

## Original Research Article

### Gibberellic acid and planting time influence on the growth and yield of cabbage

#### ABSTRACT

An experiment was conducted at the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka during the period from October 2018 to March 2019. The experiment consisted of two factors: Factor A: Planting time (three different times) as -  $T_1= 05$  November;  $T_2= 20$  November and  $T_3= 05$  December and Factor B: Gibberellic acid (four levels) as-  $G_0= 0$  ppm (control);  $G_1= 75$  ppm;  $G_2= 95$  ppm and  $G_3= 115$  ppm  $GA_3$ , respectively. The two factors experiment was laid out in Randomized Complete Block Design with three replications. Due to the combined effect 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  $T_2G_2$  and the minimum thickness of head (10.8 cm) and the lowest marketable yield (37.1 t/ha) was found from  $T_3G_0$ . Economic analysis revealed that  $T_2G_2$  gave the maximum benefit cost ratio (2.57). That's why we can consider that 20<sup>th</sup> November planting along with 95 ppm  $GA_3$  was the best combination for growth and yield of cabbage.

**Keywords:** Gibberellic acid, Planting time, Growth, Yield and Cabbage

#### 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 (Sarker et al., 2002). It has been recognized as a vital vegetable for farmers worldwide in terms of income and nutrition (FAOSTAT, 2007).

**Comment [S1]:** Which cabbage did you used? Put the scientific name also

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**Comment [S5]:** What is your objectives? Better to put your objectives. Therefore, your reader can make a judgment on your findings & your objectives

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**Comment [S10]:** If this is your conclusion, would you like to recommend this result for other similar agro-ecologies? Put your recommendation & suggestion

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**Comment [S13]:** What is the current production status of Cabbage on the world? Then in your country? Who is the leading producers/

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Cabbage is high in vitamin C and tryptophan, an essential amino acid for humans (Rashid, 1993). 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. (Rashid, 1993).

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 (Yadav et al., 2000).

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 Kryuchkov and Suddenko (1991). According to Hasan et al. (2003), 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 (Dharmender et al., 1996). 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<sub>3</sub>). Cabbage grew quickly after being treated with plant growth regulators (Islam et al., 1993). The application of GA<sub>3</sub> stimulates morphological characteristics such as plant height, number of leaves, head diameter, head thickness, and head weight. 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<sub>3</sub> concentrations on the vegetative growth, yield, and economic return of cabbage.

## Materials and methods

### Experimental site

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The experiment was carried out at the Horticulture Research Farm of Sher-e-Bangla Agricultural University (SAU). It is located in 23<sup>0</sup>74'N latitude and 90<sup>0</sup>35'E longitudes. According to data from Bangladesh Metrological Department, Agargaon, Dhaka-1207, the location is 8.2 meters above sea level.

### 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. 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.

### Planting materials

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

### Treatment of the experiment

The experiment consisted of two factors: **Factor A:** Planting time (three levels of planting time) such as T<sub>1</sub> : 5<sup>th</sup> November, T<sub>2</sub> : 20<sup>th</sup> November, T<sub>3</sub> : 5<sup>th</sup> December and **Factor B:** Gibberellic acid-GA<sub>3</sub> (four levels) such as G<sub>0</sub> : 0 ppm GA<sub>3</sub> (control), G<sub>1</sub> : 75 ppm GA<sub>3</sub>, G<sub>2</sub> : 95 ppm GA<sub>3</sub>, and G<sub>3</sub> : 115 ppm GA<sub>3</sub>. There were 12 (3×4) treatments combination such as T<sub>1</sub>G<sub>0</sub>, T<sub>1</sub>G<sub>1</sub>, T<sub>1</sub>G<sub>2</sub>, T<sub>1</sub>G<sub>3</sub>, T<sub>2</sub>G<sub>0</sub>, T<sub>2</sub>G<sub>1</sub>, T<sub>2</sub>G<sub>2</sub>, T<sub>2</sub>G<sub>3</sub>, T<sub>3</sub>G<sub>0</sub>, T<sub>3</sub>G<sub>1</sub>, T<sub>3</sub>G<sub>2</sub> and T<sub>3</sub>G<sub>3</sub>. 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.

### 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

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**Comment [S23]:** Indicate the Max & Min Rf?

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.

### **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<sup>-1</sup>, Urea 300 kg ha<sup>-1</sup>, TSP 250 kg ha<sup>-1</sup> and MoP 200 kg ha<sup>-1</sup>. 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).

**Comment [S24]:** DAT

### **Preparation and application of **growth regulator****

**Comment [S25]:** Gibberellic acid

A 1000 ppm stock solution of GA<sub>3</sub> 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<sub>3</sub> 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<sub>3</sub> as per treatment were applied at three times 30, 45 and 60 DAT by a mini hand sprayer.

### **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 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> seed sowing on seed bed were done on 5<sup>th</sup> October, 20<sup>th</sup> October and 5<sup>th</sup> 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.

### **Transplanting**

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

### **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

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### **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.

**Comment [S27]:** Is that a scientific way to press by thumbs? Is that two individuals press equally? What other harvesting indicator?

### **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<sub>3</sub> 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 Alam et al. (1989).

### **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<sub>3</sub> 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. (Gomez and Gomez, 1984).

## Results and Discussion

### 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<sub>3</sub>G<sub>0</sub> which was statistically similar to T<sub>2</sub>G<sub>3</sub> (40.04). The lowest days to head formation of cabbage (32.16 days) was provided by T<sub>2</sub>G<sub>2</sub> which was statistically similar to T<sub>2</sub>G<sub>0</sub> (32.34 days). Similar trends results were found by Patil et al. (1987) and they reported that head formation was 13 days earlier with 50 ppm GA<sub>3</sub>. Roy and Nasiruddin (2011) also showed the minimum number of days to head formation (43.54 days) and maturity (69.95 days) with 50 ppm GA<sub>3</sub>.

**Comment [S28]:** As compared to what? Other treatments or control?

### 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<sub>2</sub>G<sub>3</sub> which was statistically identical to T<sub>3</sub>G<sub>3</sub> (64.73g) and T<sub>1</sub>G<sub>3</sub>(64.55g). The lowest fresh weight of stem of cabbage (51.03 g) was obtained from T<sub>1</sub>G<sub>0</sub> which was statistically similar to T<sub>3</sub>G<sub>0</sub> (51.43 g) and T<sub>2</sub>G<sub>0</sub> (52.91 g). Similar trend results were also found by Chaurasiy et al. (2014). They noticed that GA<sub>3</sub> 60 ppm significantly increased the fresh plant weight than control.

### 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<sub>2</sub>G<sub>3</sub> which was statistically similar to T<sub>1</sub>G<sub>3</sub> (8.92 g), T<sub>2</sub>G<sub>2</sub> (8.72 g), T<sub>1</sub>G<sub>2</sub> (8.52 g), T<sub>2</sub>G<sub>3</sub> (8.94 g), and T<sub>3</sub>G<sub>2</sub> (8.62 g). The lowest dry weight of stem of cabbage (7.27 g) was obtained from T<sub>1</sub>G<sub>0</sub> which was statistically similar to T<sub>3</sub>G<sub>0</sub> (7.31g) and T<sub>2</sub>G<sub>0</sub> (7.56 g). Dharmander et al. (1996) got the similar trend of findings in their observation.

**Table 1. Effect of planting time and gibberellic acid (GA<sub>3</sub>) 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 <sub>1</sub> G <sub>0</sub>	36.48 bc	51.03 f	7.27 e
T <sub>1</sub> G <sub>1</sub>	34.27 d	56.03 e	7.88 cd
T <sub>1</sub> G <sub>2</sub>	37.64 b	61.07 c	8.52 ab
T <sub>1</sub> G <sub>3</sub>	39.52 a	64.55 ab	8.92 a
T <sub>2</sub> G <sub>0</sub>	32.34 e	52.91 f	7.56 de
T <sub>2</sub> G <sub>1</sub>	34.64 d	58.87 d	8.24 bc
T <sub>2</sub> G <sub>2</sub>	32.16 e	62.69 bc	8.72 ab
T <sub>2</sub> G <sub>3</sub>	40.04 a	65.90 a	9.08 a
T <sub>3</sub> G <sub>0</sub>	40.37 a	51.43 f	7.31 e
T <sub>3</sub> G <sub>1</sub>	36.20 c	56.69 e	7.95 cd
T <sub>3</sub> G <sub>2</sub>	37.61 b	61.87 c	8.62 ab
T <sub>3</sub> G <sub>3</sub>	33.60 d	64.73 a	8.94 a
LSD <sub>0.05</sub>	1.128	1.863	0.5052
CV (%)	8.37	10.26	11.39

T<sub>1</sub>= 5 November    T<sub>2</sub>= 20 November    T<sub>3</sub>= 5 December  
G<sub>0</sub>= Control        G<sub>1</sub>= 75 ppm GA<sub>3</sub>    G<sub>2</sub>= 95 ppm GA<sub>3</sub>    G<sub>3</sub>= 115 ppm GA<sub>3</sub>

#### 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<sub>2</sub>G<sub>2</sub> which was statistically identical to T<sub>1</sub>G<sub>2</sub> (14.14 cm) and T<sub>3</sub>G<sub>2</sub> (13.95 cm). The lowest thickness of head of cabbage (10.81 cm) was obtained from T<sub>3</sub>G<sub>0</sub> which was statistically similar to T<sub>1</sub>G<sub>0</sub> (11.57 cm) and T<sub>2</sub>G<sub>0</sub> (11.89 cm). The present finding was conformity with the results of Lendve et al. (2010), they stated that the thickness of head on cabbage increase with the application of certain levels of GA<sub>3</sub>.

#### 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<sub>2</sub>G<sub>2</sub> followed by T<sub>1</sub>G<sub>2</sub> and T<sub>3</sub>G<sub>2</sub> where the lowest diameter of head of cabbage (10.14 cm) was recorded from T<sub>3</sub>G<sub>0</sub> whereas statistically similar with T<sub>1</sub>G<sub>0</sub> (10.50 cm) and T<sub>2</sub>G<sub>0</sub> (10.80 cm). An earlier another experiment, Patil *et al.* (1987) were noticed the maximum head diameter with GA<sub>3</sub> at 50 ppm. Roy and Nasiruddin (2011) obtained the highest diameter (23.81 cm) of cabbage head with the application of 50 ppm GA<sub>3</sub> where the lowest diameter (17.89 cm) of cabbage head was found in control (0 ppm GA<sub>3</sub>)(Table 2). Similar trend results were also found by Chaurasiy *et al.* (2014). They noticed that GA<sub>3</sub> 60 ppm significantly increased the head diameter (18.88 cm) than control.

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### 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<sub>2</sub>G<sub>2</sub> which was statistically similar with T<sub>1</sub>G<sub>2</sub> (11.99 %), T<sub>1</sub>G<sub>1</sub> (11.93 %) and T<sub>3</sub>G<sub>1</sub> (11.69 %). The lowest dry matter content of head of cabbage (9.79 %) was recorded from T<sub>3</sub>G<sub>0</sub> which was statistically similar with T<sub>1</sub>G<sub>0</sub> (10.00 %) and T<sub>2</sub>G<sub>0</sub> (10.16 %). Chauhan *et al.* (2009) agreed to the findings of the present study.

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**Table 2. Effect of planting time and gibberellic acid (GA<sub>3</sub>) 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 <sub>1</sub> G <sub>0</sub>	11.57 g	10.50 ij	10.00 fg
T <sub>1</sub> G <sub>1</sub>	13.51 bc	12.13 de	11.93 ab
T <sub>1</sub> G <sub>2</sub>	14.14 ab	12.96 b	11.99 ab
T <sub>1</sub> G <sub>3</sub>	12.71 de	11.40 fg	10.89 de
T <sub>2</sub> G <sub>0</sub>	11.89 fg	10.80 hi	10.16 fg
T <sub>2</sub> G <sub>1</sub>	13.81 b	12.30 cd	11.17 cd
T <sub>2</sub> G <sub>2</sub>	14.55 a	13.44 a	12.16 a
T <sub>2</sub> G <sub>3</sub>	12.95 c-e	11.68 ef	11.19 cd

T <sub>3</sub> G <sub>0</sub>	10.81 h	10.14 j	9.79 g
T <sub>3</sub> G <sub>1</sub>	13.09 cd	11.94 de	11.69 ab
T <sub>3</sub> G <sub>2</sub>	13.95 ab	12.66 bc	11.53 bc
T <sub>3</sub> G <sub>3</sub>	12.39 ef	11.09 gh	10.49 ef
LSD <sub>0.05</sub>	0.6082	0.4759	0.4699
CV (%)	8.54	7.83	9.28

T<sub>1</sub>= 5 November    T<sub>2</sub>= 20 November    T<sub>3</sub>= 5 December  
G<sub>0</sub>= Control        G<sub>1</sub>= 75 ppm GA<sub>3</sub>    G<sub>2</sub>= 95 ppm GA<sub>3</sub>    G<sub>3</sub>= 115 ppm GA<sub>3</sub>

### Gross weight of head plant<sup>-1</sup>

Due to combined effect of different concentrations of gibberellic acid and planting time showed significant differences on gross weight of head plant<sup>-1</sup> of cabbage (Table 3). The highest gross weight of head plant<sup>-1</sup> of cabbage (1713.00 g) was obtained from T<sub>2</sub>G<sub>2</sub>. The lowest gross weight of head plant<sup>-1</sup> 1281.00 g) was recorded from T<sub>3</sub>G<sub>0</sub> followed by T<sub>1</sub>G<sub>0</sub> (1301.00 g) and T<sub>2</sub>G<sub>0</sub> (1349.00 g). Singh *et al.* (2015) recorded the highest yield per plant from earlier plantation. Khatun *et al.* (2012) found different transplanting dates showed significant influence on the yield and yield contributing characters of broccoli. They observed that weight of curd plant<sup>-1</sup> (319.11 g), were decreased with delay in transplanting. Similar results was also found by Chaurasiy *et al.* (2014). They noticed that GA<sub>3</sub> 60 ppm significantly increased the whole plant weight (2.44 kg) than control.

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### Gross yield plot<sup>-1</sup>

Combined effect of different concentrations of gibberellic acid and planting time showed significant differences for gross yield plot<sup>-1</sup> of cabbage (Table 3). The highest gross yield plot<sup>-1</sup> of cabbage (19.78 kg) was obtained from T<sub>2</sub>G<sub>2</sub> which was statistically identical to T<sub>1</sub>G<sub>2</sub> (19.16 kg). The lowest gross yield plot<sup>-1</sup> of cabbage (14.60 kg) was recorded from T<sub>3</sub>G<sub>0</sub> which was statistically similar to T<sub>1</sub>G<sub>0</sub> (14.84 kg). Singh *et al.* (2015) recorded the highest yield per plot over later date of planting. Khatun *et al.* (2012) also found different transplanting dates showed significant influence on the yield and they observed that curd yield plot<sup>-1</sup> (7.83 kg) and were decreased with delay in transplanting. Similar results was also found by Chaurasiy *et al.* (2014). They noticed that GA<sub>3</sub> 60 ppm significantly increased the head yield (51.26 t/ha) than control.

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### Gross yield ha<sup>-1</sup>

Combined effect of different concentrations of gibberellic acid and planting time showed significant differences for gross yield ha<sup>-1</sup> of cabbage (Table 3). The highest gross yield ha<sup>-1</sup> of cabbage (68.68 t/ha) was obtained from T<sub>2</sub>G<sub>2</sub>. The lowest gross yield ha<sup>-1</sup> of cabbage (50.52 t/ha) was recorded from T<sub>3</sub>G<sub>0</sub> which was statistically similar to T<sub>1</sub>G<sub>0</sub> (51.68 t/ha). Khan *et al.* (2015) observed that head yield decreased with delayed planting. Khatun *et al.* (2012) also found different transplanting dates showed significant influence on the yield and yield contributing characters of broccoli. They observed that curd yield ha<sup>-1</sup> (13.04 t/ha) was decreased with delay in transplanting. Yadav *et al.* (2000) observed the highest yield (494.78 q/ha) with 2 sprays of gibberellic acid at 100 ppm.

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### Marketable yield plant<sup>-1</sup>

Combined effect of different concentrations of gibberellic acid and planting time showed significant differences on marketable yield plant<sup>-1</sup> of cabbage (Table 3). The highest marketable yield plant<sup>-1</sup> of cabbage (1363.00 g) was obtained from T<sub>2</sub>G<sub>2</sub>. The lowest marketable yield plant<sup>-1</sup> (966.00 g) was found from T<sub>3</sub>G<sub>0</sub>. Singh *et al.* (2015) recorded the highest yield per plant from earlier plantation. Khatun *et al.* (2012) also found different transplanting dates showed significant influence on the yield and yield contributing characters of broccoli. They observed that weight of curd plant<sup>-1</sup> (319.11g), were decreased with delay in transplanting. Similar results were also found by Chaurasiyet *et al.* (2014). They noticed that GA<sub>3</sub> 60 ppm significantly increased the head weight (1.73 kg) than control.

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**Table 3. Effect of planting time and gibberellic acid (GA<sub>3</sub>) on yield of cabbage.**

Treatment	Gross weight of head plant <sup>-1</sup> (g)	Gross yield plot <sup>-1</sup> (kg)	Gross yield ha <sup>-1</sup> (ton)	Marketable yield plant <sup>-1</sup> (g)	Marketable yield plot <sup>-1</sup> (kg)
T <sub>1</sub> G <sub>0</sub>	1301.00 k	14.84 g	51.68 h	981.00 k	10.90 ij
T <sub>1</sub> G <sub>1</sub>	1523.00 e	17.50 d	60.77 d	1176.00 e	14.11 de
T <sub>1</sub> G <sub>2</sub>	1662.00 b	19.16 ab	66.52 b	1317.00 b	15.80 b
T <sub>1</sub> G <sub>3</sub>	1409.00 h	16.13 ef	56.02 ef	1070.00 h	12.84 hi
T <sub>2</sub> G <sub>0</sub>	1349.00 j	15.41 fg	53.52 g	1019.00 j	11.08 i
T <sub>2</sub> G <sub>1</sub>	1584.00 d	18.23 cd	63.31 c	1232.00 d	14.78 cd
T <sub>2</sub> G <sub>2</sub>	1713.00 a	19.78 a	68.68 a	1363.00 a	17.10 a

T <sub>2</sub> G <sub>3</sub>	1443.00 g	16.54 e	57.43 e	1099.00 g	13.19 fg
T <sub>3</sub> G <sub>0</sub>	1281.00 l	14.60 g	50.52 h	966.00 l	10.69 j
T <sub>3</sub> G <sub>1</sub>	1494.00 f	16.14 ef	59.52 d	1138.00 f	13.66 ef
T <sub>3</sub> G <sub>2</sub>	1611.00 c	18.56 bc	64.43 c	1263.00 c	15.16 bc
T <sub>3</sub> G <sub>3</sub>	1379.00 i	15.77 ef	54.77 fg	1043.00 i	12.96 gh
LSD <sub>0.05</sub>	4.540	0.8450	1.732	4.892	0.5767
CV (%)	8.33	10.27	9.67	9.74	12.32

T<sub>1</sub>= 5 November    T<sub>2</sub>= 20 November    T<sub>3</sub>= 5 December  
G<sub>0</sub>= Control        G<sub>1</sub>= 75 ppm GA<sub>3</sub>    G<sub>2</sub>= 95 ppm GA<sub>3</sub>    G<sub>3</sub>= 115 ppm GA<sub>3</sub>

### Marketable yield plot<sup>-1</sup>

Combined effect of different concentrations of gibberellic acid and planting time showed significant differences on marketable yield plot<sup>-1</sup> of cabbage (Table 3). The highest marketable yield plot<sup>-1</sup> of cabbage (17.10 kg) was obtained from T<sub>2</sub>G<sub>2</sub> which was statistically identical to T<sub>1</sub>G<sub>2</sub> (15.80 kg). The lowest marketable yield plot<sup>-1</sup> of cabbage (10.69 kg) was recorded from T<sub>3</sub>G<sub>0</sub> which was statistically similar to T<sub>1</sub>G<sub>0</sub> (10.90 kg). Singh *et al.* (2015) recorded the highest yield per plot over later date of planting. Khatun *et al.* (2012) also found different transplanting dates showed significant influence on the yield and they observed that curd yield plot<sup>-1</sup> (7.83 kg) and were decreased with delay in transplanting. Similar trends results were found by Chaurasiy *et al.* (2014). They noticed that GA<sub>3</sub> 60 ppm significantly increased the head yield (51.26 t/ha) than control.

Comment [S46]: Check the authors guideline

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### Marketable yield ha<sup>-1</sup>

Due to combined effect of different levels of planting time and GA<sub>3</sub> showed significant differences on marketable yield ha<sup>-1</sup> of cabbage. The highest marketable yield ha<sup>-1</sup> of cabbage (59.35 t/ha) was found from T<sub>2</sub>G<sub>2</sub> whereas the lowest marketable yield ha<sup>-1</sup> of cabbage (37.12 t/ha) was found from T<sub>3</sub>G<sub>0</sub> (Fig.1). Kryuchkov and Suddenko (1991) reported that late sowing reduced the head development. Hasan *et al.* (2003) revealed that cabbage cultivation is more profitable in pre-rabi period and least profitable (actually negative profitable) in the late-rabi period. Khan *et al.* (2015) observed that head yield decreased with delayed planting. Khatun *et al.* (2012) also found different transplanting dates showed significant influence on the yield

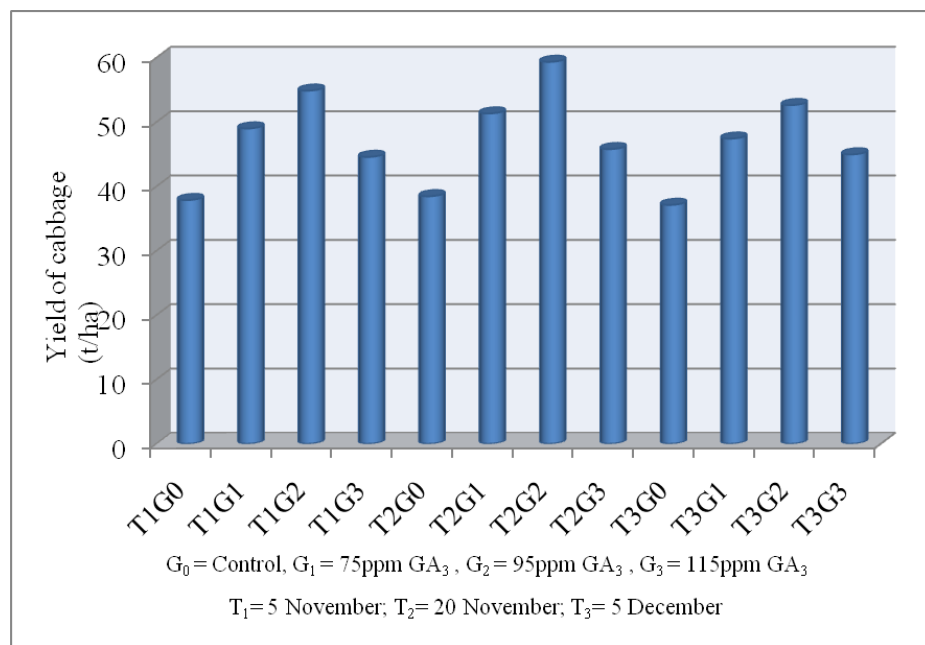
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Comment [S50]: Check the authors guideline

Comment [S51]: Check the authors guideline

and yield contributing characters of broccoli. They observed that curd yield  $\text{ha}^{-1}$  (13.04 ton) was decreased with delay in transplanting. Similar results were also found by Chaurasiy *et al.* (2014). They noticed that  $\text{GA}_3$  60 ppm significantly increased the head yield (51.26 t/ha) than control.

**Comment [S52]:** Check the authors guideline



**Figure 1.** Combined effect of planting time and gibberellic acid ( $\text{GA}_3$ ) on yield of cabbage.

### 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 Tk/ha) was obtained from T<sub>1</sub>G<sub>3</sub>, T<sub>2</sub>G<sub>3</sub> and T<sub>3</sub>G<sub>3</sub> and the second highest cost of production of cabbage (168,862.00 Tk/ha) was obtained from T<sub>1</sub>G<sub>2</sub>, T<sub>2</sub>G<sub>2</sub> and T<sub>3</sub>G<sub>2</sub>. The lowest cost of production of cabbage (161,559.00 Tk/ha) was recorded from T<sub>1</sub>G<sub>0</sub>, T<sub>2</sub>G<sub>0</sub> and T<sub>3</sub>G<sub>0</sub> where the second lowest cost of production (167,177.00 Tk/ha) was obtained from T<sub>1</sub>G<sub>1</sub>, T<sub>2</sub>G<sub>1</sub> and T<sub>3</sub>G<sub>1</sub>.

**Comment [S53]:** What is this unit Tk??

**Comment [S54]:**

#### 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 Tk/ha) was obtained from T<sub>2</sub>G<sub>2</sub> where the second and third highest gross return of cabbage (400624.00 and 384199.00 Tk/ha respectively) was obtained from T<sub>1</sub>G<sub>2</sub> and T<sub>3</sub>G<sub>2</sub> respectively. The lowest gross return of cabbage (270976.00 Tk/ha) was recorded from T<sub>3</sub>G<sub>0</sub> and the second and third lowest gross return of cabbage (276451.00 and 280758.00 Tk/ha respectively) was found from T<sub>1</sub>G<sub>0</sub> and T<sub>2</sub>G<sub>0</sub> respectively.

**Comment [S55]:** Better to use international standard units

### 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 Tk/ha) was obtained from T<sub>2</sub>G<sub>2</sub> where the second and third highest net return of cabbage (231,762.00 and 215,337.00 Tk/ha, respectively) was obtained from T<sub>1</sub>G<sub>2</sub> and T<sub>3</sub>G<sub>2</sub> respectively. The lowest net return of cabbage (109,417.00 Tk/ha) was recorded from T<sub>3</sub>G<sub>0</sub> and the second and third lowest net return of cabbage (114,892.00 and 119,199.00 Tk/ha, respectively) was found from T<sub>1</sub>G<sub>0</sub>, T<sub>2</sub>G<sub>0</sub> respectively.

### 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<sub>2</sub>G<sub>2</sub> where the lowest benefit cost ratio (1.68) was found from T<sub>3</sub>G<sub>0</sub>. The results also obtained from T<sub>1</sub>G<sub>2</sub>, T<sub>2</sub>G<sub>1</sub>, T<sub>3</sub>G<sub>2</sub>, T<sub>1</sub>G<sub>1</sub> and T<sub>3</sub>G<sub>1</sub> 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<sub>3</sub>.**

Treatment	Cost of production (Tk/ha)	Yield of cabbage (t/ha)	Gross return (Tk/ha)	Net return (Tk/ha)	Benefit cost ratio
T <sub>1</sub> G <sub>0</sub>	161,559	37.87	276451	114,892	1.71
T <sub>1</sub> G <sub>1</sub>	167,177	49.00	357700	190,523	2.14

T <sub>1</sub> G <sub>2</sub>	168,862	54.88	400624	231,762	2.37
T <sub>1</sub> G <sub>3</sub>	170,547	44.58	325434	154,887	1.91
T <sub>2</sub> G <sub>0</sub>	161,559	38.46	280758	119,199	1.74
T <sub>2</sub> G <sub>1</sub>	167,177	51.33	374709	207,532	2.24
T <sub>2</sub> G <sub>2</sub>	168,862	59.35	433255	264,393	2.57
T <sub>2</sub> G <sub>3</sub>	170,547	45.79	334267	163,720	1.96
T <sub>3</sub> G <sub>0</sub>	161,559	37.12	270976	109,417	1.68
T <sub>3</sub> G <sub>1</sub>	167,177	47.42	346166	178,989	2.07
T <sub>3</sub> G <sub>2</sub>	168,862	52.63	384199	215,337	2.28
T <sub>3</sub> G <sub>3</sub>	170,547	44.97	328281	157,734	1.92

T<sub>1</sub>= 5 November    T<sub>2</sub>= 20 November    T<sub>3</sub>= 5 December  
G<sub>0</sub>= Control        G<sub>1</sub>= 75 ppm GA<sub>3</sub>    G<sub>2</sub>= 95 ppm GA<sub>3</sub>    G<sub>3</sub>= 115 ppm GA<sub>3</sub>

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

## Conclusion

Among the combination of different levels of planting time and gibberellic acid; planting time at 20 November with 95 ppm GA<sub>3</sub> induced superior growth, yield contributing characters and yield of cabbage as well as highest economic return.

**Comment [S56]:** Conclusion is not enough and there is no recommendations

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**Comment [S57]:** These references are not enough and also too old. Thus, the authors should refer very recent journal articles