GROWTH AND YIELD OF CAULIFLOWER AS INFLUENCED BY DIFFERENT LEVEL OF GIBBERELLIC ACID AND POTASSIUM

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CERTIFICATE

This is to certify that the thesis entitled **"GROWTH AND YIELD OF CAULIFLOWER AS INFLUENCED BY DIFFERENT LEVEL OF GIBBERELLIC ACID AND POTASSIUM"** *submitted to the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE in HORTICULTURE****, embodies the result of a piece of bonafide research work carried out by* **NASRIN AKTER,** *Registration No.* ***13-05557*** *under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

I further certify that any help or source of information, received during the course of this investigation has been duly acknowledged.

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Beloved Parents

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GROWTH AND YIELD OF CAULIFLOWER AS INFLUENCED BY DIFFERENT LEVEL OF GIBBERELLIC ACID AND POTASSIUM

ABSTRACT

An experiment was carried out at the Horticultural farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207 during the period from October 2018 to February 2019 to find out the effect of gibberellic acid (GA_3) and potassium (K) on growth and yield of cauliflower (variety ‘Snowball’). The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. It consisted of two factors. Factor A: four levels of GA_3 (G_0 : 0 ppm GA_3 (control); G_1 : 95 ppm GA_3; G_2 : 115 ppm GA_3 and G_3 : 135 ppm GA_3) and factor B: three levels of potassium (K_0 : 0 kg K_2O/ha (control); K_1 : 75 kg K_2O/ha and K_2 : 100 kg K_2O/ha). In case of gibberellic acid, the highest plant height (64.13 cm) at harvest, curd diameter (24.36 cm), marketable yield per hectare (34.39 t/ha) was recorded from G_1 and the lowest was recorded from G_0. In case of potassium, the highest plant height (60.05 cm) at harvest, curd diameter (21.80 cm), marketable yield per hectare (31.42 t/ha) was recorded from K_2 and the lowest was recorded from K_0. In case of combination of gibberellic acid and potassium, the highest plant height (66.73 cm) at harvest, curd diameter (25.73 cm), marketable yield per hectare (35.50 t/ha) was recorded from G_1K_2 and the lowest was recorded from G_0K_0. The highest benefit cost ratio (1.89) was noted from the treatment combination of G_1K_2 and the lowest (1.34) was obtained from G_0K_0. From economic point of view, it is apparent from the above results that the combination of G_1K_2 was more profitable than rest of the combination.

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ABBREVIATIONS AND ACRONYMS

AEZ	=	Agro-Ecological Zone
BADC	=	Bangladesh Agricultural Development Corporation
BARC	=	Bangladesh Agricultural Research Council
BARI	=	Bangladesh Agricultural Research Institute
BAU	=	Bangladesh Agricultural University
BCR	=	Benefit cost ratio
DAT	=	Days after Transplanting
FAO	=	Food and Agricultural Organization
GA_3	=	Gibberellic acid
LSD	=	Least Significant Difference
MoP	=	Muriate of Potash
NS	=	Not significant
ppm	=	Parts per Million
PGR	=	Plant growth regulators
SRDI	=	Soil Resource Development Institute
RCBD	=	Randomized Complete Block Design
RH	=	Relative humidity
t/ha	=	Tonne per hectare
TSP	=	Triple Super Phosphate
DM	=	Dry matter
UNDP	=	United Nations Development Programme

CHAPTER I

INTRODUCTION

Vegetable plays an important role in human nutrition. These are indispensable group of food, providing vitamins, minerals, protein, carbohydrates and fibers in the diet, besides having medicinal value and provide nutritional security. Among different vegetables, cauliflower (*Brassica oleracea* var. *botrytis* L.) is one of the most important winter vegetable among the cole crops which belongs to the genus *Brassica* of the family Brassicaceae (Cruciferae).

Cauliflower is essentially a cold weather hardy crop and thrives best in cool and moist climate. The leading cauliflower producing countries of the world are China, Pakistan and India in respect of yield per hectare of land. It was introduced in India in the year of 1822 (Swarup and Chatterjee. 1972).

Cauliflower is a very tasty and much popular vegetable in Bangladesh as well as all over the world. Edible part of cauliflower is commonly known as 'Curd'. It is a highly nutritious and delicious vegetable, rich in Vitamin A, C and minerals like calcium, iron and iodine (Haque, 1999). 100 g edible part of cauliflower contains 89% moisture, 8.0 g carbohydrate. 2.3 g protein, 40 LU carotene, 0.13 mg B_1, 0.11 mg B_2, 50 mg vitamin C, 30 mg calcium and 0.8 mg iron and also contains 30 calorie (Rashid, 1999).

The yield of cauliflower depends on variety, cultivation methods, climatic conditions as well as edaphic factors etc. Among the different modern techniques of cauliflower curd production, now a days the role of plant growth regulators is considered to be an important tool. Plant growth regulators (PGR's) are organic compounds, which in small amounts, somehow modify a given physiological plant process. It plays an essential role in many aspects of plant growth and development. Many experiments have been carried out in developed country to investigate the effect of plant growth regulators on the yield and quality of cauliflower. Reports so far been made indicated a promising results on yield and quality of cauliflower and other crops due to the use of bio-chemical substances, such as Napthaline acetic acid (NAA), Gibberellic acid (GA_3). Indole acetic acid (IAA) etc. (Voronova and Kozyakov, 1983; Senthelhas *et al.* 1987; Tadzhiryan, 1990; Tomar *et al.*, 1991). However, for attaining success an appropriate level and timing in terms of growth stage of the crop is important (Voronova and Kozyakov, 1983; Tomar *et al*., 1991). However, recently done preliminary trials indicate possibility of increase yield of cauliflower in Bangladesh with the use of biochemical (Islam *et al.,* 1993; Biswas and Mondal, 1994). Plant height, curd formation and curd size of Cauliflower can be increased with foliar application of plant growth regulators.

Deficiency of soil nutrient is now considered as one of the major constraints to successful upland crop production in Bangladesh. Cauliflower responds greatly to major essential elements like N, P and K for its growth and yield. Potassium (K), an essential macronutrient taken up by the plant in very large quantities, plays a fundamental role in plant physiology and biochemistry (Marschner, 2012). It is an exceptional nuitrient in that it is not metabolized and is present within the plant almost exclusively as a univalent cation. It is highly mobile throughout the plant and associated with the transport of inorganic anions and metabolites. It activates more than 60 enzymes, has a direct function in protein synthesis, exerts an outstanding influence on plant water relations and is essential in the process of growth and development of cells. Potassium also plays a major role in photosynthesis in both the light and dark reactions culminating in the formation of sugar via the reduction of carbon dioxide. It also enhances crop resistance to biotic and abiotic stresses including insects, pests and various diseases, as well as drought and frost (Cakmak, 2005) and is beneficial in extending the keeping quality of crop produce.

With the background stated above, the present study was undertaken to investigate the effect of the level of gibberellic acid (GA_3) and potassium on growth and yield components of cauliflower applying at different growth stages.

Objectives

The present study is aimed to the following objectives:

- To determine optimum level of GA_3 for increasing cauliflower production.
- To indentify optimum level of potassium on growth and yield of cauliflower.
- To find out the suitable combination effect of GA_3 and potassium for better plant growth, the maximum yield and economic return of cauliflower.

CHAPTER II

REVIEW AND LITERATURE

Cauliflower is one of the most important cole crops and popular winter vegetables in many countries of the world including Bangladesh. Research findings regarding the effect of growth regulators applied at different growth stages of cauliflower on yield and yield components and curd size is very limited under Bangladesh condition.

Recently a good sign of interest has been developed regarding the benefit from the use of plant growth regulators of cauliflower. GA_3 has been known to play a vital role in increasing the growth and yield of cauliflower. On the otherhand, cauliflower responds greatly to major essential elements like N, P and K for its growth and yield. Potassium, an essential macronutrient taken up by the plant in very large quantities, plays a fundamental role in plant physiology. It is an exceptional nutrient in that it is not metabolized and is present within the plant almost exclusively as a univalent cation. A great deal of research work has been reported on the uses of plant growth regulators (GA_3) and potassium in different vegetables including cauliflower and the results already achieved are of outstanding importance.

Limited numbers of studies are found in this respect in Bangladesh. Therefore, literatures available from elsewhere on cauliflower and other crops on this aspect have been used in this chapter. However, some of the important research findings regarding the effects of gibberellic acid (GA_3) and potassium on the growth and yield of cauliflower have been presented in this chapter.

2.1. Effect of Growth Regulators on growth and yield of cauliflower

Kaur and Mal (2018) reported that GA_3@ 50 ppm gave maximum plant height (70.83 cm), minimum number of days taken to 50% curd initiation (63.67 days), minimum number of days taken to 50% marketable curd size (80.33 days) and also increase yield and yield attributing characters such as curd diameter (62.93 cm), individual curd weight (0.89 kg), yield per plot (10.72 kg) and yield per hectare (238.22 q).

Thapa *et al.* (2013) found that the maximum individual curd weight (0.89 kg) was recorded by the foliar application of GA_3@ 50 ppm which was maximum than control. This might be due to more accumulation of carbohydrates by maximum rate of photosynthesis.

Sitapara *et al*., (2011) found that GA_3@ 50 ppm gave maximum at the time of harvesting plant height (70.83cm), minimum days taken to 50% curd initiation (63.67 days), and minimum days taken to 50% marketable curd size (80.33 days).

Dhengle and Bhosle (2007) conducted an experiment and found that the plant height (70.83cm) significantly increased with application of GA_3 over control this might be due to increase the cell division and elongation of cells in sub apical meristem. GA_3 stimulate growth and cell expansion of cells through increasing the plasticity of cells.

Nazia (2007) conducted an experiment on cauliflower cultivar, 'Shirajuki' at Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka and found out that application of GA_3 100 ppm (G_2) resulted the highest pure curd height (14.59 cm), curd weight with leaves (1.90 kg) at harvest, marketable curd weight (1.33 kg /plant) and curd yield (53.33 t/ha) while the lowest was recorded from control treatment.

Guo *et al.* (2004) investigated that the growth and flowering response of a cold-requiring cauliflower *(*Brassica oleracca var. *bolrytis* cv. '*snowball'*) to a range of temperatures under 10 h photoperiod and to growth regulator application. Endogenous gibberellin (GA_3) concentrations were also assessed under these treatments. Flowering and growth of the inflorescence stalk were correlated with plant developmental stage at the time of a vernalizing cold treatment. Temperature and its duration also affected flowering and inflorescence development. The most effective temperature for inflorescence induction was 10°C. Flowering did not occur in non-vernalized plants (25°C) even though they had been treated with GA_3. Application of GA_3 promoted inflorescence stalk elongation greatly in vernalized plants (10^0C), but less so in partially vernalized plants (15 or 20^0C). Paclobutrazol sprayed at the 8-9 leaf stage significantly suppressed inflorescence stalk length and slightly delayed flower bud formation and anthesis. Vernalization at 10°C increased endogenous GA_3 content in both leaves and the inflorescence stalk irrespective of GA_3 treatment.

Vijay and Ray (2000) carried out an experiment that thirty day old cauliflower (cv. Pant Subhra) seedlings that were transplanted into experimental plots treated with 50 or 100 ppm GA_3, 5 or 10 ppm IBA. or 200 ppm NAA at 15 and 30 days of growth. The results clearly revealed that GA_3 at 100 ppm produced the tallest plants, the largest curds and highest curd yields.

Dharmender *et al.,* (1996) conducted an experiment to find out the effect of GA_3 or NAA (both at 25, 50 or 75 ppm) on the yield of cabbage (cv. Pride of India) in the field at Jobner, Rajstan, India. They recorded the highest yield following treatment with GA_3 at 50 ppm followed by NAA at 50 ppm (557.54 and 528.66 q/ha respectively). They also reported that combination and higher concentrations of plant growth regulators proved less effective and were uneconomic in comparison to control.

Aditya and Fordham (1995) carried out an experiment in the field and greenhouse to study the effects of cold exposure and GA_3, during early growth stages on the date of flowering of the tropical cauliflower cv. Early Patnai and the temperate cv. Lawyna. Flowering in cv. Early Patnal was advanced by approximately 25 days following vernalization (1 week at 10°C) old plants. They reported that one week old plants failed to respond to this treatment suggesting juvenile phase lasting up to about the 6 leaf stage in this cultivar.

Islam *et al.,* (1993) determined the effective concentration of NAA and GA_3 for promoting growth, yield and ascorbic acid content of cabbage. They used 12.5. 25, 50 and 100 ppm of both the NAA and GA_3 and applied in three different methods i.e. seedling soaked for 12 hours, spraying at 15 and 30 days of transplanting. They found that ascorbic acid content increased up to 50 ppm when sprayed twice with both the growth regulator, while its content was declined afterwards. They also added that two sprays with 50 ppm GA_3 was suitable both for higher yield and ascorbic acid content of cabbage.

Sharma and Mishra (1989) found that plant height, curd formation and curd size of cauliflower can increase with foliar application of plant growth regulators. Several experiments was conducted to increase the yield of cauliflower. GA_3 and IAA has a positive effect on curd formation and size of cauliflower.

Reddy (1989) reported that exogenous application of GA_3 and urea either alone or in combination enhanced curd size as well as yield. Greatest plant height at curd formation (58.2 cm), curd diameter at maturity (26.8 cm) and increase in yield over the control (164%) were obtained with the 2 applications of GA_3.

Muthoo *et al.* (1987) showed that the foliar application of different concentration of GA_3, NAA and molybdenum increased the average fresh and dry weight of leaves. Curd and yield of cauliflower among the individual treatments, gibberellic acid proved to be the best for the vegetative growth of curd and yield of cauliflower (q/ha) followed by naphthalene acetic acid. The effect of treatment combination $G_2N_2M_2$ (100 ppm GA_3, 120 ppm NAA and 0.2% molybdenum) gave the best result for all parameters of growth and yield.

Patil *et al*. (1987) conducted an experiment in a field trial with the cultivar Pride of India applied GA_3 and NAA each at 25, 50, 75 and 100 ppm one month after transplanting. Both the GA_3 and NAA increased the plant height significantly. The maximum plant height and head diameter and head weight were noticed with GA_3 at 50 ppm followed by NAA at 50 ppm. Significant increase in number of outer and inner leaves was noticed with both GA_3 and NAA. Head formation and head maturity was 13 and 12 days earlier with 50 ppm GA_3. Maximum number of leaves and maximum yield (23.83 t/ha) were obtained with 50 ppm GA_3 .

Pandey and Sinha (1987) reported that photosynthetic area of plant increased when treated with gibberellic acid and naphthalene acetic acid.

Mishra and Singh (1986) found that all possible combinations of the levels of nitrogen (0, 0,5 and 1.0 per cent), boron (0, 0.1 and 0.2 per cent) and GA_3 (0, 25 and 50 ppm) in the from of urea, boric acid and GA_3 were sprayed on snowball-16 cauliflower respectively.

Results revealed that there was significant increase in growth characters namely plants heights, diameter of stem, number of leaves per plant, weight of plant, curd yield and nitrogen content in the stem and the leaves due to N, B and GA_3 applications. However, length of stem was increased only by GA_3 spray. Application of GA_3 (50 mg/L + Urea 1%) have been reported to enhance curd yield in cauliflower.

Islam (1985) conducted an experiment at the Bangladesh Agricultural University Farm, Mymensingh with applying various growth regulators (CCC, GA_3, NAA and IBA) at 30 days after transplanting of 32 days old seedlings, CCC decreased the plant height, size of loose leaves, diameter of cabbage of head and finally the yield. GA_3 increased the plant height, number of loose leaves per plant size of leaf and finally the yield.

Yabuta *et al*. (1981) reported that application of GA_3 had significantly increased marketable weight, petiole length, and number of leaves, leaf area and height of many leafy vegetables.

Abdalla *et al.* (1980) conducted an experiment with cauliflower varieties and the plants were treated with different concentration of IBA (5-40 ppm), GA_3 (10-80 ppm) and NAA (120-160 ppm) 4 weeks after twice more at fortnightly intervals. NAA at 160 ppm gave the best result with regard to curd diameter, weight and color. Similar results were obtained from plants treated with GA_3 at 80 ppm and NAA at 40 ppm.

Badawi and Sahhar (1979) conducted a study at the experimental station of the Faculty of Agriculture, Cairo University, Egypt. They sprayed 0, 50, 100, and 200 ppm GA_3 and 0, 10, 20, and 40 ppm IBA after 4 and 8 weeks of transplanting to determine the extent of stimulating effect of different concentrations of GA_3 and IBA on cabbage.

Chauhan and Bordia (1971) carried out an experiment using Drumhead variety of cabbage to assess the effects of gibberellic acid (GA_3) at 5, 10, 25, 50, 100 ppm, Beta-napthoxy-acetic acid (NOA) at 5, 10, 25, 50, 100 ppm and 2,4- Dichlorophenoxy acetic acid (2,4-D) at 0.25, 0.5, 1.0, 2.0, 2.5 ppm as pre-sowing seed treatment on growth and yield of cabbage and mentioned that none of the treatments affected the height of the plants and the time taken for head formation. Maximum weight of head (1.72 kg) was obtained with 50 ppmGA_3 as against 0.81 kg under control.

Chhonkar and Singh (1965) conducted an experiment in Rabi season of 1962-63 with GA_3 at 5 ppm and 10 ppm after two and three weeks of transplanting. They reported that *5* ppm GA3 induced larger number of inner leaves in heads, earlier head formation by 16 days, increased head diameter, improved compactness and significantly increased the yield and quality of heads in cabbage.

Denisova and Lupinovich (1962) found that GA_3 application brought about rapid vegetable growth, which subsequently helped in the early formation of large and compact heads. The probable cause of this may be increased nutrient transport from root to the aerial parts and increased rate of photosynthesis and accelerated transport of photosynthates by GA_3.

Anderson *et al.* (1948) found increased growth in cauliflower by the application of GA_3 with NAA. This was found to have significant effect due to synergistic action.

Anonymous (2003-2004) was reported that, plant height was found significantly influenced by different levels of plant growth regulators. Plant height obtained maximum (113 cm) when the plants were treated with GA_3 350 ppm which was statistically identical to GA_3 300 ppm (110 cm).

2.2. Effect of potassium on growth and yield of cauliflower

Yildirim *et al.* (2009) found that potassium is an essential nutrient for plant growth and plays an important role in many metabolic processes such as photosynthesis, use of water and synthesis of amino acid and protein as well as translocation of sugars and assimilates within the plant and the accumulation of high molecular carbohydrates which necessary for fruit formation and development which leads to increase plant growth.

Marschner (2012) reported that potassium, an essential macronutrient taken up by the plant in very large quantities, plays a fundamental role in plant physiology and biochemistry.

Mahamud (2006) conducted an experiment at Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka and found out that the C_3 (cowdung 10 t/ha, urea 250 kg/ha, TSP 150 kg/ha, MP 200 kg/ha and agro-grow-granular 20 kg/ha) treatment gave the maximum gross yield (16.22 and 22.70 t/ha) and the minimum marketable yield (15.59 and 20.04 t/ha) in broccoli and cauliflower respectively.

Guan and Chen (2001) reported that there was a significant effect of N and K on growth and yield of cauliflower and broccoli especially N on growth and K on yield. Higher amount of nitrogen increase plant height, leaf length and stem diameter at least at a certain range. On the other hand, higher amount of potassium contribute higher curd weight, curd diameter and secondary curd number per plant at least at a certain range of K application.

Yang *et al.* (1994) carried out a field trials on cauliflower and found that the best plant growth, the highest curd yield, the highest curd yield per unit area were obtained with the lower N rate and the higher K rate. They used the combinations of 8 or 16 g urea per plant and 5 or 10 g potassium chloride per plant.

Csizinszky (1987) carried out field experiments on broccoli cv. 'Green Valiant', Cabbage cv. 'Market Prize' and cauliflower cv. 'Snow Crown' hybrid with seepage or trickle irrigation and various rates of N and K fertilizers. Broccoli, cabbage and cauliflower yields were increased by increased rates of NK fertilizers with trickle irrigation. With trickle irrigation, high fertilizer rates were still needed for higher yields but irrigation water requirement was reduced by 50-60 percent.

Politanskaya (1985) studied the effects of 4 levels of N (120, 150, 180 and 210 kg/ha) in addition to 2 basal P, K treatment (P_2O_5, K_2O at 60: 90 or 120:180 kg/ha) applied on peaty-podzolic light-loamy soil. N at 120 or 150 kg /ha with P:K at 60:90 kg/ha greatly improved yields and curd quality compared with other variant in cauliflower.

An experiment was conducted by Borna (1976) to study the effect of N, P_2O_5 and K_2O on cabbage, cauliflower, broccoli, onions, leeks, carrots, parsley, celeriac, cucumber and tomato with different levels of fertilizers. He observed that irrigation generally increased the effectiveness of mineral fertilizers, even at high rates. Fertilization, irrigation and their interactions had greater effects on marketable yield than total yield.

Singh *et al.* (1976) studied the effect of nitrogen and potassium on the curd yield of cauliflower cv. ‘Snowball-16’ and found that the curd yield increased with increasing N and K_2O application at each of 120 kg/ha. The interaction between N × K was highly significant.

Perez and Loria (1975) carried out two experiments on cauliflower. First one was conducted with cv. ‘Snowball A' and found that the response to N, P and K was linear and there were no interactions. For each additional application of 75 kg N/ha, (0, 75 and 150 kg N/ha) 150 P_2O_5/ha (0, 150 and 300 kg) and 60 kg K_2O/ha (0, 60 and 120 kg) production was increased by 1.54, 0.77 and 0.90 tons per ha, respectively. In the second experiment with the cv. Snowball `A', there was no response to N and K, but the effect of P was quadratic.

A field trial with a local variety of chinese cabbage was carried out by Li *et al.* (2010) in Fuzhou, Fujian, China in 2007 to investigate effects of different NPK applied rates on its yield. Eleven treatments were designed, with N, P and K at four different levels, respectively. The average contribution rate of soil fertility to the yield of Chinese cabbage was 47.4%. The yields of Chinese cabbages treated by N, P and K were increased by 41.26, 14.90 and 25.53% on average, respectively. The effects on yield increase was ranked as N>K>P. The output/input ratios of N, P and K were 13.8, 13.2 and 9.7, respectively. The recommended applied rates of NPK fertilizers for the Chinese cabbages in Fuzhou were 232.0 kg N, 70.5 kg P_2O_5 and 209.6 kg K_2O/ha, respectively.

The influence of mineral fertilizer rates on the yield and quality of cabbage cv. Eton F1 was studied by Rutkauskiene and Poderys (1999) in the field at the experimental station of the Lithuanian University of Agriculture. The highest harvest of cabbage was obtained at fertilizer rates (kg/ha) of $N_{240}P_{120}K_{180}$ and $N_{300}P_{120}K_{180}$. Increasing the dose of nitrogen fertilizers decreased the quantity of vitamin C (ascorbic acid) and increased the concentration of nitrates in cabbage heads. Potassium fertilizers decreased the yield, but increased head quality.

CHAPTER III

MATERIALS AND METHODS

3.1 Experimental site

The experiment was conducted at the Horticultural Farm and Laboratories of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, during the period from October 2018 to February 2019. The location of the experimental site is situated at 90° 22' E longitude and 23° 41' N latitude. The altitude of 8.6 meters above the sea level . The experimental site is presented in Appendix I.

3.2 Climate

The climate of the experimental site is subtropical, characterized by three distinct seasons, winter season from November to February and the pre-monsoon or hot season from March to April and the monsoon period from May to October (Edris *et al.*, 1979). During the experimental period the maximum temperature (32.24^0 C), highest rainfall (68.5 mm) and highest relative humidity (78.82%) was recorded in the month of September 2018, whereas the minimum temperature (13.6^0 C), minimum relative humidity (62.04%) and no rainfall was recorded for the month of January, 2019. The climatic conditions during the period of experiment was collected from the Bangladesh Meteorological Department, Agargaon, Dhaka and the data are presented in Appendix III.

3.3 Soil

The soil of the experimental area belongs to the Modhupur Tract (UNDP,1988). The analytical data of the soil sample collected from the experimental area were determined in the SRDI, Soil Testing Laboratory, Khamarbari, Dhaka have been presented in appendix II. The experimental site was a medium high land and pH of the soil was 5.6. The morphological characters of soil of the experimental plots as indicated by FAO (1988) are given below –

AEZ No. 28

Soil series :- Tejgaon

General soil :- Non-calcarious dark grey.

3.4 Plant Materials

Cauliflower *Brassica oleracea* var. *botrytis* sub var. *cauliflora* cv. '*Snowball*' were used in the experiment.

3.5 Treatment of the experiment

The experiment was designed to study the effects of different concentration of gibberellic acid (GA_3) and potassium on growth and yield of cauliflower. The experiment consisted of two factors were as follows:

Factor A: Gibbrellic acid (GA_3) (Four levels)

G_0 : 0 ppm GA_3 (control)

G_1 : 95 ppm GA_3

G_2 : 115 ppm GA_3

G_3 : 135 ppm GA_3

Factor B : Potassium (Three levels)

K_0 : 0 kg K_2O/ha (Control)

K_1 : 75 kg K_2O/ha

K_2 : 100 kg K_2O/ha

There were altogether 12 treatments combination such as G_0K_0, G_0K_1, G_0K_2, G_1K_0, G_1K_1, G_1K_2, G_2K_0, G_2K_1, G_2K_2, G_3K_0, G_3K_1, G_3K_2.

3.6 Experimental design and layout

The two factors experiment was laid out following Randomized Complete Block Desgin (RCBD) with three replications. An area of 28.1m x 9m was divided into three equal blocks. Each block was divided into 36 plots where 12 treatments were allotted at random. Thus there were 36 unit plots altogether in the experiment. The size of each plot was 2.0m x 1.8m. The distance between two blocks and two plots were kept 1m and 0.5m respectively. A layout of the experiment has been shown in Fig 1. Thirty days old seedlings were transplanted in the main field following 50cm x 60 cm spacing.

3.7 Seedbed preparation, seed germination and raising of seedlings

Two seed beds with 3m x 1m in size were selected. Seed beds were prepared with a mixture of sand, soil and compost. It was raised 15cm from ground level. Germination of cauliflower seed is a major problem in our country. Seeds were sown on 15 October, 2018. Complete germination of seed took place in seven days. When the seedlings were thirty days old they were transplanted in the experimental field on 16 November, 2018.

3.8 Land preparation

The land which was selected to conduct the experiment was opened 20 October 2018 with the help of a power tiller and then it was kept open to sun for 7 days to further ploughing. Afterwards it was prepared by ploughing and cross ploughing followed by laddering. Deep ploughing was done to have good tilth which was necessary for getting better yield of the crop. The weeds and stubbles were removed after each laddering. Simultaneously the clods were broken and the soil was made into good tilth.

3.9 Application of manures and fertilizers

Manures and fertilizers were applied according to the experimental plot considering the recommended fertilizer doses for cauliflower production per hectare by BARI (2005). The total amount of cowdung and TSP was applied as basal dose at the time of land preparation. The rest of MoP and total amount of Urea was applied equally in three installments at 10, 30 and 50 days after transplanting.

Table 1. Dose and method of application of fertilizers in cauliflower field

Fertilizers and Manure	Dose/ha	Dose/plot
Cowdung	20 tonnes	7.2 kg
Urea	240 kg	86.4 g
TSP	150 kg	54g
MoP	As per treatment	

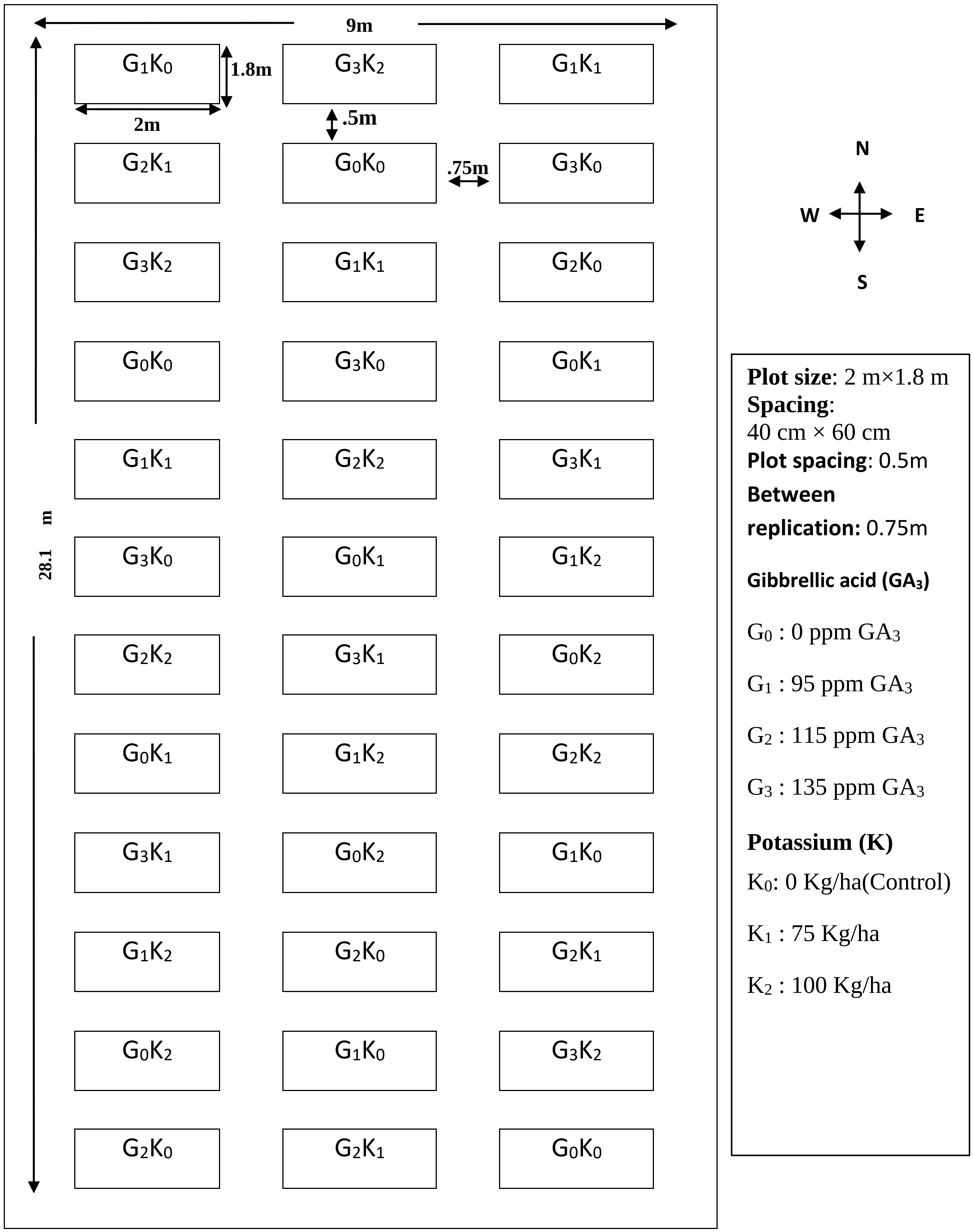

Figure1. Field layout of the two fectors experiment in the Randomized Complete Block Design (RCBD)

3.10 Transplanting of seedling and after care:

Healthy and uniform sized 30 days old seedlings were transplanted in the experimental plots on 16 November, 2018 in the afternoon at a spacing of 40 cm x 60 cm. Light irrigation was given around each seedlings for their better establishment. Dead seedlings were replaced by new seedlings from same stock. After seedling establishment, the soil around the base of each seedling was pulverized.

3.11 Preparation and application of GA_3:

Gibberellic acid in different concentrations viz. 95 ppm, 115 ppm and 135 ppm were prepared following the procedure and spraying was done during afternoon by using a hand sprayer. To prepare a 95 ppm stock solution of GA_3, taking 95 mg of GA_3 in a test tube and adding 2-5 ml of 75% ethanol to dissolve the powder. Heating gently if required. Once completely dissolved, gradually dilute the solution with 1L distilled water. Similarly 115 ppm and 135 ppm were prepared. These stock solution stored in a refrigerator and used in the field when required diluting with water.

3.12 Intercultural operation

3.12.1 Gap filing

Dead, injured and weak seedlings were replaced by new vigour seedling from the stock kept on the border line of the experiment.

3.12.2 Weeding

Weeding was done three times in the plots. First weeding was done 10 days after transplanting.

3.12.3 Earthing Up:

Earthing up required for cauliflower production. It was done at 15 days after transplanting.

3.12.4 Irrigation

Light irrigation was given just after transplanting the seedlings. A week after transplanting the requirement of irrigation was envisaged through visual estimation. During vegetative growth of plant irrigation was given properly.

3.13 Pest and disease control

The finix powder was used around the plot against the ant to protect the seedling.

3.14 Harvesting:

The compact matured curd were harvested. Randomly selected five plants were harvested from each plot for data collection.

3.15 Data collection

Data were recorded on the following parameters from the sample plants during the course of experiment. Five (5) plants were sampled randomly from each unit plot for the collection of data.

3.15.1 Plant height

Plant height was measured in centimeter (cm) by a meter scale at 30, 40, 50 DAT and at harvest from the point of ground level up to the tip of the longest leaf.

3.15.2 Number of leaves per plant

Number of leaves were counted from five randomly selected plants at 30, 40, 50 DAT and at harvest. All the leaves of each plant were counted separately. Only the smallest young leaves at the growing point of the plant were excluded from counting. The average number of leaves of five plants gave number of leaves per plant.

3.15.3 Leaf length

Leaf length of five randomly selected plants was measured in centimeter (cm). It was measured from the base of the petiol to the tip of the leaf of each plant were measured separately with a meter scale.

3.15.4 Leaf breath

Leaf breath of five randomly selected plants was measured from the widest central and two terminal portion of the lamina with a meter scale and average breath was recorded in centimeter (cm). Leaves of each plant were measured separately.

3.15.5. Days from transplanting to curd initiation

Days required from transplanting to curd initiation were counted when curds of the plants were started to its initiation.

3.15.6. Days from transplanting to 50% curd initiation

Days required from transplanting to 50% curd initiation were counted when curds of the plants were emerged about 50% of the total plants.

3.15.7. Stem length

Stem length was measured from the collar region to the base of curd in centimeter from five randomly selected plants at each plot at harvest.

3.15.8. Stem diameter

Stem diameter was measured by measuring circumference of the stem and converted it into diameter and expressed in centimeter randomly 5 selected plants at each plot at harvest.

3.15.9. Curd diameter

Curd diameter was recorded in several directions with a vernier scale from five randomly selected plants after harvesting and measured in centimeter (cm) and each of plant was measured separately.

3.15.10. Curd weight with leaves at harvest (kg) :

The curd weight with leaves were recorded with the help of a weighting balance just after maturity of the curd. It was expressed in kilogram (kg).

3.15.11. Pure curd weight (kg)

After separating all parts except the curd was weighted from five randomly selected plants was measured in kilogram per curd and each of curd was measured separately.

3.15.12. Dry matter content of 100g curd

At first 100g curd of selected plant was collected, cut into pieces and was dried under sunshine for a few days and then dried in an oven at 70^0C for 72 hours before taking dry weight till it was constant. The dry weight was recorded in gram (g) with a beam balance.

3.15.13. Marketable curd weight (kg) :

Marketable curd weight was recorded after harvesting of curd when the leaves around the curd were pruned. It was measured with a weighing balance and expressed in kilogram (kg).

3.15.14. Marketable curd weight (t/ha) :

The yield per hectare was calculated by converting from the per plot yield data to per hectare and was expressed in ton (t).

3.16 Statistical analysis:

The data for various growth and yield contributing characters were statistically analysed to find out the significance of variation from the resulting treatments. The mean for all the calculated and the analysis of variance for each of the characters under study was done by Statistix10 test for Randomized Complete Block Design (RCBD). The treatment means were compared by Least Significant Difference (Lsd) at 5% level of significance (Gomez and Gomez, 1984).

3.17 Economic analysis

The cost of production was analyzed in order to find out the most economic treatment of planting time and growth regulators. 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 @ 14% in simple rate. The market price of cauliflower was considered for estimating the cost and return. Analyses were done according to the procedure of Alam *et al.* (1989).

The benefit cost ratio (BCR) was calculated as follows:

$$\text{Benefit cost ratio (BCR)} = \frac{\text{Gross return per hectare (Tk.)}}{\text{Total cost of production per hectare (Tk.)}}$$

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to investigate the effect of gibberellic acid (GA_3) and potassium on growth and yield of cauliflower (*Brassica oleracea* L. var. *botrytis* sub var. *cauliflora* cv. 'Snowfall'). The analysis of variances for different characters has been presented in appendices IV to X. Data of the different parameters analyzed statistically and the results have been presented in the Table 2 to 11 and Figures 2 to 13. The results of the present study have been presented and discussed in this chapter under the following heading.

4.1 Effect of gibberellic acid (GA_3) and potassium on growth and yield of Cauliflower

4.1.1 Plant height (cm)

Plant height of cauliflower showed significant variation due to different dose of gibberellic acid (GA_3) at 30, 40, 50 DAT and at harvest (Table 2 and Appendix IV). The maximum plant height (27.01, 42.16, 53 and 64.13 cm) was recorded from G_1 (95 ppm) and the minimum plant height (24.51, 34.92, 44.82 and 50.10 cm) was observed from G_0 (0 ppm, control) at 30, 40, 50 DAT and at harvest, respectively. Application of gibberellic acid (GA_3) produced the tallest plant compare to the control condition. Vijay and Ray (2000) reported that 100 ppm GA_3 produced the tallest plants.

A significant variation was recorded on plant height of cauliflower due to the application of different dose of potassium at 30, 40, 50 DAT and at harvest (Table 2 and Appendix IV). At 30, 40, 50 DAT and at harvest the tallest plant (26.64, 40.28, 51.78 and 60.05 cm) was found from K_2 (100 kg K_2O/ha) and the shortest plant (24.98, 37.00, 46.98 and 55.93 cm) was obtained from K_0 (control) respectively. Yang *et al.* (1994) found that the best plant growth was obtained with the higher K rate.

Combined effect of growth regulators (GA_3) and potassium showed significant variation in terms of plant height of cauliflower under the trial at 30, 40, 50 DAT and at harvest (Table 3 and Appendix IV). The tallest plant (28.07, 44.60, 56.23 and 66.73 cm) was found from the treatment combination of G_1K_2 (95 ppm GA_3 and 100 kg K_2O/ha) which was closely followed (26.77, 42.40, 53.33 and 65.23 cm) by G_1K_1 (95 ppm GA_3 and 75 kg K_2O/ha) respectively. Whereas the shortest plant (23.73, 32.53, 40.43 and 45.33 cm) was recorded from G_0K_0 (control condition) at 30, 40, 50 DAT and at harvest, respectively. Dhengle and Bhosle (2007) found that the plant height (70.83cm) significantly increased with application of GA_3 over control this might be due to increase the cell division and elongation of cells in sub apical meristem. GA_3 stimulates growth and cell expansion of cells through increasing the plasticity of cells. Potassium also plays a major role in photosynthesis in both the light and dark reactions culminating in the formation of sugar via the reduction of carbon dioxide.

Table 2. Effect of Gibberellic acid (GA_3) and potassium on plant height of cauliflower at different days after transplanting

Treatment	Plant Height (cm)			
	30 DAT	40 DAT	50 DAT	At harvest
Gibbrellic acid (GA_3)				
G_0	24.51 d	34.92 d	44.82 d	50.10 d
G_1	27.01 a	42.16 a	53.00 b	64.13 a
G_2	25.64 c	39.93 b	51.12 a	60.27 b
G_3	25.78 b	37.78 c	49.28 c	58.74 c
$LSD_{(0.05)}$	**0.303**	**0.149**	**0.197**	**0.397**
Significance level	**	**	**	**
Potassium (K)				
K_0	24.98 c	37.00 c	46.98 c	55.93 c
K_1	25.58 b	38.82 b	49.91 b	58.95 b
K_2	26.64 a	40.28 a	51.78 a	60.05 a
$LSD_{(0.05)}$	**0.262**	**0.128**	**0.171**	**0.344**
Significance level	**	**	**	**
CV(%)	**6.36**	**5.62**	**5.92**	**8.61**

DAT: Days after transplanting, LSD: Least significant difference
In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of significance.

Gibbrellic acid (GA_3):- G_0: 0 ppm GA_3, G_1: 95 ppm GA_3, G_2: 115 ppm GA_3, G_3: 135 ppm GA_3
Potassium:- K_0: 0 kg K_2O/ha (Control), K_1 : 75 kg K_2O/ha, K_2 : 100 kg K_2O/ha

Table 3. Combined effect of gibberellic acid (GA_3) and potassium on plant height of cauliflower at different days after transplanting

Treatment combinations	Plant height (cm)			
	30 DAT	40 DAT	50 DAT	At harvest
G_0K_0	23.73 h	32.53 j	40.43 i	45.33 j
G_0K_1	24.50 g	35.70 i	46.33 h	51.50 i
G_0K_2	25.30 ef	36.53 h	47.70 g	53.47 h
G_1K_0	26.20 cd	39.47 d	49.43 cd	60.43 c
G_1K_1	26.77 b	42.40 b	53.33 b	65.23 b
G_1K_2	28.07 a	44.60 a	56.23 a	66.73 a
G_2K_0	24.90 fg	38.80 e	49.50 e	59.73 de
G_2K_1	25.37 ef	39.47 d	51.23 d	60.27 cd
G_2K_2	26.67 bc	41.53 c	52.63 c	60.80 c
G_3K_0	25.10 f	37.20 g	48.57 f	58.23 g
G_3K_1	25.70 de	37.70 f	48.73 f	58.80 fg
G_3K_2	26.53 bc	38.43 f	50.53 e	59.20 ef
Significance level	**	**	**	**
$LSD_{(0.05)}$	**0.525**	**0.257**	**0.341**	**0.687**
CV(%)	**6.36**	**5.62**	**5.92**	**8.61**

DAT: Days after transplanting LSD: Least significant difference
In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of significance.
Gibbrellic acid (GA_3):- G : 0 ppm GA_3, G_1: 95 ppm GA_3, G_2: 115 ppm GA_3, G_3: 135 ppm GA_3
Potassium:- K_0: 0 kg K_2O/ha (Control), K_1 : 75 kg K_2O/ha, K_2 : 100 kg K_2O/ha

4.2 Number of leaves per plant

Significant variation was found in case of production of leaves per plant of cauliflower due to application of different level of gibberellic acid (GA_3) at 30, 40, 50 DAT and at harvest (Figure 2 and Appendix V). The maximum number of leaves per plant (14.30, 15.87, 20.76 and 24.07) was observed in G_1 (95 ppm) at 30, 40, 50 DAT and at harvest respectively. Again, at the same DAT the minimum number of leaves per plant (10.79, 14.47, 16.80 and 19.62) was found from G_0 (0 ppm, control) respectively. Patil *et al*, (1987) supported that the control treatment gave the minimum number of leaves (22.53) per plant.

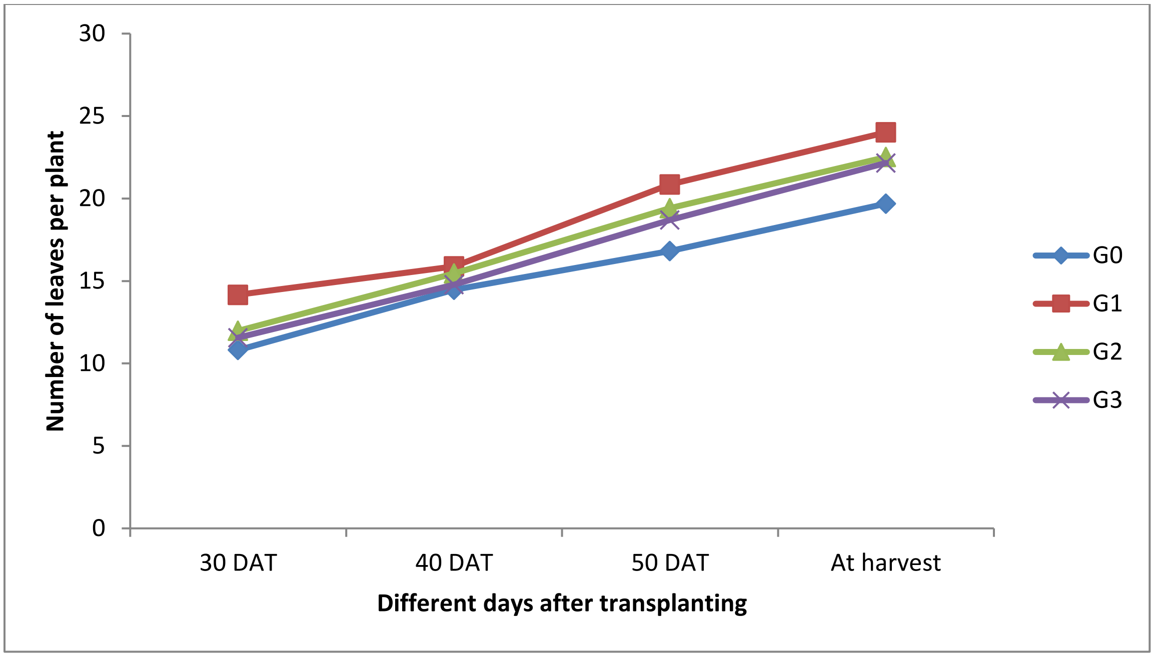

Figure 2. Effect of gibberellic acid (GA_3) on number of leaves per plant of cauliflower at different days after transplanting, where G_0 : 0 ppm GA_3, G_1 : 95 ppm GA_3, G_2 : 115 ppm GA_3, G_3 : 135 ppm GA_3

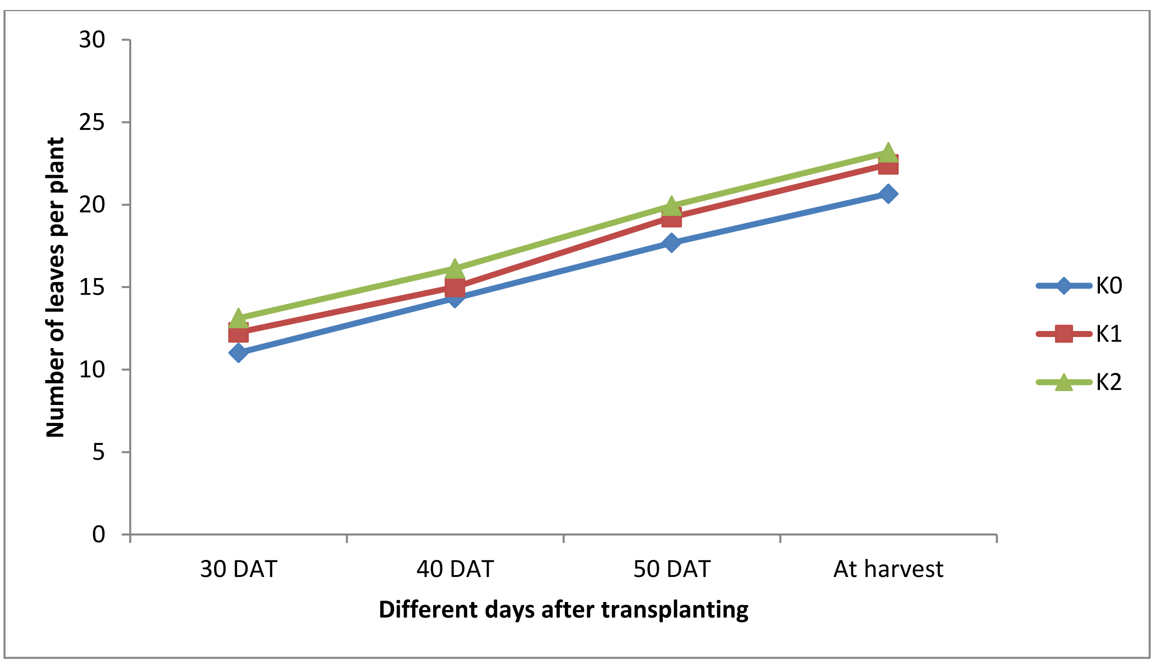

Figure 3. Effect of potassium on number of leaves per plant of cauliflower at different days after transplanting, where K_0 : 0 kg K_2O/ha (Control), K_1 : 75 kg K_2O/ha, K_2 : 100 kg K_2O/ha

Table 4. Combined effect of gibberellic acid (GA_3) and potassium on number of leaves per plant of cauliflower at different days after transplanting

Treatment	Number of Leaves per Plant			
	30 DAT	40 DAT	50 DAT	Harvest
G_0K_0	9.53 f	13.40 f	14.33 f	17.20 h
G_0K_1	10.40 e	14.33 de	17.67 e	20.40 g
G_0K_2	12.43 c	15.67 b	18.40 d	21.27 f
G_1K_0	13.47 b	15.40 bc	19.40 c	22.40 d
G_1K_1	14.63 a	15.60 b	21.40 a	24.40 b
G_1K_2	14.80 a	16.60 a	21.47 a	25.40 a
G_2K_0	11.27 d	14.60 de	18.60 d	21.60 e
G_2K_1	12.23 c	15.40 bc	19.40 c	22.53 d
G_2K_2	12.43 c	16.53 a	20.40 b	23.40 c
G_3K_0	10.47 e	14.27 e	18.47 d	21.40 ef
G_3K_1	11.37 d	14.67 d	18.60 d	22.37 d
G_3K_2	12.53 c	15.20 c	19.47 c	22.63 d
$LSD_{(0.05)}$	**0.363**	**0.363**	**0.387**	**0.327**
Significance level	**	**	**	**
CV(%)	**7.26**	**6.01**	**7.33**	**6.06**

DAT: Days after transplanting LSD: Least significant difference

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of significance.

Gibbrellic acid (GA_3):- G_0: 0 ppm GA_3, G_1: 95 ppm GA_3, G_2: 115 ppm GA_3, G_3: 135 ppm GA_3

Potassium:- K_0: 0 kg K_2O/ha (Control), K_1 : 75 kg K_2O/ha, K_2 : 100 kg K_2O/ha

Number of leaves per plant of cauliflower also differed significantly at 30, 40, 50 DAT and at harvest due to the application of different level of potassium (Figure 3 and Appendix V). At 30, 40, 50 DAT and at harvest, the maximum number of leaves per plant (13.05, 16.00, 19.93 and 23.18) was recorded from K_2 (100 kg K_2O/ha). Again, the minimum number of leaves per plant (11.18, 14.41, 17.70 and 20.65) was found from K_0 (control) for the same DAT respectively.

Statistically significant variation was recorded due to combined effect of plant growth regulator (GA_3) and potassium in terms of number of leaves per plant of cauliflower at 30, 40, 50 DAT and and at harvest (Table 4 and Appendix XI). The maximum number of leaves per plant (14.80, 16.60, 21.47 and 25.50) was observed from G_1K_2 (95 ppm GA_3

and 100 kg K_2O/ha) at 30, 40, 50 DAT and at harvest, respectively which was followed (14.63, 15.60, 21.40 and 24.40) by G_1K_1 (95 ppm GA_3 and 75 kg K_2O/ha) respectively. While the minimum number of leaves per plant (9.53, 13.40, 14.33 and 17.20) was recorded from G_0K_0 (control) at 30, 40, 50 DAT and at harvest respectively. Mishra and Singh (1986) found that there was significant increase in number of leaves per plant due to GA_3applications. However, length of stem was increased only by GA_3 spray which further helps to increase leaf number. Potassium also plays a major role in photosynthesis in both the light and dark reactions culminating in the formation of sugar via the reduction of carbon dioxide.

4.3 Leaf length

Gibberellic acid (GA_3) showed statistically significant variation for leaf length of cauliflower at 30, 40, 50 DAT and at harvest (Figure 4 and Appendix VI). At the 30, 40, 50 DAT and at harvest the longest leaf (22.08, 37.77, 49.10 and 59.96 cm) was obtained from G_1 (95 ppm GA_3) respectively. On the other hand, at the same DAT and at harvest, the shortest leaf (19.18, 30.40, 40.41 and 45.84 cm) was found from G_0 (0 ppm, control) respectively.

Leaf length of cauliflower showed significant variation due to application of different dose of potassium at 30,40, 50 DAT and at harvest (Figure 5 and Appendix VI). At 30, 40, 50 DAT and at harvest the longest leaf (21.59, 35.99, 47.68 and 55.76 cm) was obtained from K_2 (100 kg K_2O/ha). Again, the shortest leaf (19.83, 32.17, 42.73 and 50.88 cm) was observed from K_0 (control) for the same DAT respectively.

Combined effect of gibberellic acid (GA_3) and potassium showed statistically significant variation on leaf length of cauliflower at 30, 40, 50 DAT and at harvest (Table 5 and Appendix XII). The longest leaf was found (23.37, 40.50, 52.20 and 63.30 cm) from G_1K_2 (95 ppm GA_3 and 100 kg K_2O/ha) at 30, 40, 50 DAT and at harvest respectively. The shortest leaf (18.53, 27.87, 35.50 and 45.50 cm) was obtained from G_0K_0 (control) at 30, 40, 50 DAT and at harvest respectively. Dhengle and Bhosle (2007) found that the plant growth significantly increased with application of GA_3 over control this might be due to increase the cell division and elongation of cells in sub apical meristem. GA_3

stimulates growth and cell expansion of cells through increasing the plasticity of cells. Potassium also stimulates growth and development of cells by activating enzymes.

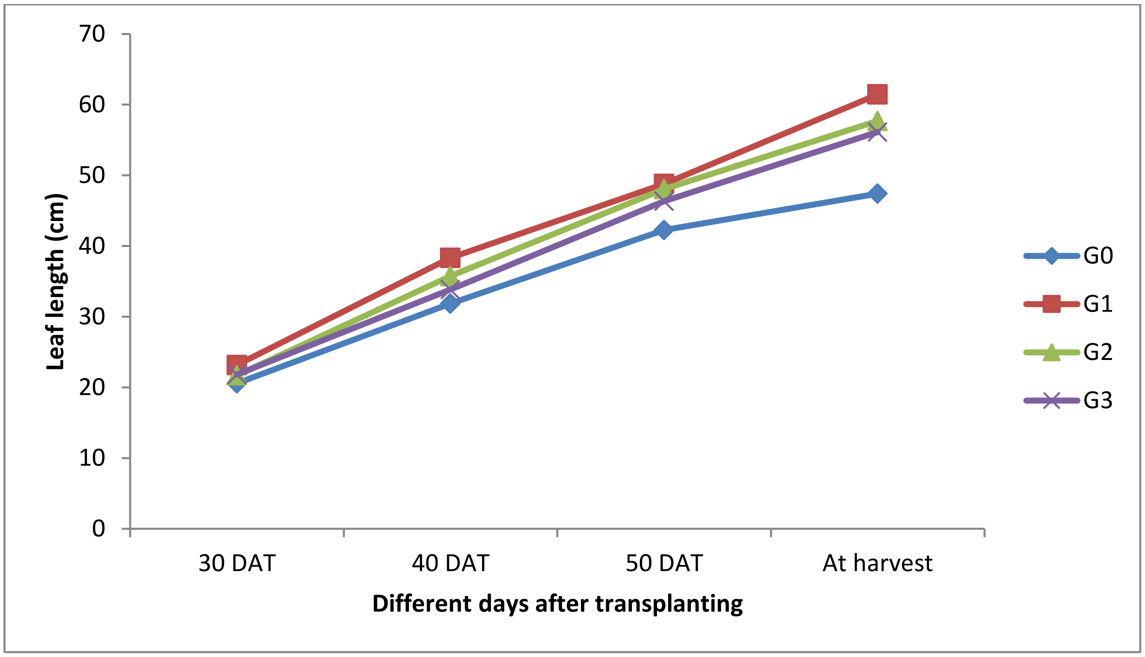

Figure 4. Effect of gibberellic acid (GA_3) on leaf length of cauliflower at different days after transplanting, where G_0 : 0 ppm GA_3, G_1 : 95 ppm GA_3, G_2 : 115 ppm GA_3, G_3 : 135 ppm GA_3

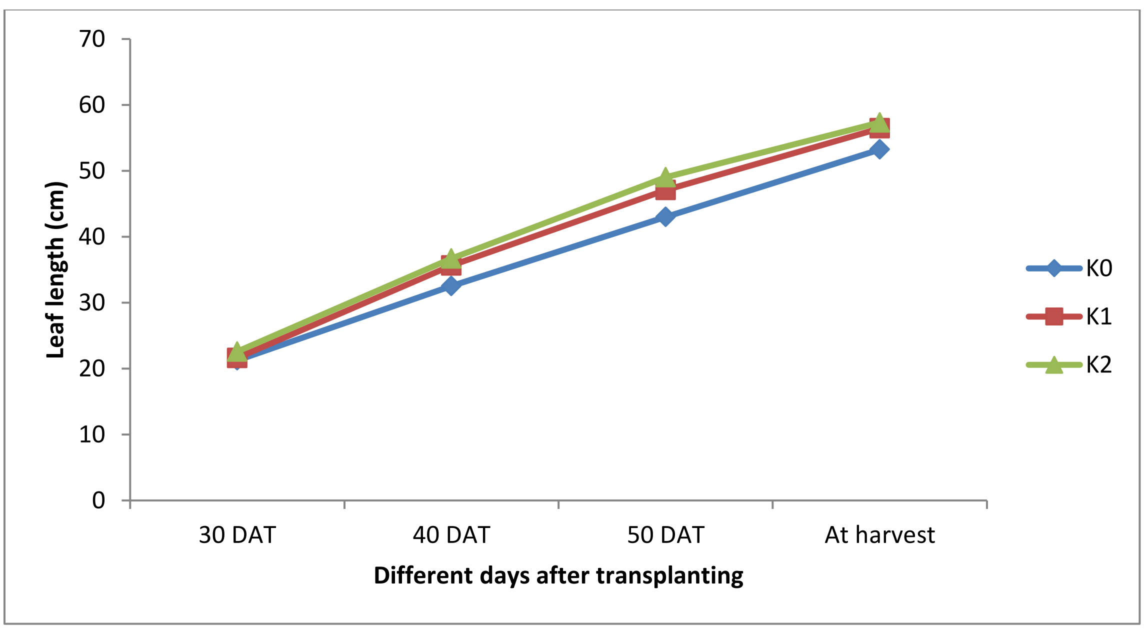

Fig. 5. Effect of potassium (K) on leaf length of cauliflower at different days after transplanting, where K_0 : 0 kg K_2O/ha (Control), K_1 : 75 kg K_2O/ha, K_2 : 100 kg K_2O/ha

Table 5. Combined effect of gibberellic acid (GA_3) and potassium on leaf length of cauliflower at different days after transplanting

Treatment	Leaf Length (cm)			
	30 DAT	40 DAT	50 DAT	Harvest
G_0K_0	18.53 h	27.87 j	35.50 i	40.50 i
G_0K_1	19.20 g	30.53 i	42.27 h	47.63 h
G_0K_2	19.80 f	32.50 h	43.47 g	49.40 g
G_1K_0	21.13 c	34.27 e	45.47 c	55.30 c
G_1K_1	21.73 b	38.53 b	49.63 b	61.27 b
G_1K_2	23.37 a	40.50 a	52.20 a	63.30 a
G_2K_0	19.43 g	34.23 e	44.43 d	54.33 e
G_2K_1	20.27 e	34.43 d	47.60 c	54.57 de
G_2K_2	21.63 b	36.57 c	48.60 c	54.83 d
G_3K_0	20.23 e	32.30 g	45.53 f	53.37 f
G_3K_1	20.77 d	33.27 f	45.43 e	54.23 e
G_3K_2	21.57 b	34.40 f	46.47 d	55.50 c
$LSD_{(0.05)}$	**0.251**	**0.233**	**0.229**	**0.333**
Significance level	**	**	**	**
CV(%)	**6.66**	**5.67**	**7.28**	**6.03**

DAT: Days after transplanting LSD: Least significant difference
In a column means having similar letter(s) are statistically identical and those having dissimilar
letter(s) differ significantly as per 0.05 level of significance.
Gibbrellic acid (GA_3):- G_0: 0 ppm GA_3, G_1: 95 ppm GA_3, G_2: 115 ppm GA_3, G_3: 135 ppm GA_3
Potassium:- K_0: 0 kg K_2O/ha (Control), K_1 : 75 kg K_2O/ha, K_2 : 100 kg K_2O/ha

4.4 Leaf breadth

Statistically significant variation was showed by the application of different level of gibberellic acid (GA_3) for leaf breadth of cauliflower at 30, 40, 50 DAT and at harvest (Figure 6 and Appendix VII). At the 50 DAT and at harvest the widest leaf (10.54, 14.56, 17.24 and 18.71 cm) was obtained from G_1 (95 ppm GA_3) respectively. On the other hand, at the same DAT the lowest leaf breadth (8.74, 12.29, 14.40 and 16.13 cm) was found from G_0 (0 ppm, control) respectively.

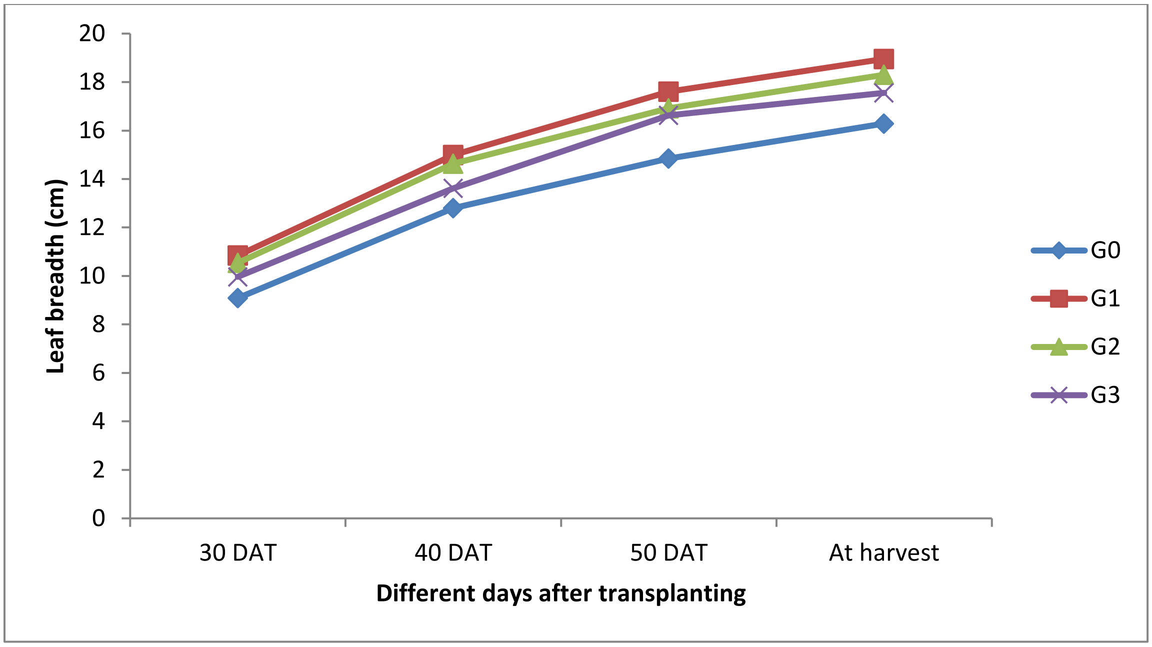

Fig. 6. Effect of gibberellic acid (GA_3) on leaf breadth of cauliflower at different days after transplanting, where G_0 : 0 ppm GA_3, G_1 : 95 ppm GA_3, G_2 : 115 ppm GA_3, G_3 : 135 ppm GA_3

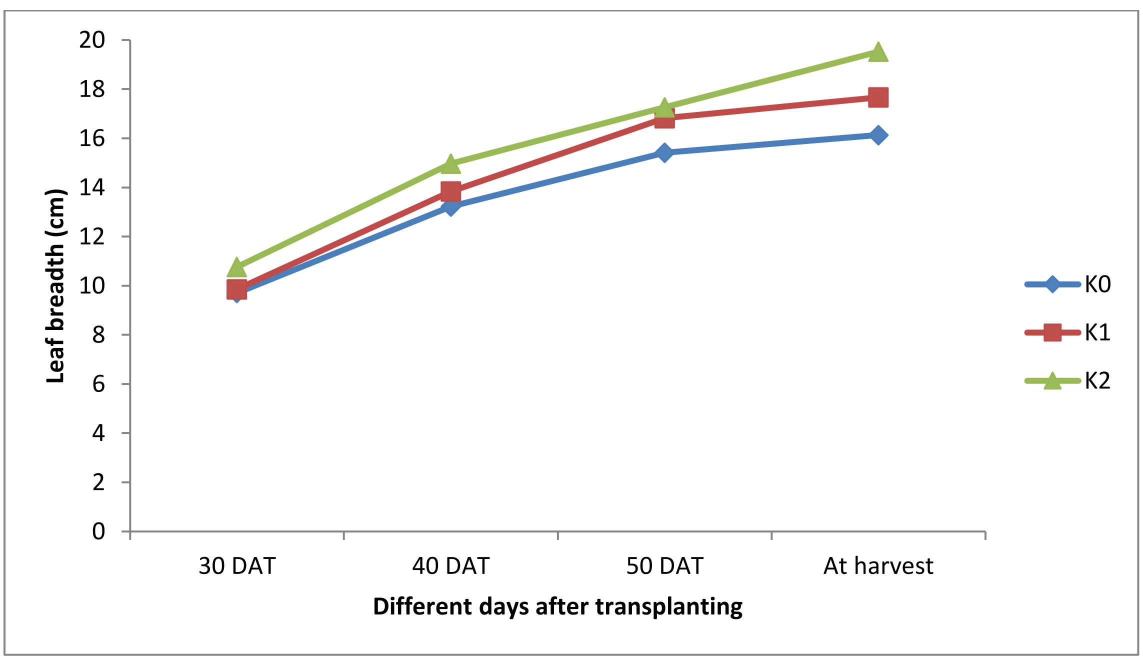

Fig. 7. Effect of potassium (K) on leaf breadth of cauliflower at different days after transplanting, where K_0 : 0 kg K_2O/ha (Control), K_1 : 75 kg K_2O/ha, K_2 : 100 kg K_2O/ha

Table 6. Combined effect of gibberellic acid (GA_3) and potassium (K) on leaf breadth of cauliflower at different days after transplanting

Treatment	Leaf Breadth (cm)			
	30 DAT	40 DAT	50 DAT	Harvest
G_0K_0	8.33 f	11.17f	12.17e	13.43 f
G_0K_1	8.43 f	12.37e	15.57d	16.53 d
G_0K_2	9.47c de	13.33d	15.47d	18.43 b
G_1K_0	9.73 c	13.60d	16.43c	17.53 c
G_1K_1	10.40 b	14.50bc	16.67c	18.27 b
G_1K_2	11.50 a	15.57a	18.63a	20.33 a
G_2K_0	9.63 cd	13.33d	15.40d	17.37 c
G_2K_1	9.57 cd	13.43d	16.67c	17.43 c
G_2K_2	10.30 b	14.63b	17.13b	18.37 b
G_3K_0	9.13 e	12.27e	15.40d	15.57 e
G_3K_1	9.33 de	13.53d	16.40c	17.53 c
G_3K_2	9.77 c	14.27c	16.33c	18.17 b
$LSD_{(0.05)}$	**0.364**	**0.327**	**0.3484**	**0.295**
Significance level	**	**	**	**
CV(%)	**8.01**	**6.01**	**5.90**	**6.35**

DAT: Days after transplanting
LSD: Least significant difference
In a column means having similar letter(s) are statistically identical and those having dissimilar
letter(s) differ significantly as per 0.05 level of significance.
Gibbrellic acid (GA_3):- G_0: 0 ppm GA_3, G_1: 95 ppm GA_3, G_2: 115 ppm GA_3, G_3: 135 ppm GA_3
Potassium:- K_0: 0 kg K_2O/ha (Control), K_1 : 75 kg K_2O/ha, K_2 : 100 kg K_2O/ha

Leaf breadth of cauliflower showed significant variation due to application of different level of potassium at 30, 40, 50 DAT and at harvest (Figure 7 and Appendix VII). At 30, 40, 50 DAT and at harvest the widest leaf (10.26, 14.45, 16.89 and 18.83 cm) was obtained from K_2 (100 kg K_2O/ha). Again, the lowest leaf breadth (9.20, 12.59, 14.85 and 15.98 cm) was observed from K_0 (control conditon) for the same DAT respectively (Figure 3).

Combined effect of plant growth regulator (GA_3) and potassium showed statistically significant variation on leaf breadth of cauliflower at 30, 40, 50 DAT and at harvest (Table 6 and Appendix XIII). The widest leaf (11.50,15.57,18.63 and 20.33 cm) was found from G_1K_2 at 30, 40, 50 DAT and at harvest. The lowest leaf breadth (8.33, 11.17, 12.17 and 13.43 cm) was obtained from G_0K_0 at 30, 40, 50 DAT and at harvest respectively. Potassium stimulates growth and development of cells by activating enzymes. The plant growth significantly increased with application of GA_3 over control this might be due to increase the cell division and elongation of cells in sub apical meristem. GA_3 stimulates growth and cell expansion of cells through increasing the plasticity of cells.

4.5 Days from transplanting to curd initiation

Days from transplanting to curd formation of cauliflower differ significantly for different gibberellic acid (GA_3) (Table 7 and Appendix VIII). The minimum (38.25) days from transplanting to curd formation was found from G_1 (95 ppm GA_3), while the maximum (46.44) days from transplanting to curd formation was noted from G_0 (0 ppm, control).

Statistically significant variation was recorded on days from transplanting to curd formation of cauliflower due to the application of different potassium (Table 7 and Appendix VIII). However the minimum (41.07) days from transplanting to curd formation was found from K_2 (100 kg K_2O/ha). On the other hand, the maximum (44.11) days from transplanting to curd formation was found from K_0 (control).

Combined effect of Gibberellic acid (GA_3) and potassium showed significant variation in terms of days from transplanting to curd formation (Table 8 and Appendix VIII). The minimum (35.44) days from transplanting to curd formation was observed from G_1K_2 (95 ppm GA_3 and 100 kg K_2O/ha) where as the maximum (48.62) days from transplanting to curd formation was recorded from G_0K_0 (control). Combination of Gibberellic acid (GA_3) and potassium (K) leads to maximum vegetative and reproductive growth and the ultimate results was the earlier curd formation. Dharmender *et al.* (1996) reported 75 ppm GA_3 reduced the mean number of days required to start head formation.

4.6 Days from transplanting to 50% curd formation

Statistically significant variation was showed from different days from transplanting to 50% curd formation of cauliflower due to application of different level of gibberellic acid (GA_3) (Table 7 and Appendix VIII). The minimum (42.16) days from transplanting to 50% curd initiation was recorded from G_1 (95 ppm GA_3) and the maximum (51.49) days from transplanting to 50% curd formation was found from G_0 (0 ppm, control). Sharma and Mishra (1989) curd formation of cauliflower can increase with foliar application of plant growth regulator.

Days from transplanting to 50% curd formation of cauliflower showed significant variation due to application of different level of potassium (Table 7 and Appendix VIII). However, the minimum (45.75) days from transplanting to 50% curd formation was observed from K_2 (100 kg K_2O/ha) whereas, the maximum (48.56) days from transplanting to 50% curd formation was observed from K_0 (control).

Significant differences were recorded due to combined effect of gibberellic acid (GA_3) and potassium in terms of days from transplanting to 50% curd formation (Table 8 and Appendix VIII). The minimum (40.26) days from transplanting to 50% curd formation was obtained from G_1K_2 (95 ppm GA_3 and 100 kg K_2O/ha) which was closely followed (41.55) days by G_1K_1 (95 ppm GA_3 and 75 kg K_2O/ha). Maximum (51.38) days from transplanting to 50% curd formation was recorded from G_0K_0. Guo *et al.* (2004) found that the growth and flowering response of a cold-requiring cauliflower *(Brassica oleracca* var. *bolrytis* cv. '*snowball'*) to a range of temperatures under 10 h photoperiod and to growth regulator application. Endogenous gibberellin (GA_3) concentrations were also assessed under these treatments. Flowering and growth of the inflorescence stalk were correlated with plant developmental stage at the time of a vernalizing cold treatment. Temperature and its duration also affected flowering and inflorescence development. The most effective temperature for inflorescence induction was 10°C. Flowering did not occur in non-vernalized plants (25°C) even though they had been treated with GA_3. Application of GA_3 promoted inflorescence stalk elongation greatly in vernalized plants (10^0C), but less so in partially vernalized plants (15 or 20^0C).

Table 7. Effect of gibberellic acid (GA_3) and potassium (K) on yield contributing characters of cauliflower

Treatments	Days from transplanting to curd initiation	Days from transplanting to 50% curd initiation	Stem length (cm)	Stem diameter (cm)
Gibberellic acid (GA_3)				
G_0	46.44 a	51.49 a	9.43 d	2.27 d
G_1	38.25 d	42.16 d	11.14 a	2.58 a
G_2	40.91 c	44.70 c	10.41 b	2.47 b
G_3	43.58 b	49.16 b	9.76 c	2.34 c
$LSD_{(0.05)}$	**0.312**	**0.085**	**0.141**	**0.067**
Significance level	**	**	**	**
Potassium (K)				
K_0	44.11 a	48.56 a	9.18 c	2.31 c
K_1	41.70 b	46.31 b	10.03 b	2.38 b
K_2	41.07 c	45.75 c	11.36 a	2.55 a
$LSD_{(0.05)}$	**0.027**	**2.7445**	**0.122**	**0.058**
Significance level	**	**	**	**
CV (%)	**6.18**	**7.19**	**6.63**	**5.67**

LSD: Least significant difference
In a column means having similar letter(s) are statistically identical and those having dissimilar
letter(s) differ significantly as per 0.05 level of significance.
Gibbrellic acid (GA_3):- G_0: 0 ppm GA_3, G_1: 95 ppm GA_3, G_2: 115 ppm GA_3, G_3: 135 ppm GA_3
Potassium:- K_0: 0 kg K_2O/ha (Control), K_1 : 75 kg K_2O/ha, K_2 : 100 kg K_2O/ha

4.7 Stem length

Gibberellic acid (GA_3) showed statistically significant variation on stem length of cauliflower (Table 7 and Appendix VIII). The longest stem (11.14 cm) was obtained from G_1 (95 ppm GA_3) and the shortest stem (9.43 cm) was found from G_0 (0 ppm, control).

A significant variation was recorded on stem length due to application of different dose of potassium (Table 7 and Appendix VIII). The longest stem length (11.36 cm) was recorded from K_2 (100 kg K_2O/ha) and the lowest stem length (9.18 cm) was observed from K_0 (control).

Significant differences were recorded due to combined effect of gibberellic acid (GA_3) and potassium in terms of stem length (Table 8 and Appendix VIII). The longest stem (12.70 cm) was obtained from G_1K_2 (95 ppm GA_3 and 100 kg K_2O/ha). The shortest stem (8.63 cm) was recorded from G_0K_0 (control). Mishra and Singh (1986) sprayed GA_3 (0, 25 and 50 ppm) on snowball-16 and found that length of stem was increased by GA_3 spray.The plant growth significantly increased with application of GA_3 over control this might be due to increase the cell division and elongation of cells in sub apical meristem. GA_3 stimulates growth and cell expansion of cells through increasing the plasticity of cells. Potassium stimulates growth and development of cells by activating enzymes.

4.8 Stem diameter

Stem diameter of cauliflower showed significant variation due to different level of gibberellic acid (GA_3) showed statistically significant variation (Table 7 and Appendix VIII). The maximum stem diameter (2.58 cm) was obtained from G_1 (95 ppm GA_3) and the minimum stem diameter (2.27 cm) was found from G_0 (0 ppm, control).

A significant variation was recorded on stem length due to application of different level of potassium (Table 7 and Appendix VIII). The maximum stem diameter (2.55 cm) was recorded from K_2 (100 kg K_2O/ha) and the minimum stem diameter (2.31 cm) was observed from K_0 (control).

Stem diameter was also not significantly influenced by the interaction effect of gibberellic acid (GA_3) and potassium in terms of stem diameter (Table 8 and Appendix VIII). The maximum stem diameter (2.77 cm) was obtained from G_1K_2 (95 ppm GA_3 and 100 kg K_2O/ha). Whereas the minimum stem diameter (2.13 cm) was recorded from G_0K_0 (control). Mishra and Singh (1986) sprayed GA_3 (0, 25 and 50 ppm) on snowball-16 and found that there was significant increase indiameter of stem. Potassium activates more than 60 enzymes, has a direct function in protein synthesis, exerts an outstanding influence on plant water relations and is essential in the process of growth and development of cells.

Table 8. Combined effect of gibberellic acid (GA_3) and potassium (K) on yield contributing characters of cauliflower

Treatment combinations	Days from transplanting to curd initiation	Days from transplanting to 50% curd initiation	Stem length (cm)	Stem diameter (cm)
G_0K_0	48.62 a	51.38 b	8.63 g	2.13 e
G_0K_1	45.03 c	52.75 a	9.27 f	2.23 de
G_0K_2	45.66 b	50.34 c	10.40 e	2.43 c
G_1K_0	40.55 i	44.66 h	9.43 f	2.40 c
G_1K_1	38.75 k	41.55 k	11.30 c	2.57 b
G_1K_2	35.44 l	40.26 l	12.70 a	2.77 a
G_2K_0	42.73 f	48.08 f	9.40 f	2.43 c
G_2K_1	40.65 h	43.38 i	10.17 e	2.40 c
G_2K_2	39.34 j	42.64 j	11.67 b	2.57 b
G_3K_0	44.54 d	50.14 d	9.23 f	2.27 d
G_3K_1	42.37 g	47.54 g	9.37 f	2.33 cd
G_3K_2	43.83 e	49.78 e	10.67 d	2.43 c
$LSD_{(0.05)}$	**0.054**	**0.148**	**0.245**	**0.116**
Significance level	**	**	**	**
CV(%)	**6.18**	**7.19**	**6.63**	**5.67**

LSD: Least significant difference
In a column means having similar letter(s) are statistically identical and those having dissimilar
letter(s) differ significantly as per 0.05 level of significance.
Gibbrellic acid (GA_3):- G_0: 0 ppm GA_3, G_1: 95 ppm GA_3, G_2: 115 ppm GA_3, G_3: 135 ppm GA_3
Potassium:- K_0: 0 kg K_2O/ha (Control), K_1 : 75 kg K_2O/ha, K_2 : 100 kg K_2O/ha

4.9 Curd diameter

Curd diameter of cauliflower showed statistically significant variation due to the application of different gibberellic acid (GA_3) concentration (Table 9 and Appendix X).

The maximum curd diameter (24.36 cm) was obtained from G_1 (95 ppm GA_3) and the minimum curd diameter (18.54 cm) was recorded from G_0 (0 ppm, control).

Curd diameter of cauliflower showed statistically significant variation due to the application of different potassium dose (Table 9 and Appendix X). The highest curd diameter (21.80 cm) was observed from K_2 (100 kg K_2O/ha). The minimum curd diameter (18.58 cm) was found from K_0 (control).

A statistically significant variation was observed due to combined effect of gibberellic acid (GA_3) and potassium for curd diameter (Table 10 and Appendix X). The highest curd diameter (25.73 cm) was obtained from G_1K_2 (95 ppm GA_3 and 100 kg K_2O/ha) which was closely followed (25.03 cm) by G_1K_1 (95 ppm GA_3 and 75 kg K_2O/ha). The minimum curd diameter (16.50 cm) was observed from G_0K_0 (control). Reddy (1989) reported that curd diameter at maturity 26.8 cm were obtained with the application of GA_3. Potassium activates more than 60 enzymes, has a direct function in protein synthesis, exerts an outstanding influence on plant water relations and is essential in the process of growth and development of cells. Potassium also plays a major role in photosynthesis in both the light and dark reactions culminating in the formation of sugar via the reduction of carbon dioxide.

4.10 Percentage of dry matter content of 100 g curd

Statistically significant variation was recorded on dry matter content of 100 g curd of cauliflower due to the application of different concentration of gibberellic acid (GA_3) (Table 9 and Appendix X). The maximum (12.29%) dry matter content of 100 g curd was observed from the G_1 (95 ppm GA_3) and minimum (10.91%) dry matter content was observed from treatment G_0 (0 ppm, control).

Significant variation was observed on percentage of dry matter content of 100 g curd influenced by different levels of potassium (Table 9 and Appendix X). Results indicated that the highest (11.92%) dry matter content of curd was observed from the K_2 (100 kg K_2O/ha) treatment while the minimum (10.76%) dry matter content of curd was recorded from K_0(control) treatment.

Combined effect of gibberellic acid (GA_3) and potassium showed statistically significant variation on percentage of dry matter content of 100 g curd (Table 10 and Appendix X). The result showed that the highest (13.38%) dry matter content of curd was observed from the G_1K_2 (95 ppm GA_3 and 100 kg K_2O/ha) treatment which was closely followed (10.33%) by G_3K_0 . The minimum (10.39%) dry matter content of curd was observed from G_3K_1 (135 ppm GA_3 and 75 kg K_2O/ha) treatment. Potassium plays a major role in photosynthesis in both the light and dark reactions culminating in the formation of sugar via the reduction of carbon dioxide. It activates more than 60 enzymes, has a direct function in protein synthesis,exerts an outstanding influence on plant water relations and is essential in the process of growth and development of cells.

4.11 Curd weight with leaf

Curd weight with leaf of cauliflower differed significantly due to different concentration of gibberellic acid (GA_3) (Table 9 and Appendix IX). The maximum curd weight with leaf (2.07 kg) was obtained from G_1 (95 ppm GA_3) and the minimum curd weight with leaf (1.68 kg) was recorded from G_0 (0 ppm, control). Sharma and Mishra (1989) stated that curd size of cauliflower can increase with foliar application of plant growth regulator.

Curd weight with leaf of cauliflower showed statistically significant variation due to the application of different dose of potassium (Table 9 and Appendix IX). The maximum curd weight with leaf (2.04 kg) was observed from K_2 (100 kg K_2O/ha). The minimum curd weight with leaf (1.60 kg) was found from K_0 (control).

Statistically significant variation was recorded due to combined effect of Gibberellic acid (GA_3) and potassium for curd weight with leaf (Table 10 and Appendix IX). The maximum curd weight with leaf (2.45kg) was obtained from G_1K_2 (95 ppm GA_3 and 100 kg K_2O/ha). The minimum curd weight with leaf (1.55 kg) was observed from G_0K_0 and G_1K_0 respectively. Thapa *et al.*(2013) found that the maximum individual curd weight (0.89 kg) was recorded by the foliar application of GA_3@ 50 ppm which was maximum than control. This might be due to more accumulation of carbohydrates by maximum rate of photosynthesis.

4.12 Marketable yield per plant

Gibberellic acid (GA_3) showed statistically significant variation on marketable yield per plant of cauliflower (Table 9 and Appendix IX). The maximum marketable yield per plant (1.38 kg) was recorded from G_1 (95 ppm GA_3) and the minimum marketable yield per plant (1.05 kg) was obtained from G_0 (0 ppm, control).

Table 9. Effect of gibberellic acid (GA_3) and potassium (K) on yield contributing characters of cauliflower

Treatments	Curd Diameter (cm)	Dry Matter Content (%)	Curd Weight with leaves (kg/plant)	Marketable Yield (kg/plant)
Gibberellic acid (GA_3)				
G_0	18.54 c	10.91	1.68c	1.05d
G_1	24.36 a	12.29	2.07a	1.38a
G_2	19.88 b	11.5	1.82b	1.23b
G_3	18.63 cd	10.59	1.81b	1.11c
$LSD_{(0.05)}$	**0.132**	**0.129**	**0.017**	**2.074**
Significance level	**	**	**	**
Potassium (K)				
K_0	18.58 c	10.76	1.6c	1.12c
K_1	20.68 b	11.29	1.9b	1.2b
K_2	21.80 a	11.92	2.04a	1.26a
$LSD_{(0.05)}$	**0.115**	**0.112**	**0.014**	**0.204**
Significance level	**	**	**	**
CV (%)	**6.32**	**7.12**	**6.90**	**5.99**

LSD: Least significant difference

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of significance.

Gibbrellic acid (GA_3):- G_0: 0 ppm GA_3, G_1: 95 ppm GA_3, G_2: 115 ppm GA_3, G_3: 135 ppm GA_3

Potassium:- K_0: 0 kg K_2O/ha (Control), K_1 : 75 kg K_2O/ha, K_2 : 100 kg K_2O/ha

Marketable yield per plant of cauliflower varied significantly due to the application of potassium (Table 9 and Appendix IX). The maximum marketable yield per plant (1.26 kg) was recorded from K_2 (100 kg K_2O/ha) and the minimum marketable yield per plant (1.12 kg) was found from K_0 (control). Vjay and Ray (2000) reported that GA_3 at 100 ppm produced the highest curd yields.

Table 10. Combined effect of gibberellic acid (GA_3) and potassium (K) on yield contributing characters of cauliflower

Treatment combinations	Curd Diameter (cm)	Dry Matter Content (%)	Curd Weight with leaves (kg/plant)	Marketable Yield (kg/plant)
G_0K_0	16.50 l	10.64 gh	1.55 i	0.98 j
G_0K_1	18.67 i	10.87 fg	1.64 h	1.06 h
G_0K_2	20.47 e	11.21 de	1.86 e	1.12 g
G_1K_0	22.30 c	11.41 d	1.55 i	1.33 c
G_1K_1	25.03 b	12.09 b	2.22 b	1.38 b
G_1K_2	25.73 a	13.38 a	2.45 a	1.42 a
G_2K_0	18.30 j	10.64 h	1.57 i	1.14 f
G_2K_1	19.80 f	11.82 c	1.92 d	1.21 d
G_2K_2	21.53 d	12.05 b	1.97 c	1.32 c
G_3K_0	17.23 k	10.33 i	1.73 g	1.02 i
G_3K_1	19.20 h	10.39 i	1.82 f	1.14 f
G_3K_2	19.47 g	11.05 ef	1.87 e	1.17 e
$LSD_{(0.05)}$	**0.229**	**0.224**	**0.029**	**0.016**
Significance level	**	**	**	**
CV(%)	**6.32**	**7.12**	**6.90**	**5.99**

LSD: Least significant difference

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of significance.

Gibbrellic acid (GA_3):- G_0: 0 ppm GA_3, G_1: 95 ppm GA_3, G_2: 115 ppm GA_3, G_3: 135 ppm GA_3

Potassium:- K_0: 0 kg K_2O/ha (Control), K_1 : 75 kg K_2O/ha, K_2 : 100 kg K_2O/ha

Combined effect of gibberellic acid (GA_3) and potassium showed significant variation on marketable yield per plant (Table 10 and Appendix IX). The maximum marketable yield per plant (1.42 kg) was recorded from the treatment combination of G_1K_2 (95 ppm GA_3 and 100 kg K_2O/ha) and the minimum marketable yield per plant (0.98 kg) was recorded from G_0K_0 (control). Thapa *et al.*(2013) found that the maximum individual curd weight (0.89 kg) was recorded by the foliar application of GA_3@ 50 ppm which was maximum than control. This might be due to more accumulation of carbohydrates by maximum rate of photosynthesis. Potassium activates more than 60 enzymes, has a direct function in protein synthesis, exerts an outstanding influence on plant water relations and is essential in the process of growth and development of cells.

4.13 Curd weight

Statistically significant variation was recorded on pure curd weight of cauliflower due to the application of different concentration of gibberellic acid (GA_3) (Figure 8 and Appendix XIV). The maximum curd weight (1.07 kg) was obtained from G_1 (95 ppm GA_3) and the minimum curd weight (0.76 kg) was recorded from G_0 (0 ppm, control). Vijay and Ray (2000) reported that GA_3 at 100 ppm produced the highest curd yields.

Curd weight of cauliflower showed statistically significant variation due to the application of different dose of potassium (Figure 9 and Appendix XIV). The maximum curd weight (0.96 kg) was observed from K_2 (100 kg K_2O/ha). The minimum curd weight (0.82 kg) was found from K_0 (control).

Statistically significant variation was recorded due to combined effect of Gibberellic acid (GA_3) and potassium (K) for curd weight (Figure 10 and Appendix XV). The maximum curdweight(1.12 kg) was obtained from G_1K_2 (95 ppm $GA_3$and 100 kg K_2O/ha)which was closely followed (1.08 kg) byG_1K_1(95 ppm $GA_3$and 75 kg K_2O/ha). The minimum curd weight(0.68 kg) was observed from G_0K_0(control). Thapa *et al.*(2013) found that the maximum individual curd weight (0.89 kg) was recorded by the foliar application of GA_3@ 50 ppm which was maximum than control. This might be due to more accumulation of carbohydrates by maximum rate of photosynthesis.

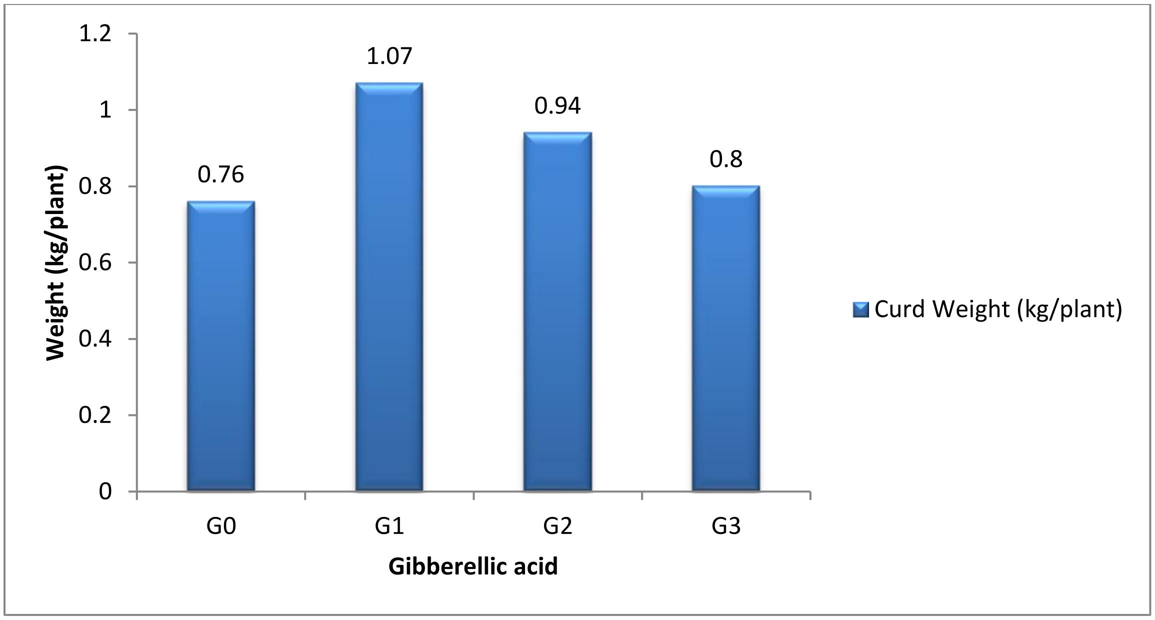

Fig. 8. Effect of gibberellic acid (GA_3) on curd weight (kg) of cauliflower, where G_0 : 0 ppm GA_3, G_1 : 95 ppm GA_3, G_2 : 115 ppm GA_3, G_3 : 135 ppm GA_3

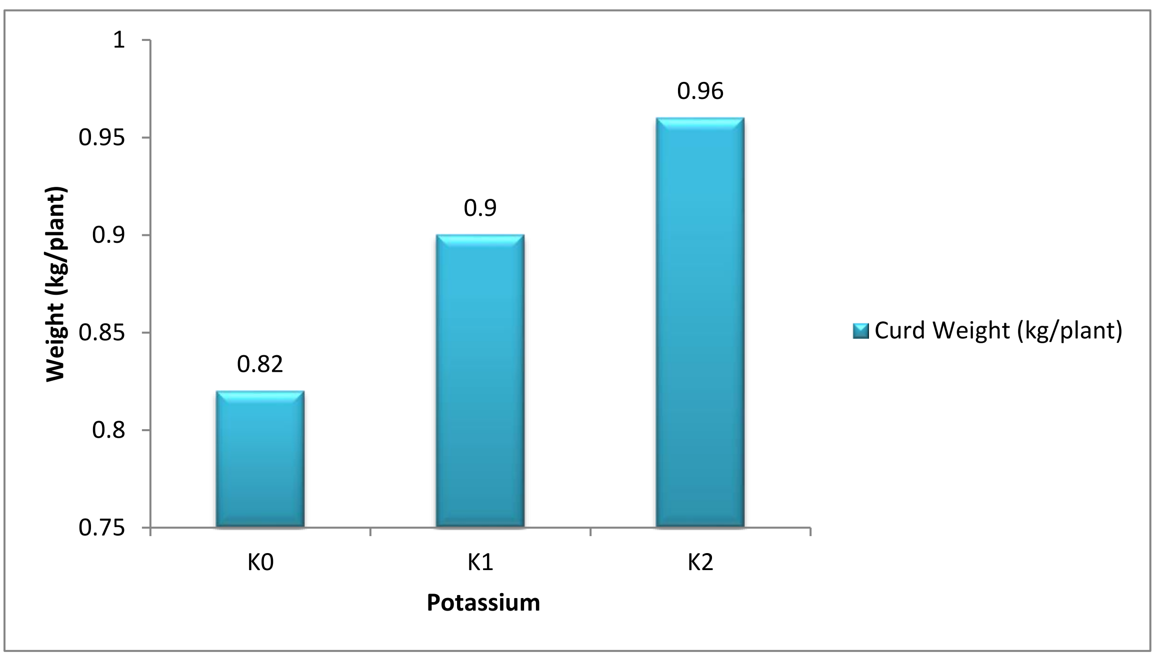

Fig. 9. Effect of potassium (K) on weight (kg) of per plant of cauliflower, where K_0 : 0 kg K_2O/ha (Control), K_1 : 75 kg K_2O/ha, K_2 : 100 kg K_2O/ha

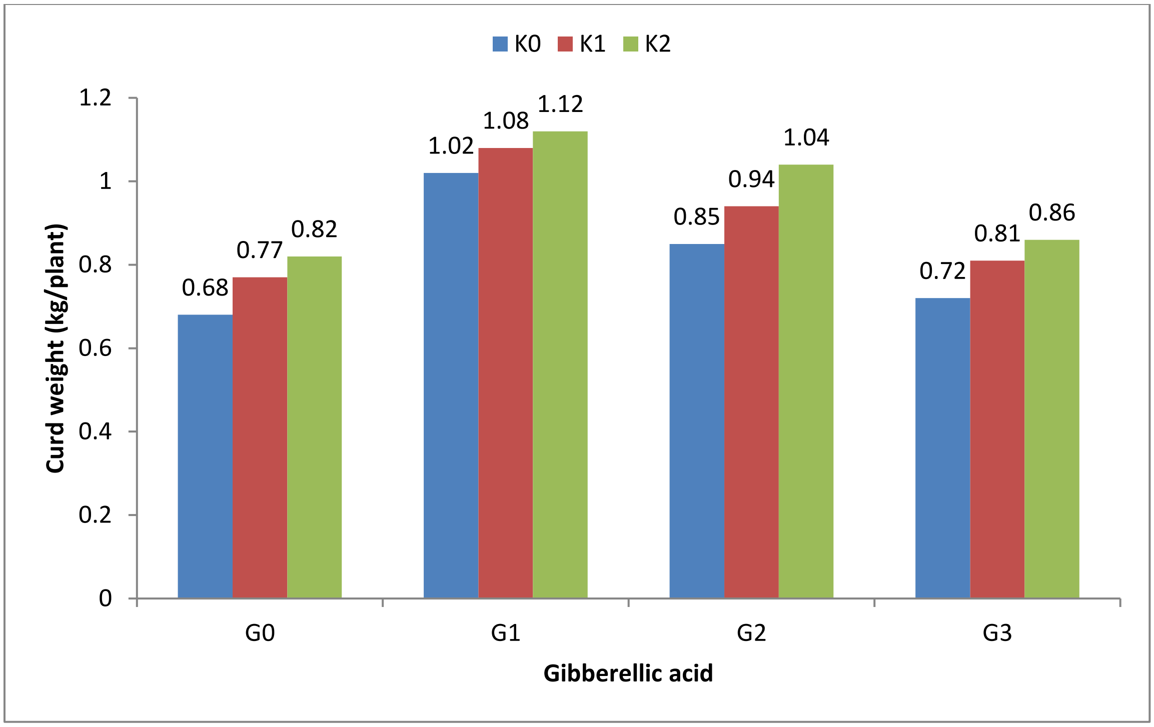

Fig. 10. Combined effect of gibberellic acid (GA_3) and potassium on curd weight (kg) per plant of cauliflower, where G_0 : 0 ppm GA_3, G_1 : 95 ppm GA_3, G_2 : 115 ppm GA_3, G_3 : 135 ppm GA_3 , K_0 : 0 kg K_2O/ha (Control), K_1 : 75 kg K_2O/ha, K_2 : 100 kg K_2O/ha

4.14 Marketable yield per hectare

Marketable yield per plant of cauliflower varied significantly due to gibberellic acid (GA_3) application (Figure 11 and Appendix XIV). The maximum marketable yield per hectare (34.39 t/ha) was recorded from G_1 (95 ppm GA_3) and the minimum marketable yield per hectare (26.31 t/ha) was obtained from G_0 (0 ppm, control).

Marketable yield per hectare of cauliflower varied significantly due to the application of potassium (Figure 12 and Appendix XIV). The maximum marketable yield per hectare (31.42 t/ha) was recorded from K_2 (100 kg K_2O/ha) and the minimum marketable yield per hectare (27.98 t/ha) was found from K_0 (control).

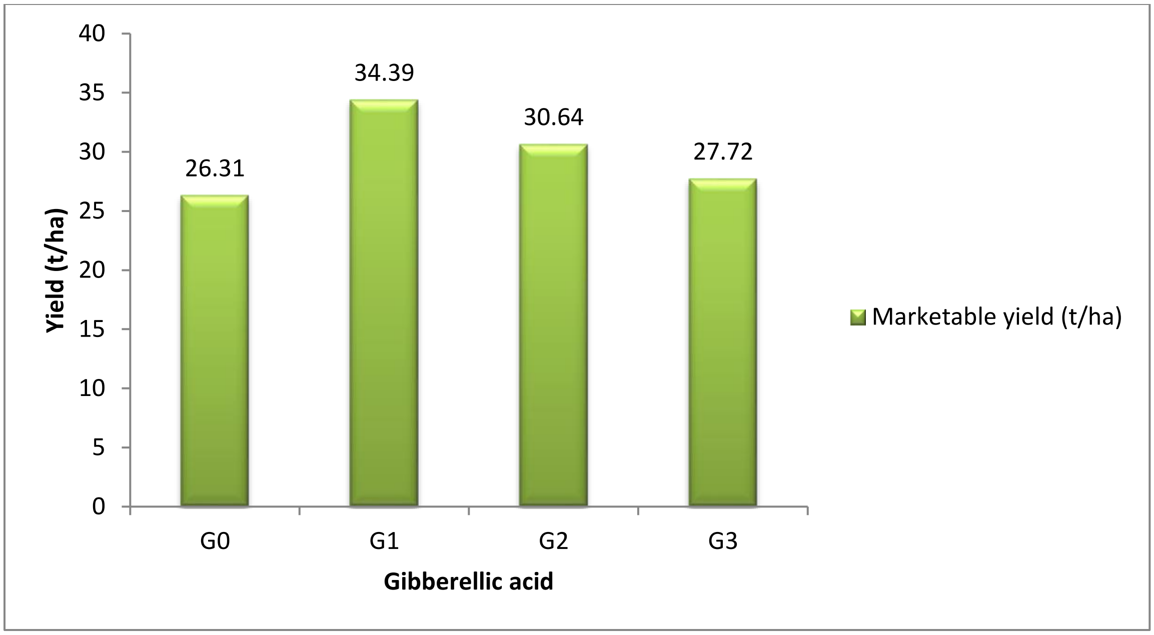

Fig. 11. Effect of gibberellic acid (GA_3) on marketable yield (t/ha) of cauliflower, where G_0 : 0 ppm GA_3, G_1 : 95 ppm GA_3, G_2 : 115 ppm GA_3, G_3 : 135 ppm GA_3

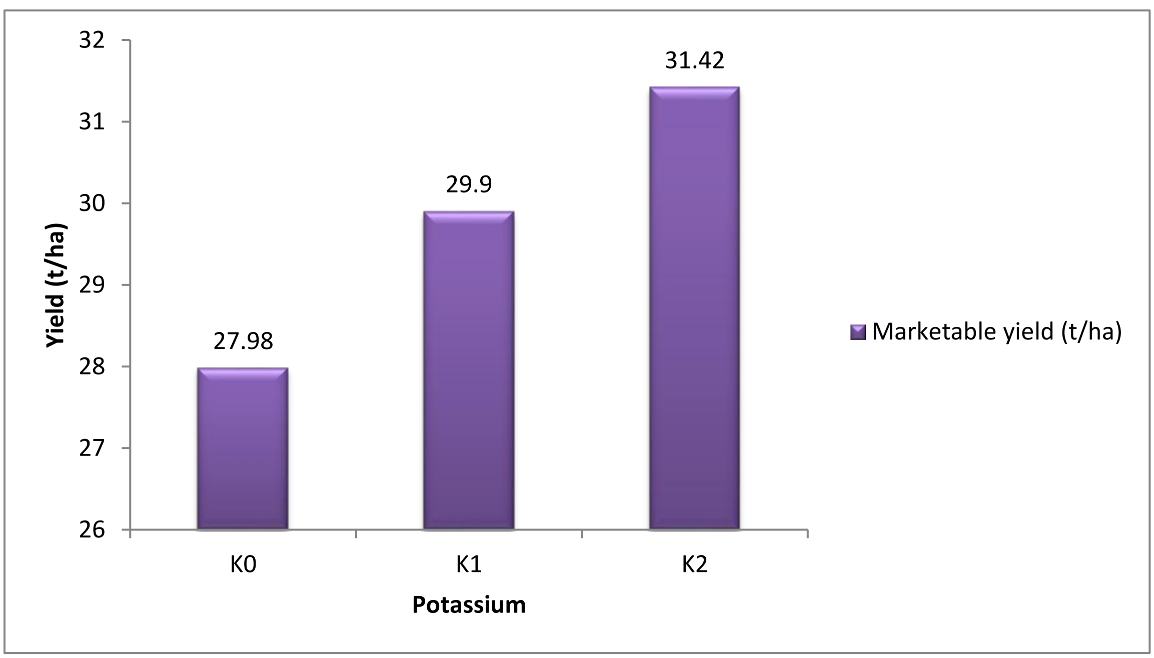

Fig. 12. Effect of potassium on marketable yield (t/ha) of per plant of cauliflower, where K_0 : 0 kg K_2O/ha (Control), K_1 : 75 kg K_2O/ha, K_2 : 100 kg K_2O/ha

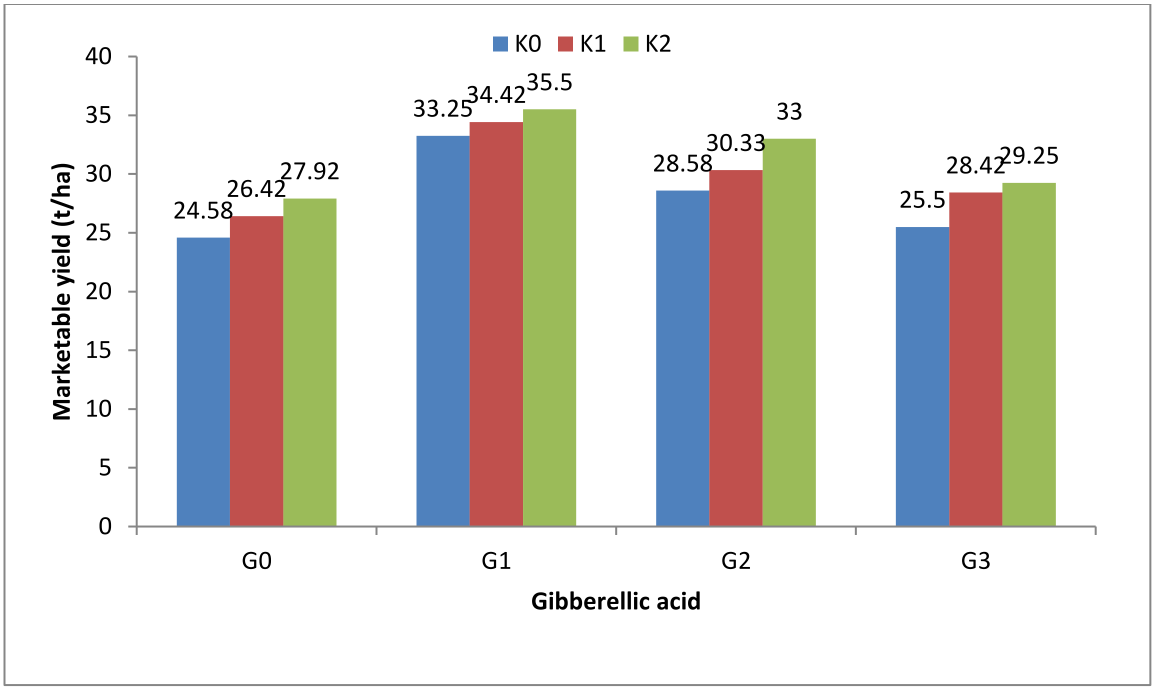

Fig. 13. Combined effect of gibberellic acid (GA_3) and potassium on marketable yield (t/ha) of cauliflower, where G_0 : 0 ppm GA_3, G_1 : 95 ppm GA_3, G_2 : 115 ppm GA_3, G_3 : 135 ppm GA_3 , K_0 : 0 kg K_2O/ha (Control), K_1 : 75 kg K_2O/ha, K_2 : 100 kg K_2O/ha

Combined effect of gibberellic acid (GA_3) and potassium showed significant variation on marketable yield per hectare (Figure 13 and Appendix XV). The maximum marketable yield per hectare (35.50 t/ha) was recorded from the treatment combination of G_1K_2 (95 ppm GA_3 and 100 kg K_2O/ha) which was closely followed (34.42 t/ha) by G_1K_1 (95 ppm GA_3 and 75 kg K_2O/ha) and the minimum marketable yield per hectare (24.58 t/ha) was recorded from G_0K_0 (control). Thapa *et al.*(2013) found that the maximum individual curd weight (0.89 kg) was recorded by the foliar application of GA_3@ 50 ppm which was maximum than control. This might be due to more accumulation of carbohydrates by maximum rate of photosynthesis. Potassium activates more than 60 enzymes, has a direct function in protein synthesis, exerts an outstanding influence on plant water relations and is essential in the process of growth and development of cells.

4.15 Economic analysis

Input costs for land preparation, fertilizer, irrigation and manpower required for all the operations from seed sowing to harvesting of cauliflower were recorded as per experimental plot and converted into cost per hectare. Price of cauliflower was considered as per market rate. The economic analysis presented under the following headings-

4.15.1 Gross return

The combination of different levels of gibberellic acid and potassium fertilizer showed different value in terms of gross return under the trial (Table 11). The highest gross return (Tk. 426,000) was obtained from the treatment combination G_1K_2 and the second highest gross return (Tk. 413040) was found in G_1K_1. The lowest gross return (Tk. 294960) was obtained from G_0K_0.

4.15.2 Net return

In case of net return, different levels of gibberellic acid and potassium fertilizer showed different levels of net return under the present trial (Table 11). The highest net return (Tk. 200796) was found from the treatment combination G_1K_2 and the second highest net return (Tk.188115) was obtained from the combination G_1K_1. The lowest (Tk. 75321) net return was obtained G_0K_0.

4.15.3 Benefit cost ratio

In the different levels of gibberellic acid and potassium fertilizer the highest benefit cost ratio (1.89) was noted from the combination of G_1K_2 and the second highest benefit cost ratio (1.84) was estimated from the combination of G_1K_1. The lowest benefit cost ratio (1.34) was obtained from G_0K_0 (Table 11). From economic point of view, it is apparent from the above results that the combination of G_1K_2 was better than rest of the combination.

Table 11. Cost and return of cauliflower cultivation as influenced by different levels of gibberellic acid and potassium

Treatment combinations	Cost of production (Tk/ha)	Yield of cauliflower (t/ha)	Gross return (Tk/ha)	Net return (Tk/ha)	Benefit cost ratio
G_0K_0	219639	24.58	294960	75321	1.34
G_0K_1	220473	26.42	317040	96567	1.44
G_0K_2	220752	27.92	335040	114288	1.52
G_1K_0	224091	33.25	399000	174909	1.78
G_1K_1	224925	34.42	413040	188115	1.84
G_1K_2	225204	35.50	426000	200796	1.89
G_2K_0	226317	28.58	342960	116643	1.51
G_2K_1	227151	30.33	363960	136809	1.6
G_2K_2	227430	33.00	396000	168570	1.74
G_3K_0	228543	25.50	306000	77457	1.34
G_3K_1	229377	28.42	341040	111663	1.49
G_3K_2	229656	29.25	351000	121344	1.53

Price of cauliflower tk. 12000/ton as per market rate of Kawran Bazar. Dhaka

Gibbrellic acid (GA_3): G_0 : 0 ppm GA_3, G_1 : 95 ppm GA_3, G_2 : 115 ppm GA_3, G_3 : 135 ppm GA_3 ,
Potassium: K_0 : 0 kg K_2O/ha (Control), K_1 : 75 kg K_2O/ha, K_2 : 100 kg K_2O/ha

CHAPTER V
SUMMARY AND CONCLUSION

An experiment was conducted at the Horticultural Farm of Sher-e-Bangla Agricultural University, Dhaka, to evaluate the effect of gibberellic acid (GA_3) and potassium (K) on the growth and yield performance Cauliflower during the period from October 2018 to February 2019. The experiment consisted of two factors. Factor A: different concentration of gibberellic acid (GA_3) as G_0 : 0 ppm, G_1 : 95 ppm, G_2 : 115 ppm and G_3 : 135 ppm and factor B: different levels of potassium (K) as K_0: 0 kg/ha (Control), K_1 : 75 kg/ha, K_2 : 100 kg/ha. These two factors made 12 treatment combinations and the numbers of plots were 36.

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. For the field experiment the size of unit plot was (2m x1.8m) and 12 plants were accommodated in each plot with a spacing of 40 cm x 60 cm. Seedlings were transplanting in the field on 16 November, 2018. From each plot, 5 plants were randomly selected for collection of data. The recorded data on different parameters were statistically analyzed using Statistic 10 software.

Cauliflower showed significant variation for all parameters due to different concentration of gibberellic acid (GA_3) on plant height. At 30, 40, 50 DAT and at harvest the tallest plant (27.01, 42.16, 53.00, 64.13 cm) was recorded from G_1 (95 ppm) and the shortest plant (24.51, 34.92, 44.82 and 50.10 cm) was observed from G_0 (0 ppm, control). The maximum number of leaves per plant (14.30, 15.87, 20.76 and 24.07) was observed in G_1 (95 ppm) and the minimum number of leaves per plant (10.79, 14.47, 16.80 and 19.62) was found from G_0 (0 ppm, control) at 30. 40, 50 and DAT and at harvest respectively. At the same DAT and at harvest the longest leaf (22.08, 37.77, 49.10 and 59.96 cm) was obtained from G_1 (95 ppm GA_3) and the the shortest leaf (19.18,30.40, 40.41 and 45.84 cm) was found from G_0 (0 ppm, control) respectively. At the same DAT and at harvest the widest leaf (10.54, 14.56, 17.24 and 18.71cm) was obtained from G_1 (95 ppm GA_3) the lowest leaf breadth (8.74, 12.29, 14.40 and 16.13 cm) was found from G_0 respectively. The minimum (38.25) days from transplanting to curd formation was found from G_1 (95 ppm GA_3), while the maximum (46.44) days from transplanting to curd formation was noted from G_0. The minimum (42.16) days from transplanting to 50% curd initiation was recorded from G_1 (95 ppm GA_3) and the maximum (51.49) days from transplanting to 50% curd formation was found from G_0 (0 ppm, control). The longest stem (11.14 cm) was obtained from G_1 (95 ppm GA_3) and the shortest stem (9.43 cm) was found from G_0 (0 ppm, control). The highest stem diameter (2.58 cm) was obtained from G_1 (95 ppm GA_3) and the lowest stem diameter (2.27 cm) was found from G_0 (no PGR). The maximum curd diameter (22.72 cm) was obtained from G_1 (95 ppm GA_3) and the minimum curd diameter (18.88 cm) was recorded from G_0. The maximum (12.29%) dry matter content of 100 g curd was observed from the G_1 (95 ppm GA_3) and minimum (10.91%) dry matter content was observed from treatment G_0. The maximum curd weight with leaf (2.07 kg) was obtained from G_1 (95 ppm GA_3) and the minimum curd weight with leaf (1.68 kg) was recorded from G_0. The highest marketable yield per plant (1.38 kg) was recorded from G_1 (95 ppm GA_3) and the lowest marketable yield per plant (1.05kg) was obtained from G_0 (0 ppm, control). The maximum curd weight (1.07 kg) was obtained from G_3 (135 ppm GA_3) and the minimum curd weight (0.76 kg) was recorded from G_0. The highest marketable yield per hectare (34.39 t/ha) was recorded from G_1 (95 ppm GA_3) and the lowest marketable yield per hectare (26.31 t/ha) was obtained from G_0 (0 ppm, control).

Significant variation was showed for all parameters of cauliflower due to different level of potassium. At 30, 40, 50 DAT and at harvest the tallest plant (26.64, 40.28, 51.78 and 60.05 cm) was found from K_2 (100 kg K_2O/ha) and the shortest plant (24.98, 37.00, 46.98 and 55.93 cm) was obtained from K_0 (control) respectively. At 30, 40, 50 DAT and at harvest, the maximum number of leaves per plant (13.05, 16.00, 19.93 and 23.18) was recorded from K_2(100 kg K_2O/ha) and the minimum number of leaves per plant (11.18, 14.41, 17.70 and 20.65) was found from K_0 (control) respectively. At the same DAT and at harvest the longest leaf (21.59, 35.99, 47.68 and 55.76 cm) was obtained from K_2 (100 kg K_2O/ha) and the shortest leaf (19.83, 32.17, 42.73 and 50.88 cm) was observed from K_0 (control) respectively. At 30, 40, 50 DAT and at harvest the widest leaf (10.26, 14.45, 16.89 and 18.83 cm) was obtained from K_2 (100 kg K_2O/ha) and the minimum leaf breadth (9.20, 12.59, 14.85 and 15.98 cm) was observed from K_0 (control) respectively.

The minimum (41.07) and the maximum (44.11) days from transplanting to curd formation was found from K_2 (100 kg K_2O/ha) and K_0 (control) respectively. The minimum (45.75) days from transplanting to 50% curd formation was observed from K_2 (100 kg K_2O/ha) whereas, the maximum (48.56) days from transplanting to 50% curd formation was observed from K_0 (control). The longest stem length (11.36 cm) was recorded from K_2 (100 kg K_2O/ha) and the lowest stem length (9.18 cm) was observed from K_0 (control). The highest stem diameter (2.55 cm) was recorded from K_2 (100 kg K_2O/ha K) and the lowest stem diameter (2.31 cm) was observed from K_0 (control). The highest curd diameter (23.48 cm) was observed from K_2 (100 kg K_2O/ha). The lowest curd diameter (17.48 cm) was found from K_0 (control). The highest (12.92%) dry matter content of 100g curd was observed from the K_2 (100 kg K_2O/ha) treatment while the minimum (10.76%) dry matter content of curd was recorded from K_0(control) treatment. The highest curd weight with leaf (2.04 kg) was observed from K_2 (100 kg K_2O/ha). The lowest curd weight with leaf (1.60 kg) was found from K_0 (control). The highest marketable yield per plant (1.26 kg) was recorded from K_2 (100 kg K_2O/ha) and the lowest marketable yield per plant (1.12kg) was found from K_0 (control). The highest curd weight (0.96) was observed from K_2 (100 kg K_2O/ha). The lowest curd weight (0.82 kg) was found from K_0 (control). The highest marketable yield (31.42 t/ha) was recorded from K_2 (100 kg K_2O/ha) and the lowest marketable yield (27.98 t/ha) was found from K_0 (control).

Combined effect of gibberellic acid (GA_3) and potassium showed significant variation on all parameters of cauliflower. At 30, 40, 50 DAT and at harvest the tallest plant (28.07, 44.60, 56.23 and 66.73 cm) was found from the treatment combination of G_1K_2 (95 ppm GA_3 and 100 kg K_2O/ha).Whereas the shortest plant (23.73, 32.53,40.43 and 45.33 cm) was recorded from G_0K_0 (control) at same DAT and at harvest, respectively. The maximum number of leaves per plant (14.80, 16.60, 21.47 and 25.40) was observed from G_1K_2 at 30, 40, 50 DAT and at harvest respectively. While the minimum number of leaves per plant (9.53, 13.40, 14.33 and 17.20) was recorded from G_0K_0 (control condition) at 30, 40, 50 DAT and at harvest respectively. The longest leaf (23.37, 40.50, 52.20 and 63.30 cm) was found from G_1K_2 (95 ppm GA_3 and 100 kg K_2O/ha) at 30, 40, 50 DAT and at harvest respectively. The shortest leaf (18.53, 27.87, 35.50 and 40.50 cm) was obtained from G_0K_0 at 30, 40, 50 DAT and at harvest respectively. The widest leaf (11.50, 15.57, 18.63 and 20.33 cm) was found from G_1K_2 at 30, 40, 50 DAT. The lowest leaf breadth (8.33, 11.17, 12.17 and 13.43 cm) was obtained from G_0K_0 at 30, 40, 50 DAT and at harvest respectively. The minimum (35.44) days and the maximum (48.62) days from transplanting to curd formation was recorded from G_0K_0 respectively. The minimum (40.26) days from transplanting to 50% curd formation was obtained from G_1K_2 which was closely followed (41.55) days by G_1K_1. Maximum (51.38) days from transplanting to 50% curd formation was recorded from G_0K_0. The longest stem (12.70 cm) was obtained from G_1K_2. The shortest stem (8.90 cm) was recorded from G_0K_0. The highest stem diameter (2.77 cm) was obtained from G_1K_2 where as the lowest stem diameter (2.13 cm) was recorded from G_0K_0. The highest curd diameter (25.73) cm was obtained from G_1K_2 which was closely followed (25.03 cm) by G_1K_1. The lowest curd diameter (16.50 cm) was observed from G_0K_0. The result showed that the highest (13.38%) dry matter content of curd was observed from the G_1K_2 treatment which is significantly different from other treatment combinations while the lowest (10.33%) dry matter content of curd was observed from G_3K_0 treatment. The highest curd weight with leaf (2.45 kg) was obtained from G_1K_2. The lowest curd weight with leaf (1.55 kg) was observed from G_0K_0 and G_1K_0. The highest marketable yield per plant (1.42 kg) was recorded from the treatment combination of G_1K_2 and the lowest marketable yield per plant (0.98 kg) was recorded from G_0K_0. The highest curd weight (1.12 kg) was obtained from G_1K_2 which was closely followed (1.08 kg) by G_1K_1. The lowest curd weight (0.68 kg) was observed from G_0K_0. The highest marketable yield (35.58 t/ha) was recorded from the treatment combination of G_1K_2 which was closely followed (35.50t/ha) by G_1K_1 (95 ppm GA_3 and 75 kg K_2O/ha) and the lowest marketable yield (24.58 t/ha) was recorded from G_0K_0. The highest benefit cost ratio (1.89) was noted from the combination of G_1K_2 (95 ppm GA_3 and 100 kg K_2O/ha) and the second highest benefit cost ratio (1.84) was estimated from the combination of G_1K_1.The lowest benefit cost ratio (1.34) was obtained from G_3K_0 and G_0K_0.

Conclusion

Considering the above result of this experiment, it can be concluded that application of G_1 (95 ppm GA_3) and K_2 (100 kg/ha K) were the best individual performer and G_1K_2 (95 ppm GA_3 and 100 kg/ha K) performed better among other treatment combination due to better plant growth, maximum yield and highest economic return of cauliflower. Further investigation is needed in different agro-ecological zones (AEZ) of Bangladesh under variable field condition to confirm the result of the present experiment before recommending it to the growers.

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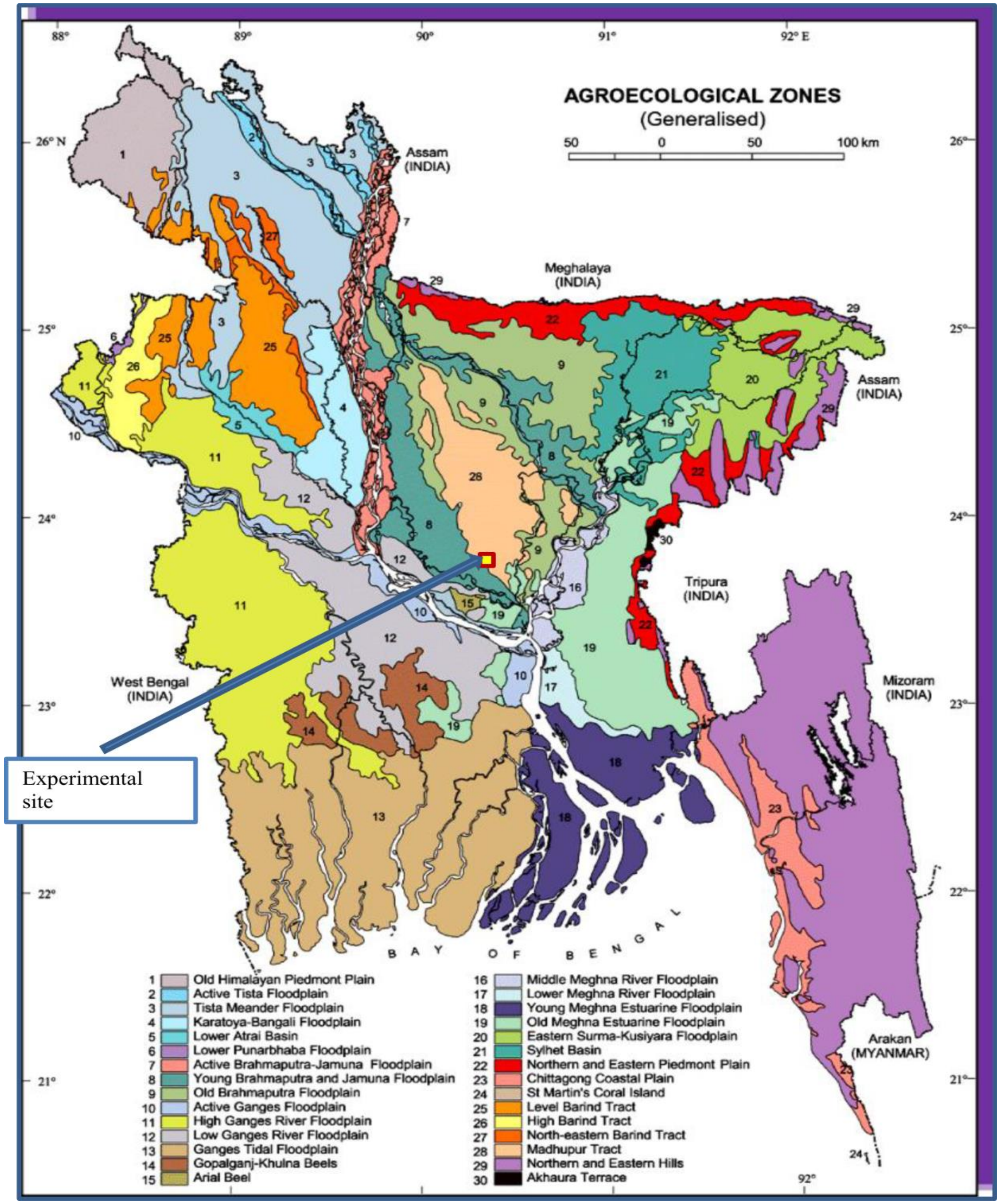
APPENDICES

Appendix I. Map showing the experimental site



Appendix II: Characteristics of Sher-e-Bangla Agricultural University soil is analysed by Soil Resources Development Institute (SRDI), Khamar Bari, Farmgate, Dhaka

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Sher-e-Bangla Agricultural
AEZ	Madhupur Tract (28)
General soil type	Shallow Red Brown Terrace Soil
Land Type	High land
Soil Series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	Fellow-Tomato

B. Physical and chemical properties of initial soil

CHARACTERISTICS	VALUE
Partial Size Analysis	
% Sand	27
% Silt	43
% Clay	30
Textural Class	
PH	5.47 – 5.63
Organic carbon (%)	0.46
Organic matter (%)	0.83
Total N (%)	0.05
Available P (ppm)	20.00
Exchangeable K (me/100 gm soil)	0.12
Available S (ppm)	46

Source: Soil Resources Development Institute (SRDI)

Appendix III: Monthly record of annual temperature, rainfall, relative humidity, soil temperature and sunshine of the experimental site during the period from September 2018 to March 2019 (Site-Dhaka)

Year	Month	Air temperature			Relative humidity (%)	Rainfall (mm)	Sunhine
		Max.	Mini.	Average			
2018	September	31.35	25.15	28.25	71.02	26	20.33
	October	30.60	24.2	27.40	75.87	04	206.9
	November	29.85	18.50	24.17	70.12	00	235.2
	December	26.76	16.72	21.74	70.63	00	190.5
2019	January	24.05	13.82	18.93	62.04	00	197.6
	February	28.90	18.03	23.46	68.79	09	220.5
	March	32.24	22.10	27.17	78.82	68.5	208.2

Source: Bangladesh Meteorological Department (Climatic Division), Agargaon, Dhaka-1212.

Appendix IV: Analysis of variance of the data on plant height at different days after transplanting (DAT) of cauliflower as influenced by different concentration of gibberellic acid (GA_3) and levels of potassium (K)

Source of variation	Degree of freedom	Mean square: Plant height (cm) at different days after transplanting			
		30 DAT	40DAT	50 DAT	At harvest
Replication	2	0.391	8.527	38.887	88.88
Gibberellic acid (A)	3	33.434**	277.679**	231.096**	953.23**
Potassium (B)	2	13.769**	104.032**	227.265**	111.59**
Interaction (AxB)	6	2.436**	13.504**	114.833**	64.63**
Error	22	79.423	221.607	276.02	226.06

* **:** Significant at 0.05 level of probability
** **:** Significant at 0.01 level of probability

Appendix V: Analysis of variance of the data on number of leaves per plant at different days after transplanting (DAT) of cauliflower as influenced by different concentration of gibberellic acid (GA_3) and levels of potassium (K)

Source of variation	Degree of freedom	Mean square			
		Number of leaves per plant at different days after transplanting			
		30 DAT	40DAT	50 DAT	At harvest
Replication	2	3.271	0.0739	11.216	2.745
Gibberellic acid (A)	3	56.052**	11.1186**	75.953**	86.739**
Potassium (B)	2	26.754**	20.0106**	31.877**	40.207**
Interaction (AxB)	6	5.131**	3.1339**	12.385**	8.716**
Error	22	24.489	24.4928	47.638	28.542

* **:** Significant at 0.05 level of probability
** **:** Significant at 0.01 level of probability

Appendix VI: Analysis of variance of the data on leaf length at different days after transplanting (DAT) of cauliflower as influenced by different concentration of gibberellic acid (GA_3) and levels of potassium (K)

Source of variation	Degree of freedom	Mean square			
		Leaf length (cm) at different days after transplanting			
		30 DAT	40DAT	50 DAT	At harvest
Replication	2	0.244	3.302	38.887	89.76
Gibberellic acid (A)	3	30.587**	205.823**	231.096**	953.41**
Potassium (B)	2	11.501**	112.167**	227.265**	112.26**
Interaction (AxB)	6	1.695**	36.72**	114.833**	64.18**
Error	22	77.756	255.578	276.02	226.59

* **:** Significant at 0.05 level of probability
** **:** Significant at 0.01 level of probability

Appendix VII: Analysis of variance of the data on leaf breadth at different days after transplanting (DAT) of cauliflower as influenced by different concentration of gibberellic acid (GA_3) and levels of potassium (K)

Source of variation	Degree of freedom	Mean square			
		Leaf breadth (cm) at different days after transplanting			
		30 DAT	40DAT	50 DAT	At harvest
Replication	2	8.7672	36.487	22.727	1.995
Gibberellic acid (A)	3	16.1222**	26.651**	37.322**	35.334**
Potassium (B)	2	7.8706**	18.717**	22.622**	69.232**
Interaction (AxB)	6	8.2028**	5.854**	17.009**	8.455**
Error	22	40.8128	38.566	30.22	29.212

* **:** Significant at 0.05 level of probability
** **:** Significant at 0.01 level of probability

Appendix VIII: Analysis of variance of the data on yield contributing characters of cauliflower as influenced by different concentration of gibberellic acid (GA_3) and levels of potassium (K)

Source of variation	Degree of freedom	Mean square			
		Days from transplanting to curd initiation	Days from transplanting to 50% curd initiation	Stem Diameter	Stem length
Replication	2	38.887	91.902	0.30722	7.1572
Gibberellic acid (A)	3	362.512**	453.744**	0.15556**	16.4556**
Potassium (B)	2	59.765*	55.792**	0.23722**	22.6606**
Interaction (AxB)	6	28.466**	43.304**	0.02944**	9.1728**
Error	22	276.02	231.178	0.48611	42.1428

* **:** Significant at 0.05 level of probability
** **:** Significant at 0.01 level of probability

Appendix IX: Analysis of variance of the data on yield contributing characters of cauliflower as influenced by different concentration of gibberellic acid (GA_3) and levels of potassium (K)

Source of variation	Degree of freedom	Mean square			
		Curd Weight with leaves (kg)	Marketable Yield (kg/plant)	Pure Curd Weight	Marketable Yield (t/ha)
Replication	2	0.03977	0.01762	0.01654	11.01
Gibberellic acid (A)	3	0.28137**	0.52708**	0.529**	329.422**
Potassium (B)	2	0.47027**	0.10955**	0.10889**	68.469**
Interaction (AxB)	6	0.15125**	0.01118**	0.00333**	6.99**
Error	22	0.02073	0.15265	0.14639	95.406

* **:** Significant at 0.05 level of probability
** **:** Significant at 0.01 level of probability

Appendix X: Analysis of variance of the data on yield contributing characters of cauliflower as influenced by different concentration of gibberellic acid (GA_3) and levels of potassium (K)

Source of variation	Degree of freedom	Mean square		
		Curd Diameter	Curd Height	Dry matter content of curd
Replication	2	17.976	3.6017	3.2706
Gibberellic acid (A)	3	122.516**	32.2822**	16.6519**
Potassium (B)	2	43.524**	26.8017**	16.1206**
Interaction (AxB)	6	11.956**	17.5094**	2.0306**
Error	22	33.791	12.905	24.4894

* **:** Significant at 0.05 level of probability
** **:** Significant at 0.01 level of probability

Appendix XI: Effect of gibberellic acid (GA_3) and of potassium (K) on number of leaves per plant at different days after transplanting (DAT) of cauliflower

Treatment	Number of leaves per plant			
	30 DAT	40 DAT	50 DAT	Harvest
Gibberellic acid (GA_3)				
G_0	10.81 c	14.47 b	16.82 c	19.69 c
G_1	14.17 a	15.88 a	20.86 a	24.01 a
G_2	11.98 b	15.47 ab	19.41 b	22.51 b
G_3	11.57 bc	14.78 b	18.69 b	22.16 b
$LSD_{(0.05)}$	**1.0315**	**1.0315**	**1.4386**	**1.1135**
Potassium (K)				
K_0	11.02 b	14.32 b	17.68 b	20.66 b
K_1	12.26 a	15.00 b	19.23 a	22.44 a
K_2	13.12 a	16.13 a	19.93 a	23.18 a
$LSD_{(0.05)}$	**0.8933**	**0.8933**	**1.2459**	**.9644**
CV (%)	**8.70**	**6.97**	**7.77**	**5.16**

DAT: Days after transplanting
LSD: Least significant difference
In a column, means with similar letter (s) are not significantly different and those having dissimilar letter (s) are significantly different by LSD at 5% level of significance.
Gibbrellic acid (GA_3): G_0 : 0 ppm, G_1 : 95 ppm, G_2 : 115 ppm, G_3 : 135 ppm
Potassium (K): K_0: 0 kg/ha (Control), K_1 : 75 kg/ha, K_2 : 100 kg/ha

Appendix XII: Effect of gibberellic acid (GA_3) and of potassium (K) on leaf length at different days after transplanting (DAT) of cauliflower

Treatment	Leaf Length (cm)			
	30 DAT	40 DAT	50 DAT	Harvest
Gibberellic acid (GA_3)				
G_0	20.58b	31.86c	42.27b	47.41c
G_1	23.18a	38.33a	48.81a	61.44a
G_2	21.71ab	35.76ab	48.07a	57.71b
G_3	21.82ab	33.86bc	46.32a	56.13b
$LSD_{(0.05)}$	**1.8379**	**3.3322**	**3.4629**	**3.1375**
Potassium (K)				
K_0	21.25a	32.53b	42.99b	53.23b
K_1	21.63a	35.62a	47.09a	56.44a
K_2	22.59a	36.70a	49.02a	57.35a
$LSD_{(0.05)}$	**1.5917**	**2.8857**	**2.9989**	**2.7172**
CV (%)	**8.62**	**9.75**	**7.64**	**5.76**

DAT: Days after transplanting
LSD: Least significant difference
In a column, means with similar letter (s) are not significantly different and those having dissimilar letter (s) are significantly different by LSD at 5% level of significance.
Gibbrellic acid (GA_3): G_0 : 0 ppm, G_1 : 95 ppm, G_2 : 115 ppm, G_3 : 135 ppm
Potassium (K): K_0: 0 kg/ha (Control), K_1 : 75 kg/ha, K_2 : 100 kg/ha

Appendix XIII: Effect of gibberellic acid (GA_3) and of potassium (K) on leaf breadth at different days after transplanting (DAT) of cauliflower

Treatment	Leaf breadth (cm)			
	30 DAT	40 DAT	50 DAT	Harvest
Gibberellic acid (GA_3)				
G_0	9.09b	12.80c	14.84b	16.29c
G_1	10.84a	14.99a	17.60a	18.96a
G_2	10.54a	14.63ab	16.92a	18.30ab
G_3	9.97ab	13.62bc	16.63a	17.56b
$LSD_{(0.05)}$	**1.3316**	**1.2944**	**1.1458**	**1.1265**
Potassium (K)				
K_0	9.71a	13.23b	15.41b	16.13c
K_1	9.86a	13.84b	16.83a	17.67b
K_2	10.77a	14.97a	17.27a	19.53a
$LSD_{(0.05)}$	**1.1532**	**1.1210**	**0.9923**	**0.9756**
CV (%)	**13.47**	**9.45**	**7.10**	**6.48**

DAT: Days after transplanting
LSD: Least significant difference
In a column, means with similar letter (s) are not significantly different and those having dissimilar letter (s) are significantly different by LSD at 5% level of significance.
Gibbrellic acid (GA_3): G_0 : 0 ppm, G_1 : 95 ppm, G_2 : 115 ppm, G_3 : 135 ppm
Potassium (K): K_0: 0 kg/ha (Control), K_1 : 75 kg/ha, K_2 : 100 kg/ha

Appendix XIV: Effect of gibberellic acid (GA_3) and of potassium (K) on pure curd yield and marketable yield (t/ha) of cauliflower

Treatment	Pure Curd Weight (kg/plant)	Marketable Yield (t/ha)
Gibberellic acid (GA_3)		
G_0	0.76c	26.58c
G_1	1.07a	34.42a
G_2	0.93b	30.67b
G_3	0.80c	27.75c
$LSD_{(0.05)}$	**0.0797**	**2.0359**
Potassium (K)		
K_0	0.82b	28.13b
K_1	0.90a	29.94a
K_2	0.95a	31.50a
$LSD_{(0.05)}$	**0.0691**	**1.7631**
CV (%)	**9.18**	**6.98**

DAT: Days after transplanting
LSD: Least significant difference
In a column, means with similar letter (s) are not significantly different and those having dissimilar letter (s) are significantly different by LSD at 5% level of significance.
Gibbrellic acid (GA_3): G_0 : 0 ppm, G_1 : 95 ppm, G_2 : 115 ppm, G_3 : 135 ppm
Potassium (K): K_0: 0 kg/ha (Control), K_1 : 75 kg/ha, K_2 : 100 kg/ha

Appendix XV: Combined effect of gibberellic acid (GA_3) and of potassium (K) on pure curd yield (kg/plant) and marketable yield (t/ha) of cauliflower

Treatment	Pure Curd Weight (kg/plant)	Marketable Yield (t/ha)
G_0K_0	0.69 f	25.25 e
G_0K_1	0.78 def	26.42 de
G_0K_2	0.82 cdef	28.08 cde
G_1K_0	1.02 ab	33.17 ab
G_1K_1	1.08 a	34.50 a
G_1K_2	1.11 a	35.58 a
G_2K_0	0.84 cde	28.58 cde
G_2K_1	0.93 bc	30.33 bc
G_2K_2	1.00 ab	33.08 ab
G_3K_0	0.72 ef	25.50 e
G_3K_1	0.81 cdef	28.50 cde
G_3K_2	0.86 cd	29.25 cd
$LSD_{(0.05)}$	**0.1381**	**3.5263**
CV(%)	**9.18**	**6.98**

DAT: Days after transplanting
LSD: Least significant difference
In a column, means with similar letter (s) are not significantly different and those having dissimilar letter (s) are significantly different by LSD at 5% level of significance.
Gibbrellic acid (GA_3): G_0 : 0 ppm, G_1 : 95 ppm, G_2 : 115 ppm, G_3 : 135 ppm
Potassium (K): K_0: 0 kg/ha (Control), K_1 : 75 kg/ha, K_2 : 100 kg/ha

Appendix XVI: Per hectare production cost of cauliflower

A. Input cost

Treatment combination	Labour cost	Ploughing cost	Seed cost	Cost of growth regula Tors	Irrigation	Manure and fertilizers				Insecticide /Pesticide	Sub Total (A)
						Cow dung	Urea	TSP	MP		
G_0K_0	60000	8000	5000	0	8000	20000	3840	4500	0	8000	117340
G_0K_1	60000	8000	5000	0	8000	20000	3840	4500	750	8000	118090
G_0K_2	60000	8000	5000	0	8000	20000	3840	4500	1000	8000	118340
G_1K_0	60000	8000	5000	4000	8000	20000	3840	4500	0	8000	121340
G_1K_1	60000	8000	5000	4000	8000	20000	3840	4500	750	8000	122090
G_1K_2	60000	8000	5000	4000	8000	20000	3840	4500	1000	8000	122340
G_2K_0	60000	8000	5000	6000	8000	20000	3840	4500	0	8000	123340
G_2K_1	60000	8000	5000	6000	8000	20000	3840	4500	750	8000	124090
G_2K_2	60000	8000	5000	6000	8000	20000	3840	4500	1000	8000	124340
G_3K_0	60000	8000	5000	8000	8000	20000	3840	4500	0	8000	125340
G_3K_1	60000	8000	5000	8000	8000	20000	3840	4500	750	8000	126090
G_3K_2	60000	8000	5000	8000	8000	20000	3840	4500	1000	8000	126340

Gibbrellic acid (GA_3):- G_0 : 0 ppm GA_3, G_1 : 95 ppm GA_3, G_2 : 115 ppm GA_3, G_3 : 135 ppm GA_3
Potassium:- K_0: 0 kg K_2O/ha (Control), K_1 : 75 kg K_2O/ha, K_2 : 100 kg K_2O/ha

Appendix XVI: (cont'd)

B. Overhead cost

Treatment combination	Cost of lease of land for 6 months (14% of value of land tk. 1200000/year)	Miscellaneous cost (Tk 5% of the input cost)	Interest on running capital for 6 months (Tk 14% of cost/year)	Sub total (Tk)	Total cost of production (Tk/ha)[Input cost (A)+overhead cost (B)]
G_0K_0	84000	5867	12432	102299	219639
G_0K_1	84000	5904	12479	102383	220473
G_0K_2	84000	5917	12495	102412	220752
G_1K_0	84000	6067	12684	102751	224091
G_1K_1	84000	6104	12731	102835	224925
G_1K_2	84000	6117	12747	102864	225204
G_2K_0	84000	6167	12810	102977	226317
G_2K_1	84000	6204	12857	103061	227151
G_2K_2	84000	6217	12873	103090	227430
G_3K_0	84000	6267	12936	103203	228543
G_3K_1	84000	6304	12983	103287	229377
G_3K_2	84000	6317	12999	103316	229656

Gibbrellic acid (GA_3):- G_0 : 0 ppm GA_3, G_1 : 95 ppm GA_3, G_2 : 115 ppm GA_3, G_3 : 135 ppm GA_3

Potassium:- K_0: 0 kg K_2O/ha (Control), K_1 : 75 kg K_2O/ha, K_2 : 100 kg K_2O/ha