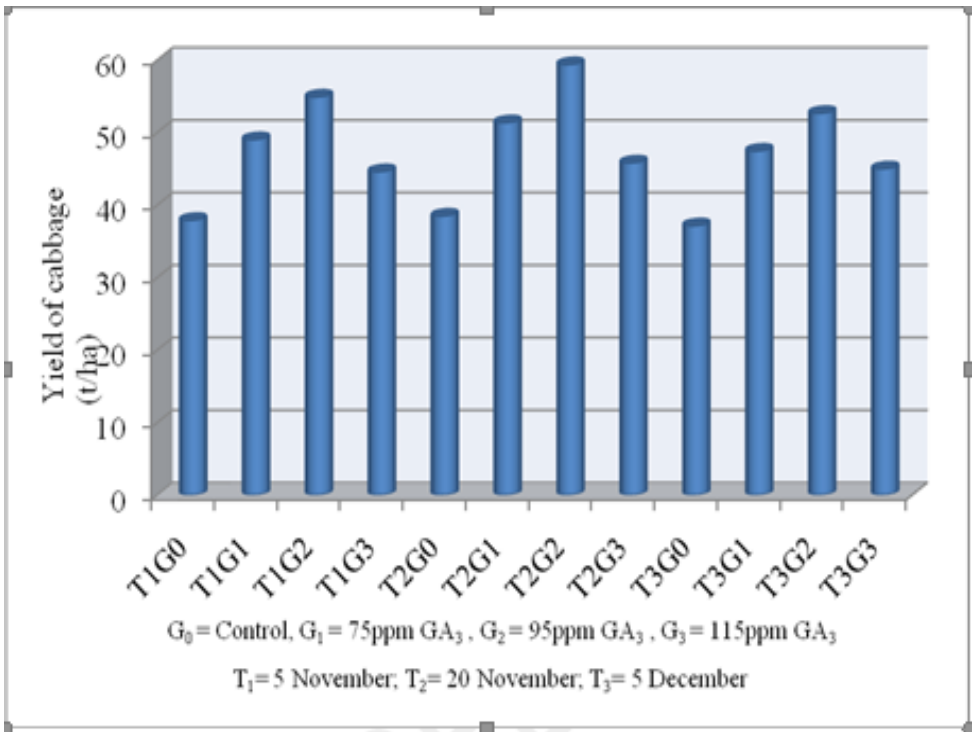

Fig. 1. Combined effect of planting time and gibberellic acid (GA_3) on yield of cabbage.

3.4 Performance on Economic Return

Cost of production

Due to effect of different treatment combinations showed major differences in terms of cost of production of cabbage (Table 4). The highest cost of production of cabbage (170,547.00 Taka/ha) was obtained from T_1G_3, T_2G_3 and T_3G_3 and the second highest cost of production of cabbage (168,862.00 Taka/ha) was obtained from T_1G_2, T_2G_2 and T_3G_2. The lowest cost of production of cabbage (161,559.00 Taka/ha) was recorded from T_1G_0, T_2G_0 and T_3G_0 where the second lowest cost of production (167,177.00 Taka/ha) was obtained from T_1G_1, T_2G_1 and T_3G_1.

3.4.1 Gross return

In case of gross return, different treatment combination showed considerable gross return of cabbage (Table 4). The highest gross return of cabbage (433255.00 Taka/ha) was obtained from T_2G_2 where the second and third highest gross return of cabbage (400624.00 and 384199.00 Taka/ha respectively) was obtained from T_1G_2 and T_3G_2 respectively. The lowest gross return of cabbage (270976.00 Taka/ha) was recorded from T_3G_0 and the second and third lowest gross return of cabbage (276451.00 and 280758.00 Taka/ha respectively) was found fromT_1G_0 and T_2G_0 respectively.

3.4.2 Net return

Different treatment combinations showed large differences in terms of net return from cabbage (Table 4). The highest net return of cabbage (264,393.00 Taka/ha) was obtained from T_2G_2 where the second and third highest net return of cabbage (231,762.00 and 215,337.00 Taka/ha, respectively) was obtained from T_1G_2 and T_3G_2 respectively. The lowest net return of cabbage (109,417.00 Taka/ha) was recorded from T_3G_0 and the second and third lowest net return of cabbage (114,892.00 and 119,199.00 Taka/ha, respectively) was found from T_1G_0, T_2G_0 respectively.

3.4.3 Benefit cost ratio (BCR)

Different treatment combination showed imperative differences on benefit cost ratio of cabbage production (Table 4). Results indicated that the highest benefit cost ratio of cabbage (2.57) was obtained from T_2G_2 where the lowest benefit cost ratio (1.68) was found from T_3G_0. The results also obtained from T_1G_2, T_2G_1, T_3G_2, T_1G_1 and T_3G_1 also gave promising results in terms of BCR but lower than the highest results.

Table 4. Cost and return of cabbage cultivation as influenced by different levels of planting time and GA_3.

Treatment	Cost of production (Tk/ha)	Yield of cabbage (t/ha)	Gross return (Tk/ha)	Net return (Tk/ha)	Benefit cost ratio
T_1G_0	161,559	37.87	276451	114,892	1.71
T_1G_1	167,177	49.00	357700	190,523	2.14
T_1G_2	168,862	54.88	400624	231,762	2.37
T_1G_3	170,547	44.58	325434	154,887	1.91
T_2G_0	161,559	38.46	280758	119,199	1.74
T_2G_1	167,177	51.33	374709	207,532	2.24
T_2G_2	168,862	59.35	433255	264,393	2.57
T_2G_3	170,547	45.79	334267	163,720	1.96
T_3G_0	161,559	37.12	270976	109,417	1.68
T_3G_1	167,177	47.42	346166	178,989	2.07
T_3G_2	168,862	52.63	384199	215,337	2.28
T_3G_3	170,547	44.97	328281	157,734	1.92

T_1= 5 November *T_2= 20 November* *T_3= 5 December*
G_0= Control *G_1= 75 ppm GA_3* *G_2= 95 ppm GA_3* *G_3= 115 ppm GA_3*
Rate of cabbage: 7300 Tk/ton
Gross return = Total yield (t/ha) × Tk. 7,300
Net return = Gross return - Total cost of production
Benefit Cost Ratio (BCR) = Gross return/Total cost of production

4. CONCLUSION

Among the combination of different levels of planting time and gibberellic acid; planting time at 20 November with 95 ppm GA_3 induced superior growth, yield contributing characters and yield of cabbage as well as highest economic return. Further investigation is needed in different Agro-Ecological zones (AEZ) of Bangladesh to justify the result for economic returns. After consecutive trial, best result could be proposed for commercial cultivation in all over the country.

DISCLAIMER

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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