GROWTH AND YIELD OF CAULIFLOWR AS INFLUENCED BY MULCHING AND GIBBRELLIC ACID (GA_3)

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CERTIFICATE

This is to certify that the thesis entitled ***"GROWTH AND YIELD OF CAULIFLOWER AS INFLUENCED BY MULCHING AND GIBBRELLIC ACID (GA_3)"*** *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 bona fide research work carried out by* ***ZENITH AFRIN,*** *Registration No.* ***11-04305*** *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.

Date: June, 2018
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"Read in the name of your Lord who created"

DEDICATED TO

My Beloved Parents

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ABSTRACT

A field experiment was conducted at the Horticulture farm, Sher-e-Bangla Agricultural University, Dhaka during October 2017 to February 2018 with different mulch materials and gibbrellic acid to investigate the growth, curd size and yield contributing characters of cauliflower cultivar, 'snowball'. The experiment was laid out in the Randomized Complete Block Design with three replications. There were three different types of mulch material (M_0:control, M_1:black polythene and M_2: rice straw) and four levels of GA_3 (G_0:control, G_1:50ppm, G_2:75ppm and G_3:100ppm) concentrations. Application of rice straw (M_2) resulted the highest curd yield (27.27 t/ha) whereas the lowest curd yield (22.39t/ha) was found from control treatment (M_0). In case of gibbrellic acid, 75ppm (G_2) performed highest curd yield (26.53 t/ha) where lowest curd yield (23.29t/ha) was found from control treatment (G_0). For combined effect, M_2G_2 gave the highest curd yield (28.83t/ha) and lowest curd yield (20.26t/ha) was found from M_0G_0. The highest benefit cost ratio was noted from the combination of M_2G_2 and the lowest benefit cost ratio from M_0G_0. From this experiment it can be concluded that rice straw with 75ppm GA_3 treatment combination is suitable for higher production of cauliflower.

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SOME COMMONLY USED ABBREVIATIONS

FULL WORD	ABBREVIATION
Agro-Ecological Zone	AEZ
Bangladesh Bureau of Statistics	BBS
Bangladesh Rice Research Institute	BRRI
Co-efficient of variation	Cv
Days After Transplanting	DAT
and others	*et al.*
Etcetera	Etc
Food and Agriculture Organization of the United Nation	FAO
Gibberellic Acid	GA_3
Journal	J.
Least Significance Difference	LSD
Muriate of Potash	MoP
Non significant	NS
Parts per million	ppm
Sher-e-Bangla Agricultural University	SAU
Soil Resources Development Institute	SRDI
Triple Superphosphate	TSP

CHAPTER I

INTRODUCTION

Cauliflower (*Brassica oleracea* var. botrytis L.) is an important vitamin rich cole crop belongs to the Brassicaceae. Cauliflower is thought to have been domesticated in the Mediterranean region since the greatest range of variability in the wild types of *B. oleracea* is found there. It originated in the island of Cyprus from where it moved to other areas like Syria, Turkey, Egypt, Italy, Spain and northwestern Europe. It has been in cultivation in India since last 150 years. It was introduced from England in 1822 by Dr. Jemson, In-charge of Company Bagh, Saharanpur, U.P. The imported seeds were tested in various parts of India. The growers raised the crop during May to July which corresponded with the growing period in England. It is a very popular winter vegetable and grown without branching. Cauliflower has high quality protein and stability of vitamin C after cooking. The leading cauliflower producing countries of the world are China, India, France, Italy, Spain, United States of America and United Kingdom (FAO, 2011). It covers about 4% of the total area under vegetables. Edible part of cauliflower is commonly known as “curd”. Fresh curd contain moisture 90.8%, protein 2.6g, fat 0.4g, mineral 1.0g, fiber 1.2g, carbohydrates 4.0g, energy 30kcal, calcium 33mg, phosphorus 57mg, iron 1.5mg, carotene 30mg, thiamin 0.04mg, riboflavin 0.1mg, niacin 1.0mg and 56mg per 100g of edible portion (Jood and khetrapaul, 2011). Clubroot, a fungal disease, is a common problem for cauliflower crops, and the plants are fairly susceptible to a number of foliage-eating insects, including cabbage loopers, cabbage whites, andaphids.

The quantity of vegetable consumption in Bangladesh is below than actual requirement. Only 62g is consumed per person per day against the minimum recommended quantity of 200g per day (FAO, 2016). Cauliflower covered in an area of 48725 hectares with a total production of 277500 metric tons (BBS, 2017). Average yield per hectare of cauliflower is below than its actual yield potentiality. In our country, Vegetable production is very low than the annual requirement.

To meet up the demand of vegetable, cauliflower production is very essential. Successful production of cauliflower depends on various factor of which mulching, plant growth regulators are the most important. Mulching has a positive impact on yield and yield attributes of the cauliflower (Salim *et al*. 2008).

Any practices that acts as a barrier to the evaporation of water from soil surface can be defined as mulching. There are two types of mulching practices viz, natural mulching; breaking the upper crust of soil to disconnect the capillary pore for cheking evaporation and artificial mulching; covering the soil surface with plant species, crop residues or polythene sheet.The benefit of mulching also includes regulation of soil moisture, temperature and suppressing weeds resulting in higher quality of cabbage. Moisture distribution in the uppersoil layer is more uniform compared with unmulched soil and more roots develop in the upper soil layer which usually has richer nutrients and useful microorganism. (Knavel and Mohr,1997).

The efficient use of land fron the economic point of view can be achieved by soil moisture management through mulching. Mulching may be practical in crop cultivation which can minimized cost of production. The efficiency of land use was normally 70% under Banglaadesh context, which was increased up to 85% with special arrangement (Sweeney *et al.,* 1987).

Mulching retention of soil moisture, reduction of soil erosion, maintenance of soil temperature, improves soil structure, soil fertility and soil biological regime (Patil *et al*. 2013). Mulching has miscellaneous effects on pest management, prevention of bolting and increased quality of produce as well as yield.

Growth regulators are organic compounds other than nutrients; small amount which are capable of modifying growth. Application of GA_3 stimulates morphological characters like plant height, number of leaves, head diameter, thickness of head as well as the weight of the head. Plant growth regulators modify the physiological processes within the plants, which ultimately affect the yield and quality of the crop. The application of growth regulators has been found effective in stimulating growth and ultimately yields in vegetable crops (Wang *et al*. 2008).

It is necessary to find out the effective dose of GA_3 in promoting growth and yield components of cabbage even in higher temperature that prevails in the later part of the growing season under Bangladesh condition. Nowadays plant growth regulators have been tried to improve growth and ultimately yield. Among the growth regulators GA_3

exhibited beneficial effects in cauliflower. Patil *et al*.(1987) tried various growth regulators to obtain better yield of good quality heads in cabbage and obtained encouraging results. Among the growth regulator, auxin causes enlargement of plant cell and gibbrellins stimulate cell divison, cell enlargement or both. Early head initiation and maturity may be due to the suppressive action of GA_3 on apical meristem and interference with gibberellins synthesis.

Due to the diversified use of productive land, it is necessary to increase the food production and gibbrellic acid(GA_3) may be a contributor in achieving the desire goal. The production of cabbage can be increased by using of GA_3 (Islam *et al.*, 1993). Application of GA_3 stimulates morpho-physiological, and yield and yield contributing characters of cauliflower.

Considering the above factors, the present study was undertaken to find out the effect of different mulch materials and concentrations of GA_3 for better growth and maximum yield of cauliflower. In view of the above facts, the present research work will undertaken with the following objectives-

Objectives:

1. To study the effects of mulch on growth and yield of cauliflower.
2. To find out the suitable concentration of GA_3 on growth and yield of cauliflower.
3. To study the combined effect of mulching and GA_3 on growth and yield of cauliflower.

CHAPTER II

REVIEW OF LITERATURE

A field experiment was conducted by Jadon *et al*. (2009) at the Gwalior (Madhya Pradesh) during kharif-2009 to study the effect of gibberellic acid as foliar spray of cauliflower. The result indicated that growth characters like plant height (cm), diameter of the stem (cm), spread of the plant (cm) and number of leaves per plants were increased significantly under different treatments. Yield attributing characters viz., diameter of curd (cm),weight of curd per plant (kg), weight of the head per plant (kg), length of head per plant (cm), yield (q/ha) and dry weight of curd per 100 g of fresh weight were also increased significantly with different treatments. The higher concentration of GA_3 were found more effective than their respective lower concentrations. The growth regulator GA_3 at 150ppm showed significantly higher performance over the remaining treatment in all the growth characters viz., plant height etc. Growth regulator GA_3 at 150ppm performed significantly better than the other treatments regarding the yield and yield attribute characters. Growth regulator GA_3 at 15ppm with recommend fertilizer dose of NPK gave highest additional net profit over control followed by GA_3 at 100ppm.

Dynamic soil temperature and yield of cauliflower (*Brassica oleracea* var. *botrytis*) were studied at the Agricultural Education and training center at Al- OHA-U.A.E (Ahmed *et al.*1988) using different mulching treatments evaluated under the three different; Clear polythene (PE), Black PE and KURI-COAT (Latex mulch). The differences of soil temperature under three different mulch treatment were not statistically significant; however, clear mulch treatment averaged yield 22.00 ton/ha followed by control treatment amounting 20.01 ton/ha; KURI-COAT 19.9 t/ha and black PE gave 19.7 t/ha. Lower yield by black surface PE was attributed to the roughness of mulch which decreased heat transmission to the soil and to the loss of tensile strength due to prolong exposure to the sun and high temperature. Response of cauliflower to polyethylene mulch was evaluated during September’03 to January ’04 at Regional Agricultural Research Station (RARS), Ishurdi, Pabna to find out whether black polyethylene mulch is suitable or not for cauliflower production in Bangladesh.

The treatments were polyethylene mulch (with or without) and the three varieties (Poushali, Snow crown and IPSA-1). Salim *et al*. (2008) found that there was a positive impact of mulch on yield and yield attributes of the crops. The highest marketable yield (31.32t/ha) was obtained from hybrid variety Snow crown with mulch was 35.16% higher than without mulch. Other two varieties also produced higher yield under mulched condition than the without mulch.

Attallah *et al.* (2012) carried out an work to study the effect of using gibberellic acid on earliness of curd in two cauliflower genotypes. Seeds were sown on August 6 in a nursery in 2007/2008 and 2008/2009 seasons respectively. The obtained transplants were planted on September 17 in both seasons. Plants were sprayed twice, first at 2 months after transplanting with gibberellic acid (GA_3) at 0, 50,100, 200, 400, 800 ppm concentrations, and the second time was after one month from the first spray. The results revealed that, gibberellic acid stimulate plant growth as it increase the height, number of leaves per plant and the fresh weight of whole plant. The results showed that GA_3 at 800ppm concentration was the most appropriate one for floral induction and this concentration also gave the highest total yield in both cultivars.

Job *et al*. (2018) taken 7 treatments that were T_1-Drip at 0.6 ET + Mulching, T_2-Drip at 0.6 ET +without Mulching, T_3-Drip at 0.8 ET + Mulching, T_4-Drip at 0.8 ET + without Mulching, T_5-Drip at 1.0 ET + Mulching, T_6- Drip at 1.0 ET + without Mulching, T_7- Conventional method of irrigation + without Mulching. The highest yield was observed in the treatment. Drip at 1.0ET with mulch (T_5) which was significantly superior to all other treatments. However, water productivity was highest for 0.6 ET with mulch (T_1) followed by 0.8 ET with Mulch (T_3) at 0.37 and 0.35 Kg/liter of water. Mulches have effected moderation of soil temperature across all treatments. Soil temperature was increased by an average degree in month January and February while there was a reduction on around 2 degree in March. The cultivation of cauliflower through drip irrigation with black plastic mulch (25 micron) increases the productivity and quality of produce with added benefit of water saving.

Kosterna (2014) carried out an experiment between 2010 and 2012 at the Experimental Farm in Zawady as a split-block design with three replicates. The effect of the kind of straw (rye, corn, rape, and buckwheat) and its dose (10 and 20 t/ha) applied as mulch on the yield and quality of broccoli 'Milady F1' cultivated for early harvest was investigated. The effect of straw was compared to a control plot without mulch. Weather conditions in the successive years of the study had a significant influence on the yield and quality of broccoli. The highest yields with the best parameters were obtained in 2010 and 2012, which were characterized by sufficient rainfall for broccoli. It was not found significant differences in the yield level and weight of head between particular kinds of straw, however, all kinds of straw investigated in the experiment, irrespective of dose, contributed to a significant increase in the yield and favorably influenced the biometric features of broccoli compared to that achieved from cultivation without straw. Soil mulching with corn straw was most favorable to yield and its parameters.

A field experiment was conducted by Mohanto *et al.* (2015) at the Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh during winter season of 2006-2007 to determine the effect of plant growth regulators on seed yield of carrot. Three plant growth regulators viz. NAA 100ppm, Ethrel 100ppm, GA_3 50ppm, GA_3 100ppm, GA_3 150ppm, GA_3 200ppm and untreated control were included in this study. The application of different plant growth regulators in different concentrations had significant impact on the seed yield of carrot. The highest seed yield (256.90 kg/ha) of carrot was found by GA_3 200ppm treatment. The highest seed germination percentage (93.33) and seed vigor index (3.16) were also recorded from GA3 200ppm treatment. This treatment therefore may be recommended for seed production of carrot in Shallow Red Brown Terrace soil of Madhupur tract. An experiment was conducted at the Horticulture Farm of Bangladesh Agricultural University, Mymensingh, during the period from October 2014 to March 2015 to study the effects of planting date and growth hormone on the growth and yield of cauliflower. The experiment consisted of two factors; Factor A: Three planting dates, such as P_1: Planting on 1 November; P_2: Planting on 15 November and P_3: Planting on 1 December; Factor B: Four levels of Growth hormone, such as H0: No Hormone (control); H1: 10 ppm IAA (Indole-3 Acetic Acid); H2: 70 ppm GA_3 (Gibberellic Acid) and H3: 10 ppm IAA + 70 ppm GA_3.

The experiment was laid out following Randomized Complete Block Design (RCBD) with three replications. Rahman *et al*. (2016) found that, In case of planting date, the highest plant height (63.26 cm), number of leaves per plant (24.13), leaf length (59.26 cm), leaf breadth (19.31 cm) at harvest, curd diameter (22.25 cm), marketable yield per hectare (28.11 t ha^{-1}) were recorded from P2 and the lowest of those parameters were recorded from P3. In case of growth hormone the highest plant height (63.10 cm), number of leaves per plant (23.66), leaf length (59.05 cm), leaf breadth (18.98 cm) at harvest, curd diameter (22.39 cm), marketable yield per hectare (29.88 t/ha) were recorded from H3 and the lowest of those parameters were recorded from H0. Combination of planting date and growth hormone the highest plant height (65.96 cm), number of leaves per plant (26.42), leaf length (63.64 cm), leaf breadth (20.92 cm) at harvest, curd diameter (25.75 cm), marketable yield per hectare (31.03 t/ ha) were recorded from planting on 15 November and 10 ppm IAA with 70ppm GA_3 (P_2H_3) and the lowest parameters (21.75 t ha^{-1}) were recorded from planting on 1 December and no hormone (P_3H_0). It is apparent from the above results that the combination of planting on15 November and 10ppm IAA with 70ppm GA_3 (P_2H_3) was more productive from the other combinations.

A field experiment was carried out by Singh *et al.* (2011) during the winter season of 2009 to 2010 on sprouting broccoli cultivar "Palam samridhi" at Horticultural Research Centre and Department of Horticulture, H.N.B Garhwal University, Srinagar (Garhwal) Uttarakhand, India. 4 weeks old seedlings were treated before transplanting by dipping their roots for 24 h in different concentration of GA_3 (gibberellic acid), kinetin and their combinations solutions. The GA3, kinetin and their combination significantly influenced the growth performance, yield and quality characters of sprouting broccoli. GA_3 30 mg/L + kinetin 30 mg/ L treatment gave maximum growth and yield of sprouting broccoli whereas, highest vitamin A content found with 40 mg/L GA_3 and vitamin C was found maximum in GA_3 20 mg/L + kinetin 20 mg/Ldipping. The effect of ancymidol, chlormequat, daminozide, ethephon, gibberellin 3 (GA3) and a mixture of gibberellins 4 and 7 (GA4+7) on curd diameter of cauliflower was tested in an experiment conducted by Booij (1988). GA4+7 increased curd diameter as a consequence of earlier curd initiation. The effect was directly related to the concentration (10–120 mg l^{-1}) of GA4+7 and plant age at the time of application.

The effect of GA4+7 was more pronounced when curd initiation of the untreated cauliflowers was delayed by high temperatures. Multiple applications of GA4+7 were more effective than a single application. The prospects of using GA4+7 to control the growing period of cauliflower and the role of GA4+7 in harvest planning are discussed.

According to Meena *et al*. (2018), the experiment consisting 15 treatments combination with two factors i.e. bio fertilizers with three levels (control, PSB and mycorrhiza) and growth regulators with five levels (control, NAA 50ppm, NAA 100ppm, GA3 50ppm and GA3 100ppm) in cauliflower. Individual application of bio-fertilizer treatment B2 (mycorrhiza) recorded maximum plant height (63.02 cm), numbers of leaves per plant (22.83), length of stem (8.96 cm), minimum days taken to 50 per cent curd initiation (33.20), days taken to 50 per cent marketable curd size (59.35) and maximum chlorophyll content in leaves at 45 DAT (0.45 mg g^{-1}). Similarly, the individual application growth regulator treatment G3 (GA3 50 ppm) found maximum plant height (64.58 cm), number of leaves per plant (24.05), length of stem (9.39 cm), minimum days taken to 50 per cent curd initiation (32.48), days taken to 50 per cent marketable curd size (58.32) and maximum chlorophyll content in leaves at 45 DAT (0.45 mg g^{-1}) compared to control. Further, the interaction effect due to application of bio-fertilizer and growth regulator had significant increased growth and yield over the control. The maximum plant height (65.91 cm), number of leaves per plant (24.45), stem length (9.78 cm), minimum days taken to 50 per cent curd initiation (31.57), days taken to 50 per cent marketable curd size (55.85) and maximum chlorophyll content in leaves at 45 DAT (0.48 mg g^{-1}) with application treatment B2G3 (mycorrhiza + GA3 50 ppm) compared to control. Teame *et al.* (2017) conducted an experiment and the aim of this research was to study the effect of organic mulches on sesame productivity and in situ moisture conservation. This experiment was carried out in Humera Agricultural Research Center, Western Tigray, during 2015 growing season. The experimental design was Randomized Complete Block Design with three replications. There were four types of organic mulches; rice straw, sorghum straw, sesame straw, and Sudan grass were compared with control. The organic mulching rate of application was 10 ton /ha and this was applied evenly to the soil immediately after germination. Soil water content, phonological characteristics yield, and yield components of sesame were collected.

The analyzed results indicated that organic mulching had significant effect on soil moisture content at 0–0.2 m, 0.21–0.4 m, and 0.41–0.6 m in every two-week interval after sowing and yield of sesame.

To investigate the best type of soil mulch in saving soil temperature and reducing soil borne diseases to avoid the fungicides used, four types of mulches and its impact on these targets as well as tomato growth and productivity (super strain B) were studied by Moursy *et al*. (2015) during 2013/2014 and 2014/2015 seasons at the Central Laboratory for Agricultural Climate (CLAC), Giza, Egypt. Two thickness of organic mulch (rice straw, 3 and 6 cm) and two colors of polyethylene mulch (transparent and black) were used compared with non-mulched soil as control. The obtained results indicated that, soil temperature increased by all mulch types tested (organic and polyethylene) compared to control treatment. Transparent mulch, however, recorded the highest soil temperature, followed by the black one. Moreover, soil temperature in the two thicknesses of organic mulch was relatively similar and less than the other treatments. On the other hand, transparent mulch followed by 3 cm rice straw mulch recorded the highest significant values in vegetative growth parameters. However, transparent mulch followed by 6 cm rice straw mulch reflected significantly the highest early and total yield followed by the 3 cm rice straw mulch and black polyethylene mulch. In a review Bhardwaj (2013) said that, mulching is an agricultural and horticultural technique in which the use of organic is involved.This technique is very useful in protecting the roots of the plants from heat, cold. Mulch is used to cover soil surface around the plants to create congenial condition for the growth. This may include temperature moderation, reduce salinity and weed control. It exerts decisive effects on earliness, yield and quality of the crop. Mulching is also applicable to most field crops. However, it is preferred in fruit orchard, flower and vegetable production, nurseries and forest where frequent cultivation is not required for raising the crops. Black plastic mulch is most commonly used in agriculture. Clear plastic mulch is used in some areas due to its increased soil warming characteristics. Research has shown that white or aluminum reflective mulch also repels aphids which spread some virus diseases in vine crops such as squash. So, mulching can be effective change in increasing horticultural crop production in water scarcityregions. An experiment was conducted at Meghalaya, during 2006-08 to study the effect of rice straw mulching on growth, yield attributes and yield of different rapeseed (*Brassica campestris*) varieties, namely ‘M 27’, ‘TS 38’ and ‘Sikkim Sarson’. According to Sarangi *et al*. (2010), the plant height of

rapeseed increased by 7.2% at harvest due to rice straw mulching @ 5.0 tonnes/ha over the non-mulching and it was highest (96.88 cm) in 'TS 38

Lower values (–2.9°C) of canopy air temperature difference were recorded in the mulch treatment than under control (–2.3°C). Mulching resulted in storage of 2.0% more soil moisture in the root zone of the crop over the un-mulched control, indicating better microclimate for crop growth and development. Leaf area index was higher in 'TS 38' and in mulching treatment. Number of siliquae/plant (24.6%), seeds/siliqua (17.6%) and seed yield (35.4%) increased due to mulching over the non-mulching. The varieties differed significantly with respect to 100-seed weight and it was highest (0.37 g) in 'TS 38'. Highest seed yield was obtained in 'TS 38' (1.51 tonnes/ha), followed by 'M 27' (1.46 tonnes/ha) and significantly superior over the 'Sikkim Sarson' (0.97 tonnes/ha).

Organic mulches, like peel and rice-straw, besides other materials affect the UV and temperature, which cause a reduction in the aphid arrival. The aim was to evaluate the effect of covering the soil with straw on the populations of the green peach aphid, *Myzuspersicae*on the kale, *Brassica oleracea* var. acephala plants. The first experiment conducted by Silva-Filho *et al*. (2014), evaluated the direct effect of the rice-straw mulch and the second its indirect effect on aphid immigration, testing the plant characteristics that could lead to the landing preference of this insect. The third experiment evaluated the direct effect of the mulch on the aphid population. The temperature increased in the mulched plots to a maximum of 21-36°C and to 18-32°C in the plots with or without soil covering, respectively. Plant growth reduced the numbers of the

winged aphids landing before and after they were moved to the bare soil plots. The nutrient content was similar in plants in both the mulched and no mulched plots. The population growth of *M. persicae* was higher in the control than in the mulched plots. This was partially due to temperatures close to 30°C in these plots and changes in the plant physiology. The soil mulching with rice-straw decreased the *M. persicae* landing, increased the plot temperatures and improved the vegetative growth of the kale plants.

Ahmed *et al*. (2015) conducted a field experiment during two successive early summer seasons of 2013and 2014 at El-Dokki Experimental Farm, Central Laboratory for Agricultural Climate, to study the effect of different irrigation requirements on plant growth and yield of tomato (*Lycopersicon esculentum*, F_1hybrid) under the white net house. The treatments were four applied irrigation levels 0.60, 0.80, 1.00 and 1.20 of ETo for tomato cultivated in rice straw as well as 1.00 of ETo for tomato cultivated in the clay soil

(control); all irrigation treatments were applied by using drip irrigation system. Data revealed that increasing water level up to 1.00 ETo enhanced plant growth and yield followed by 1.20 ETo for tomato which cultivated in rice straw bales; control treatment came in the third option. Using 0.60 ETo increased water use efficiency compared to other irrigation treatments in this study. The experiment also revealed that, using rice straw as cultivation media for producing tomato can be useful for reuse the agriculture wastes and improve water use efficiency.

Rahman *et al*. (2004) conducted an experiment with garlic to study the effects of planting date and gibberellic acid (GA3) on the growth and yield of a local cultivar of garlic were investigated during the growing period from November 2001 to April, 2002. The experiment was consisted of four planting dates and different concentrations of GA3 (0, 100 and 200 ppm). Early planting favorably influenced plant height, number of leaves per plant, dry weights of leaves, bulbs and roots,total dry matter (TDM), leaf area index (LAI), crop growth rate (CGR), bulb diameter, individual bulb weight as well as yield. With the delay in planting time starting from November 07, the yield was chronologically reduced in later plantings. The highest bulb yield (2.67 t ha-1) was recorded from November 07 planting and the minimum (0.92 t ha-1) from December 22. There was deleterious effect of GA3 concentrations used in this experiment. Control plants produced higher yield than the plants treated with different concentrations of GA3. The interaction effect of planting dates and GA3 concentrations indicated that early plantings grown without GA3 showed better performance than the late plantings grown with or without GA3.

The effects of intercropping and mulching on growth and yield of three tomato varieties were evaluated in four field trials in 1982 and 1983. Fruit yields of the improved varieties were significantly reduced by intercropping with okra but the yield of a local variety was unaffected. Though the yield of okra when grown with tomato varieties was less than that of a sole crop, the combined yield of the two crops in mixtures was more than the means of the species in monoculture. Relative Yield Totals (RYT) increased to maxima of about 1.42 and 1.39 when the local variety was grown with okra in 1982 and 1983 trials, respectively. Mulching and staking significantly increased vegetative growth, yield and yield components of the tomato plants. Mulched plants grew taller and had more branches and a greater number and weight of fruits than staked plants. Improved varieties responded better to mulching and staking than the local variety. Olaantan (1985) mentioned that growing improved varieties of tomato in sole stands with proper mulching and staking is

therefore beneficial. The experiment was conducted during rabi season 2012-13 at the Horticultural Research Farm of the Department of Applied Plant Science (Horticulture), Babasaheb Bhimrao Ambedkar University-India, to study the response of cabbage cv. Pride of india. The experiment was laid out in Randomized block design with three replications and seven treatments, the treatments comprised of three levels of each PGRs namely GA3 (30, 60, 90 ppm) and NAA (40, 80, 120 ppm) along with control. Foliar spray of GA3 and NAA was given at 30 and 45 DAT of cabbage. Chaurasiy *et al*. (2014) noticed that GA3 60ppm significantly increased the plant height(33.26cm), number of leaves(21.48), plant spread (55.59 cm), stem diameter (3.05 cm), plant weight(2.44 kg), head weight (1.73 kg), head diameter (18.88 cm) as well as head yield (51.26 t/ha) than the other treatments and control. Therefore it may be concluded that foliar application of GA_3 60 ppm or NAA 80 ppm can be recommended to cabbage growers for obtaining better growth and yield of cabbage.

Roy and Nasiruddin (2011) conducted a research work to study the effect of GA_3 on growth and yield of cabbage. Single factor experiment consisted of four concentrations of GA3, viz., 0, 25, 50 and 75 ppm. Significantly the minimum number of days to head formation (43.54 days) and maturity (69.95 days) was recorded with 50ppm GA_3 and 50ppm GA3 gave the highest diameter (23.81 cm) of cabbage head while the lowest diameter (17.89 cm) of cabbage head was found in control (0 ppm GA_3) treatment. The application of different concentrations of GA3 as influenced independently on the growth and yield of cabbage. Significantly the highest yield (45.22 kg/plot and 104.66 t/ha) was found from 50 ppm GA_3.

The effect of different mulching materials such as transparent plastic sheet, rice straw and black plastic sheet was investigated on growth and flowering of Freesia cv. Aurora. There were four treatments, i.e. rice straw, white plastic sheet (transparent PS), black plastic sheets (black PS), and control (no mulching) and each treatment was replicated thrice. The results showed that time to germination was decreased and germination percentage was significantly improved by black mulch as compared to control in freesia plants. Straw mulch produced maximum plant height; earlier flower emergence, highest number of flower spikes per plant, floret per spike and flowers per plant. Maximum flower diameter was also observed in black polythene mulch. Younis *et al*. (2012) concluded that black plastic mulch triggers plant growth and development (vegetative growth) while straw mulch encourages flower production both qualitatively and quantitatively in freesia plants.

A field experiment was conducted by Karim *et al*. (2011) at the Horticulture Farm of the Bangladesh Agricultural University, Mymensingh to evaluate the effects of NPKS and mulching on growth and yield of garlic. The experiment consisted of four levels of NPKS and two levels of mulching viz. control and rice straw. Application of NPKS and mulching had significant effects on growth and yield components of garlic. Application of 140:50:150:30 kg NPKS/ha produced the highest bulb yield (10.73 t/ha) and the lowest bulb yield (8.31 t/ha) was recorded from control treatment. Rice straw mulch produced higher bulb yield (11.12 t/ha) than that (8.72 t/ha) of the control treatment. Among the treatment combinations, the application of NPKS @ 140:50:150:30 kg/ha with rice straw mulch gave the highest yield (12.18 t/ha) of garlic followed by 160:60:170:40 kg NPKS/ha+rice straw (12.04 t/ha) and 120:40:130:20 kg NPKS/ha + rice straw (11.51 t/ha), while the lowest yield (7.88 t/ha) was obtained from control treatment.

A field experiment was conducted at the Spices Research Center, BARI, Bogra, Bangladesh during 2009-10 to determine the impact of irrigation and suitability of mulch materials on the growth and yield of ginger. The experiment was laid out in the randomized complete block design (RCBD) with three replications. The treatments comprising of two factors viz., two irrigation (I1: irrigation in dry period and I2: control i.e. no irrigation and three mulching material (M0: control (no mulch) M1: water hyacinth and M2: rice straw). According to Islam *et al*. (2015) treatment I1: (irrigation in dry period) showed early emergence, highest plant height, number of leaves/plant, number of tillers/plant with maximum weight of primary and secondary rhizome, highest dry matter % and weight of old mother rhizome t ha^{-1}. The highest yield of rhizome (21.19 t ha^{-1}) was obtained from I1: (irrigation in dry period). Among the mulch treatments, the highest rhizome yield (22.51 t ha^{-1}) was obtained from M2 (rice straw mulch). The combined effect of I1M2 (irrigation in dry period with rice straw mulch) produced the highest rhizome yield (25.07 t ha^{-1}).

A field experiment was carried out by Razzaque and Alib (2009) during rabi season of 1999-2000 to 2000-2001 with five recommended potato varieties viz. Heera, Dhera, Diamant, Chamak and Cardinal along with two types of mulching materials viz., rice straw and water hyacinth to find out suitable variety (ies) and mulching material(s) for obtaining higher yield under no tillage condition.

Heera produced highest yield under both rice straw (19.45 t/ha) and water hyacinth (23.15 t/ha) mulch. Rest of the variety performed moreor less similar in both cases. Both Heera and Dhera seemed to be suitable for cultivation in no tillage condition.

Production gaps exist in vegetable crops at the farm level in inland and coastal regions of Bangladesh and these gaps could be minimized using different innovative/new agricultural technologies and improved crop management practices. The present study was conducted by Ferdous *et al*. (2017) to compare yield, yield components of cauliflower (*Brassica oleracea* var. botrytis) and tomato (*Solanum lycopersicum* L.), and income of smallholder vegetable farmers within different innovative technology practices (with plastic mulch and indigenous microorganism (IMO) vs. without plastic mulch and IMO) at Baliakandi, Rajbari (inland region); and Dashmina, Patuakhali; and Charfession, Bhola (coastal region) in Bangladesh. Yield and gross margins of cauliflower and tomato with plastic mulch and IMO were higher compared with no plastic mulch and no IMO, regardless of location. At Baliakandi, Rajbari, cauliflower yield with plastic mulch was 42.5 t/ha, which was a 24.3% improvement over cauliflower yield obtained without plastic mulch (34.2 t ha^{-1}). At Charfession, Bhola, the highest yield of tomato (57.6 t ha^{-1}) was obtained with IMO compared with tomato yield (49.2 t ha^{-1}) without IMO, indicating a 17.1% improvement in yield. Similar trends were obtained at Dashmina, Patuakhali. The difference in gross margin between tomato with and without plastic mulch was US$ 1146/ha at Dashmina, Patuakhali. Similar trends were obtained in other locations.

The aim of the present study was to effect of mulching on yield and quality of potato.Ahmed*et al.* (2017) conducted a field experiment at Tuber Crops Research Sub Centre (TCRSC), Munshiganj during rabi season 2014-2015 to evaluate the performance of mulching on potato production. For meet up the demand six treatments viz. Rice straw, Water hyacinth, Saw dust, Black polythene and, White polythene along with Control (no mulch) were used to find the best materials that can help the farmers to improve their production practice. Now a day's mulching has become an important factor for potato production. All the mulches have significant influence on the growth, yield and yield contributing characters. The result indicated that the highest yield (34.21 t/ha) was found in the black polythene mulch that was statistically different from other mulch materials. The lowest yield (25.64) was found in control (no mulch) treatment.

Ali *et al*. (2015) conducted an experiment at Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur during the year 2011 to 2012. The purpose of the study was to evaluate the performance of different doses of GA 3 on quality seed production of onion (CV. Taherpuri). The field experiment was laid out in Randomized complete Block Design (RCBD) with three replications. Bulbs were planted on November 16, 2011. The depth of planting was 5 cm from the surface of the soil. There were four different treatments viz. G0 (0ppm), G1 (50ppm), G2 (100ppm), G3 (150ppm) was sprayed at 45 and 60 days after planting. Data were recorded from randomly selected ten plants from each plot and their averages were taken for treating as per plant. In laboratory, thousand seed weight, Germination and Electrical conductivity of the seeds were measured. GA3 influenced the seed yield and quality of onion. Higher doses were more effective and showed a linear relationship in plant growth and seed yield of onion. The highest seed yield (1576.67 $kgha^{-1}$) was obtained with application of 100 ppm GA3. GA3 application significantly varied the scape length, umble diameter, seed yield per plant, thousand seed weight, germination percentage and electrical conductivity. However, application of Gibberelic acid has a positive impact on growth and seed yield of onion.

Singh *et al*. (2016) conducted an experiment entitled “Effect of Gibberellic acid and Nitrogen on yield and marketability of cabbage (*Brassica oleracea* var capitata L.) cv. Pride of India” was conducted at Rampur Farm and (PG) Laboratory of Doon (PG) College of Agriculture Science & Technology, Selaqui, Dehradun during the Rabi season (2016) in India. The recorded data were analyzed with Factorial Randomized Complete Block Design having sixteen treatments combining two factors (four each) like N0G0, N0G1, N0G2, N0G3, N1G0, N1G1, N1G2, N1G3, N2G0, N2G1, N2G2, N2G3, N3G0, N3G1, N3G2 and N3G3 which were replicated three times. The data were recorded for pre harvest parameters like plant height, number of leaves per plant and plant canopy while post-harvest observations like fresh weight of the whole plant, fresh weight of heads, diameter of head, thickness of head and yield of head and economic of production. The significantly superior results were observed with the treatment N1G3 (8Kg Nitrogen and 20ppm GA3 respectively) while minimum with control (N0G0).

Kaur and Mal. (2018) was conducted an experiment at School of Agriculture under Department of Vegetables Science at Lovely Professional University, Jalandhar during winter season from September 2017- January 2018. The experiment was laid out in Randomized Block Design (RBD) with three replications. The three different concentrations of NAA viz. (50, 75 and 100 ppm) and three different concentrations of GA3 (50, 75 and 100 ppm) were used over control. Among all the treatments, it was concluded that GA3@ 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). From this experiment, it was concluded that 50ppm of GA3 can be recommended in cauliflower for higher yield.

Vishwakarma *et al*. (2017) laid out an experiment in RBD with three replications, at the UdaiPratap Autonomous College, Varanasi during the year 2013-14. The treatments used were i.e. nitrogen 0, 1 and 2 % NAA in 60 and 120 ppm and Gibberellic acid 0%, 50 and 100 ppm concentrations. Nitrogen at 1.0 and 2.0% improved the vegetative growth attributes of broccoli plant recorded in terms of the height of the plant, length of the root, number of outer leaves, total number of leaves per plant, fresh weight and dry weight of the plant at all the three stages (after 30, 60 and 90 days) of observation. Maximum diameter (19.35 cm), fresh weight of curd (1432.75g), yield (421 q/ha) and ascorbic acid content (24.68 mg/100g) were recorded at 2.0% nitrogen, 120 ppm (NA2) and 100 ppm GA (G2). In first order interaction, combination of nitrogen with NAA gave better response as compared to nitrogen with GA and NAA with GA combination and in two/three factor combinations, maximum values were under N2NA2, N2NA2G2 i.e. (19.88cm), fresh weight (1520.40g), yield (454.41q/ha) and ascorbic acid content (26.22mg/100g) of the curd. The application of nitrogen at 2.0%, NAA at 120 ppm and GA3 at 100 ppm are recommended for better growth, yield and quality of broccoli.

To assess the impact of foliar spray of boron, Urea and GA3 on earliness in curd production of broccoli cv. FIESTA under Ranchi condition, Verma *et al*. (2018) carried out an experiments at the Department of Horticulture, Birsa Agricultural University, Ranchi, Jharkhand during winter season of 2013-14 and 2014-15, The

experiment wasdone in Randomized Block Design having sixteen different treatments with three replications. It was recorded that various treatments have influenced the days to curd initiation, days to 50% of curd initiation, days to curd maturity. In general it was recorded that urea application @ 1.0% and 1.5% had advanced the days of initiation and maturity of the curd. Spray of GA3 at different concentrations of 25ppm, 50ppm and 75ppm had influenced the earliness of the curd positively. GA3 @ (75ppm) in combination of urea @ (0.5%) and Boron @ (2%) however enhanced the earliness maximum.

Chowdhury *et al*. (2014) conducted a study at the Horticulture Farm, Sher-e- Bangla Agricultural University, Bangladesh during April to September, 2012 to determine the suitability of selected plant growth regulators and the proper use and effectiveness of selected organic manures and also their suitable combinations for successful okra production. The experiment consisted of two factors: factor A: growth regulators as - G0: control (water), G1: GA3 (100 ppm) and G2: Miraculan (1000 ppm) and factor B: organic manures as - OM0: control (no manure), OM1: vermicompost (9 t/ha) and OM2: poultry manure (11.5 t/ha). The combined use of GA3 and poultry manure produced the tallest plants. Both the growth regulators and organic manures enhanced early flowering. In case of growth hormone, the highest yield (16.67 t/ha) was recorded from G1 followed by G2 (16.49 t/ha). The highest yield (18.03 t/ha) was found from OM2, closely followed by OM1 (17.59 t/h). Considering the treatment combinations, the highest yield was harvested from G1OM2 (19.62 t/ha), followed by G1OM1 (19.01 t/h), G2OM1 (18.42 t/h) and G2OM2 (18.30 t/h), respectively.

Gibberellic acid has been shown to promote earliness in artichokes and thus is interesting for timing harvest. However, its effectiveness is influenced by cultivar, time and concentration of treatment, climatic conditions and other factors. A study was conducted by Halter *et al*. (2005) to understand the physiological processes of plants influenced by exogenous application of GA_3 by optimising treatments. The phonological changes after spray application, the effect on earliness and yield as well as the influence on quality were studied and results will be presented. GA_3 at a concentration of 50 ppm was applied to 10 and 12 week old plants of Green Globe cultivar grown from seed.

Changes concerning colour and plant habit were visible shortly after the treatments, although the effect was continuous for the later treatment alone. Treated plants were lighter in colour and grew more upright. The specific leaf area was higher for plants undergoing treatment 2. Influence on photosynthetic activity was also observed. The harvest period of treated plants started earlier and total yield as well as yield per date of harvest was increased, although it was only significant for the earlier treatment on 10 week old plants. Thus, the phenological changes did not directly relate to the effect on earliness. Negative influence on external quality of the harvested heads was not observed. As regards the internal quality, the valuable fructanes even tended to be increased for treatment 1. In the years 2009-2011 the research on the influence of gibberelic acid (GA3) on yield and morphology of artichoke plants was conducted by Salata *et al*. (2013).

In order to establish the optimal date of spraying and development stage of plants GA3 was used in 2 different variants: spraying done once at the stage of 8 leaves, spraying done twice at the stages of 8+12 leaves, in comparison to the control (without use of GA3). Plants which were sprayed with gibberellic acid once or twice formed inflorescences up to 45 days earlier in comparison to control plants. Plants treated with GA3 were shorter, formed less leaves in rosettes, leaves had blades of smaller length and width and shoots at the base were thicker in comparison to control plants. Plants sprayed with GA3 formed less floral heads on inflorescence shoots but they characterized with higher mean weight in comparison to plants not treated with the gibberellic acid. Plants sprayed once gave higher yield of heads by 0.4 kg plant^{-1} in comparison to control plants and plants sprayed twice.

An experiment was conducted by Rahman *et al.* (2015) at the Horticulture Farm of Bangladesh Agricultural University, Mymensingh to test the impact of plant growth regulators on growth and yield of summer tomato. The experiment consisted of two tomato varieties viz. BARI Hybrid Tomato-4 and BARI Hybrid Tomato-8 and four types of plant growth regulator (PGR)viz.,(i) control (without PGR), (ii) 4-CPA (4-chlorophenoxy acetic acid), GA3 (gibberellic acid) and 4-CPA + GA3. The two-factor experiment was laid out in randomized complete block design with three replications. The results of the experiment revealed that significant variations were observed for most of the characters studied. At 75 DAT, the tallest plant (79.35 cm), number of

flowers and fruits (38.11 and 19.04, respectively) plant^{-1}, individual weight (58.44 g) and fruit yield (22.75 t ha^{-1}) were found in BARI Hybrid Tomato-8.At 75 DAT the maximum plant height (87.90 cm), number of flowers and fruits (49.04 and 21.9 respectively) plant^{-1}, individual fruit weight (61.16g), and fruit yield (27.28 tha^{-1}) were found when 4-CPA+ GA3 applied together, whereas the minimum for these characters were recorded from control plants. In case of combined effect of variety and plant growth regulator, the maximum plant height (87.90 cm), number of flowers and fruits (49.04 and 21.91, respectively) plant-1, individual fruit weight (61.16 g) and fruit yield (27.28 t ha^{-1}) were observed in BARI Hybrid Tomato-8 when treated with 4-CPA+ GA3 together, and the minimum for all these parameters were found in control plants.

High temperature stress in summer season at plastic house is a limiting factor for tomato fruit set and yield. This study was performed by Luitel*et al.* (2015) to assess the effects of gibberellic acid (GA3) and 2,4-Dichlophenoxy acetic acid (2,4-D) spray on fruit set, yield, and quality of tomato cv. 'Adoration'(EnzaZaden Co., Ltd.) under the plastic house in Hwacheon, 2011. Four concentrations (0-, 5-, 10- and 15mg·L^{-}1) of GA3, and three concentrations (0-, 5- and 10mg·L^{-1}) 2,4-D were sprayed in early flowering of tomato in the plastic house, and fruit set, yield and quality characters were observed. The results showed that spray of 10mg·L^{-1}GA3 significantly increased the fruit set by 14.2% than unsprayed. The spray of GA3 significantly increased the marketable fruit number, fruit weight, and yield. The spray of 2,4-D on blossoms significantly affected the fruit set percentage, fruit weight, marketable fruit weight and yield, and the highest fruit set observed as 62.5% in combined spray of GA3 and 2,4-D at each 5mg·L^{-1}. Fruit size and total soluble solids significantly varied with the concentrations of GA3 sprayed. The result indicates that the spray of 10mg·L−1 GA3 and 5mg·L^{-1}2,4-D can be more economic and effective to increase the fruit set, and yield in tomato under high temperature condition in plastic house.

A field experiment was conducted by Meena *et al.* (2017) at Department of Horticulture, MJRP College of Agriculture and Research Achrol, Jaipur, During Zaid Season, 2015. The eight treatment consisting of three levels of GA3 (10, 20, 30 ppm), three levels of naphthalene acetic acid (10, 20, 30 ppm), were tested in randomized block design with three replications.

Results showed that spray of naphthalene acetic acid, gibberellic acid significantly influenced the performance of growth attributes viz., plant height, fruit length, fruit diameter, number of fruits per plant, average weight of fruits per plant, yield per plot as well as per hectare. The best treatment for growth parameter and yield attributes was found at 20-ppm naphthalene acetic acid (T6) 40 days after sowing.

The present experiment was carried out by Balakrishnan and Arunprasath (2018) to assess the effect of organic manure and Plant growth regulators on morphological changes and biochemical composition of fenugreek. The experiment comprising of Control, Organic manure and three different Growth regulators such as IAA (Indole Acetic Acid), IBA (Indole Butyric Acid) and NAA (Naphthalene Acetic Acid). These three growth regulators are taken in four different combinations such as NAA+IAA, IAA+IBA, IBA+NAA and NAA+IBA+IAA. The hormones were prepared with distilled water and treated to the plants. The plants were irrigated with tap water regularly for 30 days. After 30 days the fresh plants were taken for the further analysis like morphological studies and biochemical analysis.

The results reveals that the morphological parameters such as root length, shoot length, leaf area, fresh weight and dry weight are increased in the treatment of NAA+IBA, and in biochemical analysis chlorophyll, carotenoids, total sugar, starch, protein and amino acid contents were increased in plants treated with organic manure, when compared to all others treatments.

CHAPTER III

MATERIALS AND METHODS

3.1 Experimental site

The experiment was carried out at Horticulture farm in Sher-e- Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from October, 2017 to February, 2018. The location of the site in 23°46' N latitude and 90°23' E longitude with an elevation of 8.24 meter from sea level in the Agro-Ecological Zone of Madhupur Tract (AEZ No. 28).

3.2 Climatic condition

The climate of the experimental site is subtropical, characterized by heavy rainfall for the time it lasts the months from April to September (Rabi season). The total rainfall of the experimental site was 218 mm during the period of the experiment. The average temperature was 29.45°C during Rabi season with plenty of sunshine which is suitable for cauliflower production (experimental plant).

3.3 Land preparation

The selected plot of the experiment was opened in the 2nd week of November 2017 with a power tiller, and left exposed to the sun for a week. Subsequently cross ploughing was done five times with a country plough followed by laddering to make the land suitable for transplanting the seedlings. All weeds, stubbles and residues were eliminated from the field. Finally, a good tilth was achieved. The soil was treated with insecticides (Cinocarb 3G @ 4 kg/ha) at the time of final land preparation to protect young plants from the attack of soil inhibiting insects such as cutworm and mole cricket.

3.4 Planting material

The Seed of hybrid cauliflower variety namely (snowball) were used as planting material for this experiment and it was collected from Siddique Bazar market, Dhaka.

3.5 Treatments of the experiment

The double factor experiment was conducted to study the effects of $GA_3$and mulching on growth, curd yield and quality of cauliflower. Two different factors were as follows:

Factor A: Three types of mulching

M_0 = Control

M_1 = Black polythene

M_2 = Rice straw

Factor B: Four levels of GA_3

G_0 = Control

G_1 = 50 ppm

G_2 = 75 ppm

G_3 = 100 ppm

The treatment combinations (total 12) were as follows:

M_0G_0, M_0G_1, M_0G_2, M_0G_3, M_1G_0, M_1G_1, M_1G_2, M_1G_3, M_2G_0, M_2G_1, M_2G_2, M_2G_3.

3.6 Design and layout of experiment

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications which comprised in 36 plots. An area of 190.18 m^2 was divided into three equal blocks. Each block was divided into 12 plots of 1.8m length and 1.6m breath each. In individual plot, 12 plants were allocated randomly maintaining 60cm X 40cm spacing. Thirty day old seedlings were transplanted in the main field on 10 November 2017 (Figure-1)

3.7 Raising of seedling

The seedlings were raised at the Horticultural Farm, SAU, Dhaka under special care in a 3 m × 1 m size seed bed. The soil of the seed bed was well ploughed with a spade and prepared into loose friable dried masses and to obtain good tilt to provide a favorable condition for the vigorous growth of young seedlings. Weeds, stubbles and dead roots of the previous crop were removed. The seedbed was dried in the sun to destroy the soil insects and protect the young seedlings from the attack of damping off disease. To control damping off disease, Cupravit fungicide were applied. Decomposed cowdung was applied to the prepared seedbed at the rate of 10 t/ha. Ten (10) grams of seeds were sown in seed bed on October 26, 2017. After sowing, the seeds were covered with the finished light soil. At the end of germination

shading was done by bamboo mat (chatai) over the seedbed to protect the young seedlings from scorching sunshine and heavy rainfall. Light watering, weeding was done as and when necessary to provide seedlings with ideal condition for growth. Seeds were germinated after 6-7 days of seeds sowing.

Plate 1. Photograph showing seedlings raised in the seed bed

3.8 Transplanting of seedlings and aftercare

Healthy and uniform seedlings were transplanting in the experimental plots on November 21, 2017. The seedlings were uprooting carefully from the seed bed to avoid damage to the root system. To minimize the damage to the roots of seedlings, the seed beds were watered one hour before uprooting the seedlings. Transplanting was done in the afternoon. The seedlings were watered immediately after transplanting. Seedlings were sown in the plot with maintaining distance between row to row was 60 cm and plant to plant was40 cm. As a result there are 12 seedlings were accommodated in each plot according to the design of the plot size at 1.8 m × 1.6 m. The young transplanted seedlings were shaded by banana leaf sheath during day to protect them from scorching sunshine up to 7 days until they were set in the soil. They (transplants)were kept open at night to allow them receiving dew. A number of seedlings were also planted in the border of the experimental plots for gap filling.

Plate 2. Photograph showing transplanted seedlings in the experimental plot

3.9 Mulching

Mulch materials (black polythene and rice straw) were applied immediately after seedlings transplanting.

Plate 3. Photograph showing mulching (rice straw)

Plate 4. Photograph showing mulching (Black Polythene)

3.10 Collection preparation and application of GA3

Gibberellic acid (GA_3) was collected from Hatkhola Road, Dhaka. A 1000 ppm stock solution of GA3 was prepared by dissolving 1 g of it in a small quantity of ethanol prior to dilution with distilled water in one liter of volumetric flask. The stock solution was used to prepare the required concentration for different treatment i.e., 50 ml of stock solution was diluted in 1 liter of distilled water to 19 get 50 ppm GA3 solution. Similarly, 75ppm and 100 ppm stock solutions were diluted to 1litre of distilled water to get 75 ppm and 100 ppm solution. GA3 as per treatment were applied at three times 15, 25 and 35 DAT by a mini hand sprayer.

3.11 Manuring and fertilization

Fertilizers were applied at the rate of 15 ton cowdung, 240 kg urea, 150 kg TSP, 220 kg MP per hectare. Cowdung, TSP, 50% MP were applied during final land preparation. Urea and the rest MP were applied as top dressing in three installments at 15, 30 and 45 days after transplanting.

3.12. Intercultural operation

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

3.12.1 Gap filling

The transplanted seedlings in the experimental plot were kept under careful observation. Very few seedlings were damaged after transplanting and such seedling were replaced by new seedlings from the same stock. Replacement was done with healthy seedling having a ball of earth which was also planted on the same date by the side of the unit plot. The transplants were given shading and watering for 7 days for their proper establishment.

3.12.2 Weeding

The hand weeding was done 15, 30 and 45 DAT to keep the experimental plots free from weeds.

3.12.3 Earthing up

Earthing up was done at 50 days after transplanting on both sides of rows by taking the soil from the space between the rows by a small spade

3.12 Pest and disease control

Insect infestation was a serious problem during the period of establishment of seedling in the field. In spite of Cirocarb 3G applications during final land preparation, few young plants were damaged due to attack of mole cricket and cut worm. Cut worms were controlled both mechanically and spraying Darsban 29 EC @ 3%. Some plants were infected by *Alternaria* leaf spot diseases caused by *Alternaria brassicae*. To prevent the spread of the disease Rovral @ 2g per20liter of water was sprayed in the field. The diseased leaves were also collected from the infested plant and removed from the field. Birds pest such as nightingales (common Bulbuli) were seen visiting the broccoli field very frequently. The nightingale visited the fields in the morning and afternoon. The birds found to puncture the newly initiated curd and were controlled by striking a kerosene tin of metallic container frequently during day time.

3.13 Harvesting of cauliflower

The best stage of maturity detection is by visual determination of curd size and condition. Local growers usually harvest the head upon the desired size and before the curds become discolored, loose or otherwise blemished. The head should be compact and not to be broken into segments. Over mature head which turned too long. In over matured head flower stalks elongates resulting in loose, leafy condition and possess poor market value.

3.14 Data collection

Five plants were randomly selected from the middle rows of each unit plot for avoiding border effect, except yields of curds, which was recorded plot wise. Data were collected in respect of the following parameters to assess plant growth; yield attributes and yields as affected by different treatments of this experiment. Data on plant height, number of leaves/plant, leaf length and length breadth were collected at 30, 45 DAT and at harvest. All other yield contributing characters and yield parameters were recorded during harvest and after harvest.

3.14.1 Plant height

Plant height was measured from five randomly selected plants by using meter scale in centimeter from the ground level to the tip of the longest leaf at 15 days interval starting from 30 DAT and continued up to 45 DAT and at harvest and their mean value was calculated.

3.14.2 Number of leaves per plant

Number of leaves per plant was counted from five randomly selected plants at 15 days interval starting from 30 DAT and continued upto 45 DAT and at harvest and their average was recorded.

3.14.3 Leaf length (cm)

Leaf length was measured from five randomly selected plants at 15 days interval starting from 30 DAT and continued up to 45 DAT and at harvest and their average was recorded.

3.14.4 Leaf breath (cm)

Leaf breadth was counted from five randomly selected plants at 15 days interval starting from 30 DAT and continued up to 45 DAT and at harvest and their average was recorded.

3.14.5 Canopy (cm)

Canopy was recorded at harvesting stage from the selected plants in each treatment and expressed as centimeter (cm).

3.14.6 Stem length (cm)

Stem length was taken from the ground level to base of the curd of plant during harvesting. A meter scale used to measure stem length and was expressed in centimeter (cm).

3.14.7 Stem diameter (cm)

Data regarding stem diameter were collected at harvesting stage from selected plants and expressed as centimeter (cm).

3.14.8 Dry weight of 100g root (%)

Dry weight of 100g roots were recorded after harvesting in each selected plants and calculated in percentage.

3.14.9 Dry weight of leaf (%)

Dry weight of 100g leaf was recorded after harvesting stage from five randomly selected leaves in each treatments and average were recorded.

3.14.10 Dry weight of curd (%)

Dry weight of 100g curd was calculated after harvesting from five randomly selected curds and expressed in percentage.

3.14.11 Shelf life (days)

The selected cauliflower was stored in open, perforated polythene and non-perforated polythene and self life of curd was monitored both room temperature and refrigerated condition.

3.14.12 Days from transplanting to crown initiation

Days required from transplanting to crown initiation were recorded from first crown initiation. Data were recorded as minimum days to maximum days.

3.14.13 Curd weight (g)

Curd weights were recorded with the help of a digital balance machine just after harvesting of the curd. It was expressed in gram (g).

Plate 5. Photograph showing cauliflower in marketable size

3.14.14 Curd yield plot^{-1} (kg)

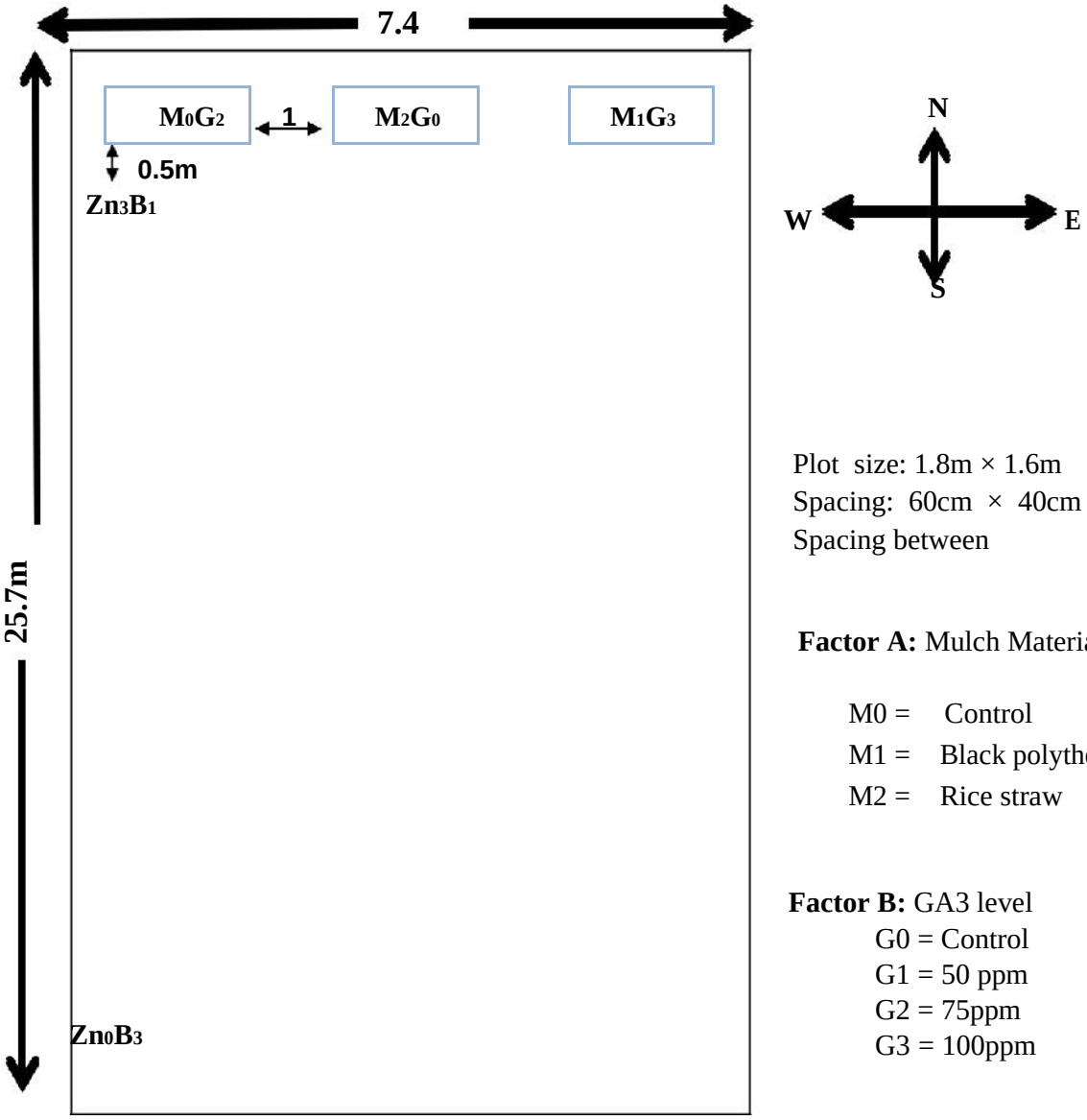
Curd weight per plot were recorded by weighing all the cauliflower curds from each unit plot separately excluding roots and outer leaves and it was expressed in kilogram (kg).

3.14.15 Curd yield ha^{-1} (ton)

Yield per hectare was calculated from per plot yield data and was expressed in ton.

3.15 Statistical analysis

The observations (data) for various growth and yield contributing characters were statistically analyzed 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 F (variance ratio) 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).



Plot size: 1.8m × 1.6m
Spacing: 60cm × 40cm
Spacing between

Factor A: Mulch Materials

M0 = Control
M1 = Black polythene
M2 = Rice straw

Factor B: GA3 level
G0 = Control
G1 = 50 ppm
G2 = 75ppm
G3 = 100ppm

Figure 1: Layout of the experimental Plot

CHAPTER IV

RESULTS AND DISCUSSION

4.1 Plant height

Significant differences were observed in case of plant height at 30, 45 DAT and at harvest (Appendix I) due to mulching. Maximum plant heights (39.8cm, 53.49 cm and 67.25 cm) was obtained from straw mulches (M_2). On the other hand minimum plant height (11.20 cm, 20.86 cm and 37.03 cm at 30, 45 DAT and at harvest respectively) was recorded from M_0 (control) treatment. The result was in accordance with Moursy *et al*. (2015) and Younis *et al*. (2012) who stated that plant height increased gradually due to straw mulching at early and later stages of the plant growth in case of tomato plant and freesia plant respectively.

Due to different levels of GA_3 application plant height also varied significantly in case of cauliflower production. During the period of plant growth, highest plant height at 30, 45 DAT and at harvest was 37.73cm, 49.66 cm and 63.41cm respectively in case G_2 (75 ppm) (Figure 5). On the other hand, plant height was recorded lowest from G_0 (control) i.e. 32.33 cm, 42.79 cm and 55.64 cm respectively (Appendix I). The results were in support to those of Chaurasiy *et al*. (2014) in term of cabbage in which plant height increased due to GA_3 application.

Plant height of cauliflower was significantly influenced by the combined effect of mulching and GA_3 application. At 30, 45 DAT and at harvest, highest plant height (42.17 cm, 58.09 cm and 71.07 cm respectively was recorded from the treatment combination of M_2G_2 i.e. straw mulching and 75 ppm GA_3 application (Appendix I). Lowest plant height (28.39 cm, 35.71 cm and 48.96 cm was recorded from M_0G_0 treatment combination (control) (Table1).

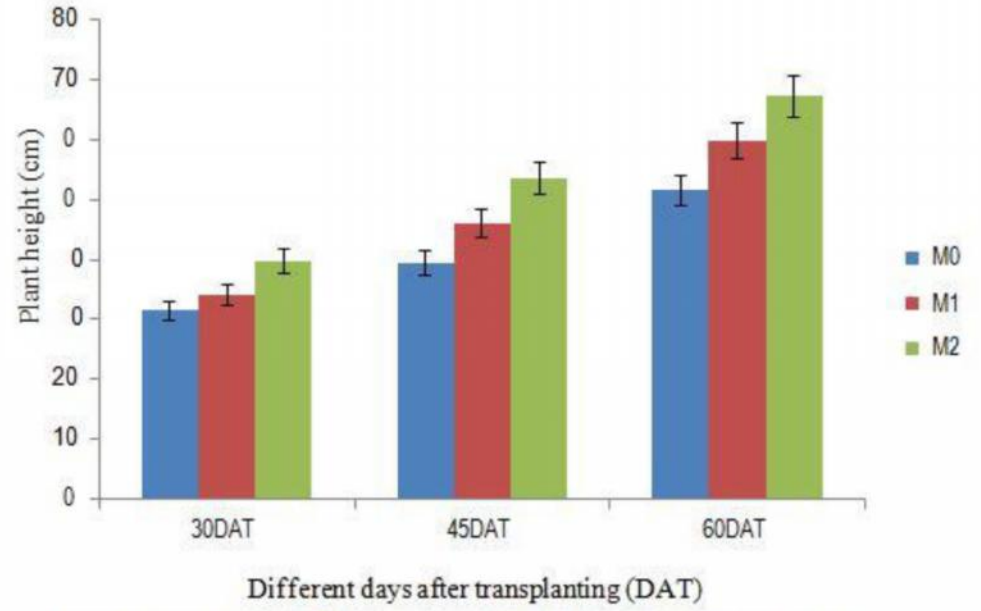


Figure2. Effect of Mulching on plant height of cauliflower

M_0: Control, M_1: Black polythene, M_2: Rice straw

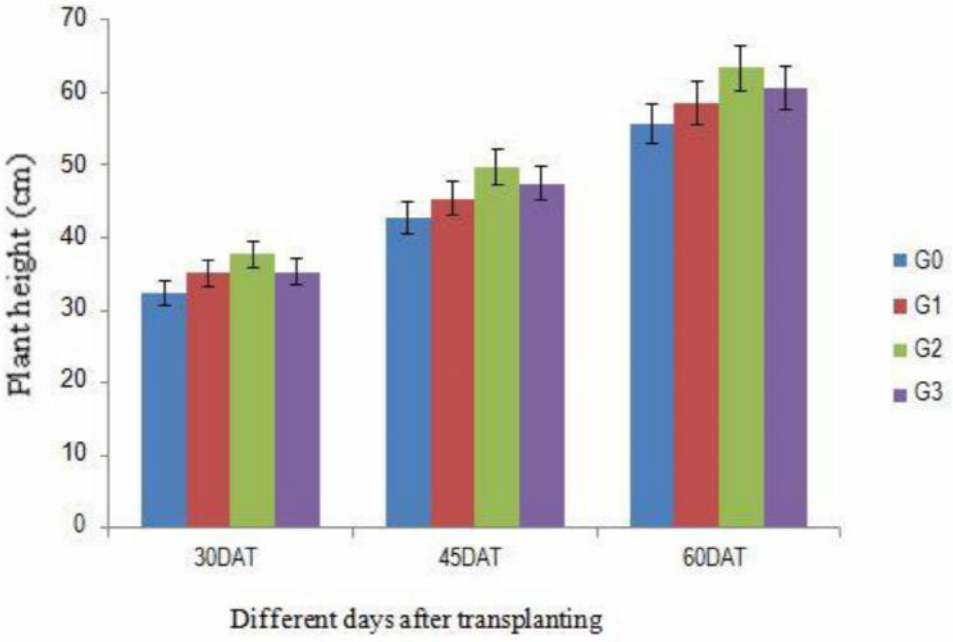


Figure3. Effect of GA_3 on plant height of cauliflower

G_0: Control, G_1: 50ppm, G_2: 75ppm, G_3: 100ppm

Table 1. Combination effect of mulching and Level of GA3 on plant height of cauliflower at different days after transplanting (DAT) and at harvest of cauliflower

Treatments	Plant height at 30 DAT	Plant height at 45 DAT	Plant height at harvest
M_0G_0	28.39 i	35.71 i	48.96 h
M_0G_1	31.23 gh	38.41 hi	51.97 g
M_0G_2	34.39 def	42.92 fg	54.46 f
M_0G_3	32.26 fgh	41.05 gh	50.95 gh
M_1G_0	30.83 hi	43.06 fg	54.99 ef
M_1G_1	33.46 efg	45.84 ef	56.96 e
M_1G_2	36.62 cd	47.98 de	64.70 cd
M_1G_3	35.14 de	47.20 de	62.48 d
M_2G_0	37.76 c	49.60 cd	62.98 d
M_2G_1	40.65 ab	52.05 bc	66.70 bc
M_2G_2	42.17 a	58.09 a	71.07a
M_2G_3	38.62 bc	54.24 b	68.25b
LSD (0.05)	2.45	3.08	2.48
CV%	4.11	3.93	2.46

M_0 :Control, M_1 : Black polythene, M_2 : Rice straw
G_0: Control, G_1 : 50 ppm, G_2 : 75 ppm, G_3 : 100 ppm

4.2 Number of leaves plant^{-1}

Different mulch materials significantly changes leaf number per plant in cauliflower. (Figure 6). Maximum number of leaves was recorded from M_2 treatment (straw mulching) i.e. 13.08 at 30 DAT followed by 21.33 and 19.42 at 45 DAT and at harvest respectively (Appendix II). Whereas, leaf number per plant were lower (7.25, 11.83 and 15.08 at 30, 45 DAT and at harvest respectively) in case of no mulching (M_0). Duraishami *et al.* (2005) also found similar results. Teame *et al*. (2017) also found similar result in case of mulching application in sesame. Leaves per plant varied significantly due different levels of GA_3 application at 30, 45 DAT and at harvest. GA_3 at 75ppm (G_2 treatment) produced the maximum number of leaves per plant i.e. 12.89, 20.89 and 24.11 respectively where as G_0 (no GA_3 application) produced minimum number of leaves per plant (6.78, 11.56 and 11.33 at 30, 45 DAT and at harvest respectively) (Figure7). Attallah *et al.* (2012) and Meena *et al*. (2018)

also found similar results in case of cauliflower due to GA_3 application (AppendixII). The number of leaves per plant was significantly influenced by the interaction effect of mulching and GA_3 application (Table 2). At 30, 45 DAT and at harvest the maximum number of leaves per plant were 15.67, 25.33 and 27.33 respectively in case of M_2G_2 treatment combination while minimum number of leaves per plant were recorded from M_0G_0 treatment combination ((5.0, 8.33 and 10.0 at 30, 45 DAT and at harvest respectively). (Appendix II).

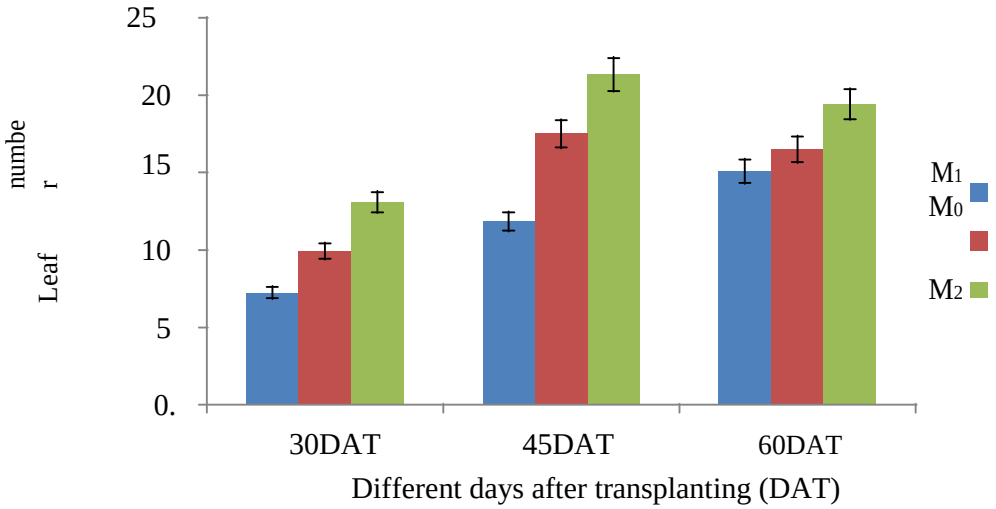


Figure 4. Effect of Mulching on leaf number of cauliflower
M_0 :Control, M_1 : Black polythene, M_2 : Rice straw

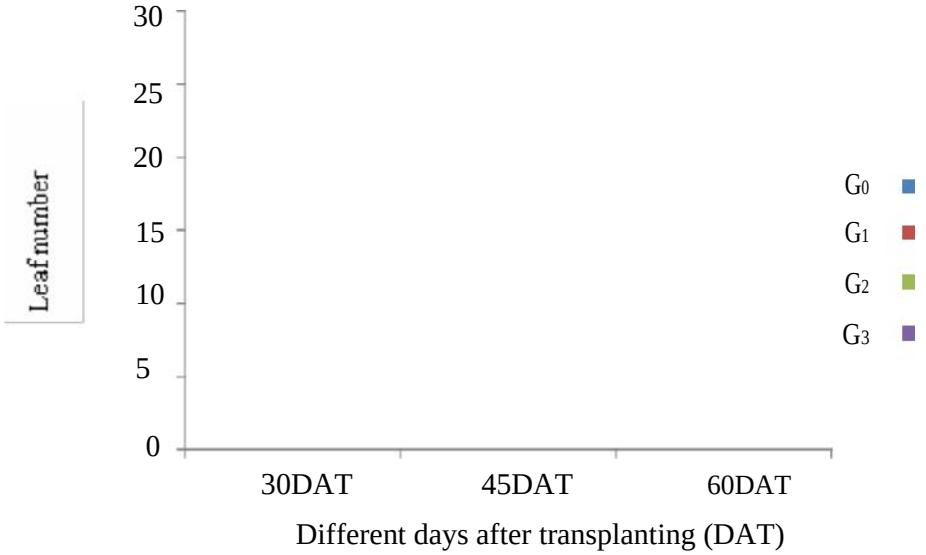


Figure 5. Effect of GA_3 on leaf number of cauliflower
G_0: Control, G_1 : 50 ppm, G_2 : 75 ppm, G_3 : 100 ppm

Table 2. Combination effect of mulching and level of GA_3 on number of leaves per plant at different days after transplanting(DAT) and at harvest of cauliflower

Treatments	Leaf number at 30 DAT	Leaf number at 45 DAT	Leaf number at 60 DAT
M_0G_0	5.00 h	8.33 j	10.00 h
M_0G_1	6.67 gh	10.33 i	13.00 efg
M_0G_2	9.33 ef	15.00 f	22.00 b
M_0G_3	8.00 fg	13.67 g	15.33 cd
M_1G_0	6.00 h	11.67 h	11.67 gh
M_1G_1	9.00 f	17.00 e	14.33 def
M_1G_2	13.67 bc	22.33 b	23.00 b
M_1G_3	11.00 de	19.00 d	17.00 c
M_2G_0	9.33 ef	14.67 fg	12.33 fg
M_2G_1	12.33 cd	21.00 c	15.00 cde
M_2G_2	15.67 a	25.33 a	27.33 a
M_2G_3	15.00 ab	24.33 a	23.00 b
LSD (0.05)	1.94	1.05	2.30
CV%	11.35	3.67	8.00

M_0 :Control, M_1 : Black polythene, M_2 : Rice straw
G_0: Control, G_1 : 50 ppm, G_2 : 75 ppm, G_3 : 100 ppm

4.3 Leaf length

A significant variation was observed in leaf length due to mulching. Maximum leaf length **(**41.33 cm**)** was recorded from the M_2 treatment (straw mulching) while minimum leaf length (23.92 cm) was found in (control) M_0 treatment (Table 3). Moursy *et al*. (2015) also recorded similar result in case of straw mulching in tomato cultivation (Appendix III).

Leaf length was significantly differed by different level of GA_3 application. However, leaf length was maximum (35.89 cm) and minimum length (29.11 cm) was recorded from the G_3 (2 kg boron ha^{-1}) and G0 (control) treatment respectively (Table 4). Attallah *et al.* (2012) also mentioned that GA_3 stimulate vegetative growth in cauliflower production (Appendix III).

The interaction effect between mulching and GA_3 on leaf length was also significant. Leaf length was highest (45 cm) recorded from M_2G_2 (straw mulching and 75ppm GA_3) treatment and the lowest value (20.67 cm) was obtained from control treatment (M_0G_0) (Table 5) (Appendix III).

4.4 Leaf breadth (cm)

Maximum leaf breadth **(**21.11 cm) was recorded from the M_2 (straw mulching) treatment while minimum leaf breadth (12.34 cm) was found in (M_0) control treatment where no mulching was applied (Table 3) (Appendix III).

Data showed that leaf breadth was significantly differs by GA_3 application and maximum leaf breadth (20.09 cm) and minimum leaf breadth (13.22 cm) was found from G_2 (75 ppm GA_3) and control (no GA_3 application) treatment respectively (Table 4). This result was in accordance with that of Rahman *et al*. (2016) (Appendix III).

Leaf breadth variation was significant due to interaction effects of mulching and GA_3 application. Highest leaf breadth was (25.04 cm) recorded from M_2G_2 (straw mulching and 75 ppm GA_3) treatment and the lowest value (10.08 cm) was obtained from treatment M_0G_0 i.e. no mulching and GA_3 application (control) (Table 5) (AppendixIII).

4.5 Stem length(cm)

Due to different types of mulching stem length of cauliflower changed significantly. Maximum **(**18.26 cm) stem length was recorded from M_2 i.e. straw mulching. On the other hand minimum stem length (7.82 cm) was found in M_0 treatment where no mulching was applied (Table 3). The result was found similar to that of Moursy *et al.* (2015) in tomato cultivation (Appendix III).

GA_3 application at different level caused significant variation in case stems length in cauliflower cultivation. GA_3 at 75 ppm resulted in maximum stem length (17.04 cm) than other treatment. However, minimum (9.70 cm) stem length was found in G_0 treatment (Table 4). Meena *et al*. (2018) found similar result in case of GA_3 applied in cauliflower (Appendix III).

Mulching and GA_3 caused interaction effect in cauliflower production. The treatment combination M_2G_2 (straw mulching and 75 ppm GA_3 application) resulted in highest stem length (22.43 cm). On the other hand, M_0G_0 treatment combination where no mulching and GA_3 was applied caused lowest stem length (5.01 cm) (Table 5) (Appendix III).

4.6 Stem diameter (cm)

Stem diameter was recorded highest (2.05 cm) in M_2 treatment where rice straw mulching was applied than other mulch materials. On the other hand, lowest stem diameter (0.88 cm) was found in M_0 treatment where no mulching was applied (Table 3). The result was found similar to that of Olaantan (1985) (Appendix III).

In term of GA_3 application, stem diameter was recorded maximum (1.88 cm) in G_2 treatment i.e. GA_3 75 ppm while minimum stem diameter (1.11 cm) was found in control i.e. no GA_3 applied (Table 4). Jadon *et al.* (2009) also reported similar results in case GA_3 application in cauliflower (Appendix III).

In case of interaction effect of mulching and GA_3, the treatment combination M_2G_2 (rice straw mulching and 75 ppm GA_3 application) resulted maximum stem diameter (2.64 cm) whereas minimum stem diameter (0.63 cm) was found in case M_0G_0 i.e. no mulching and GA_3 application treatment combination (Table 5) (Appendix III).

4.7 Canopy (cm)

Application of different types of mulching caused variation in cauliflower canopy (cm) **(**Table 3). Largest canopy (57.81 cm) was recorded from M_2 (straw mulching) treatment while lowest canopy (42.68 cm) was obtained from (control) M_0 treatment (Table 3) (Appendix IV). Different level of GA_3 resulted in canopy variation significantly in case of cauliflower production. GA_3 (75 ppm) i.e. G_2 treatment produced the maximum (53.05 cm) canopy whereas (G_0) treatment represented minimum canopy (46.68 cm). This result is in support to that of Jadon *et al*. (2009) (Table 4) (Appendix IV). Canopy (cm) was also significantly influenced by the interaction effect of mulching and GA_3 application at different level (Table 5). Maximum (62.02 cm) canopy was recorded from the treatment combination of M_2G_2 treatment (straw mulching and 75 ppm GA_3 application) and minimum (40.06 cm) canopy was found from M_0G_0 (control) treatment (Appendix IV).

Table 3. Effect of mulching on leaf length, leaf breadth, stem length, stem diameter and canopy length of cauliflower

Treatments	Leaf length (cm)	Leaf breadth (cm)	Stem length (cm)	Stem diameter (cm)	Canopy (cm)
M_0	23.92 c	12.30 c	7.81 c	0.88 c	42.68 c
M_1	32.50 b	16.87 b	14.36 b	1.60 b	49.26 b
M_2	41.33 a	21.11 a	18.26 a	2.05 a	57.80 a
LSD $_{(0.05)}$	0.87	0.67	1.33	0.15	1.32
CV (%)	3.18	4.70	11.70	11.89	3.12

M_0 :Control, M_1 : Black polythene, M_2 : Rice straw

Table 4. Effect of GA_3 on leaf length, leaf breadth, stem length, stem diameter and canopy length of cauliflower

Treatment	Leaf length (cm)	Leaf Breath (cm)	Stem Length (cm)	Stem Diameter (cm)	Canopy (cm)
G_0	29.11 d	13.22 d	9.70 d	1.11 d	46.68 d
G_1	31.56 c	15.84 c	12.41 c	1.41 c	48.99 c
G_2	35.89 a	20.09 a	17.04 a	1.88 a	53.05 a
G_3	33.89 b	17.95 b	14.77 b	1.65 b	50.94 b
LSD(0.05)	1.01	0.77	1.54	0.17	1.53
CV%	3.18	4.70	11.70	11.89	3.12

G_0: Control, G_1 : 50 ppm, G_2 : 75 ppm, G_3 : 100 ppm

Table 5. Combination effect of mulching and level of GA_3 on leaf length, leaf breadth, stem length, stem diameter and canopy length of cauliflower

Treatments	Leaf length (cm)	Leaf breath (cm)	Stem length (cm)	Stem diameter (cm)	Canopy (cm)
M_0G_0	20.67 i	10.08 g	5.01 h	0.63 h	40.06 j
M_0G_1	23.33 h	10.96 g	7.21 gh	0.82 gh	42.47 ij
M_0G_2	26.67 fg	15.19 e	10.18 f	1.11 fg	44.87 hi
M_0G_3	25.00 gh	13.12 f	8.86 fg	0.95 fg	43.31 i
M_1G_0	28.33 f	13.74 f	9.88 fg	1.23 ef	45.96 gh
M_1G_1	31.33 e	16.02 e	13.00 e	1.60 cd	48.52 fg
M_1G_2	36.00 d	20.03 c	18.51 bc	1.87 c	52.26 de
M_1G_3	34.67 d	17.71 d	16.08 cd	1.69 cd	50.32 ef
M_2G_0	38.33 c	15.84 e	14.21 de	1.46 de	54.02 cd
M_2G_1	40.00 c	20.56 c	17.03 bc	1.80 c	55.98 c
M_2G_2	45.00 a	25.04 a	22.43 a	2.64 a	62.02 a
M_2G_3	42.00 b	23.02 b	19.38 b	2.31 b	59.20 b
LSD (0.05)	1.75	1.34	2.67	0.30	2.64
CV (%)	3.18	4.70	11.70	11.89	3.12

M_0: Control, M_1 : Black polythene, M_2 : Rice straw
G_0: Control, G_1 : 50 ppm, G_2 : 75 ppm, G_3 : 100 ppm

4.8 Days from transplanting to curd initiation

Significant difference was noted on days required from transplanting to curd initiation by different mulching materials applied to cauliflower production. Maximum days (50.83) were required in case of M_0 treatment (no mulching) and the minimum days were required (43.00) in M_2 (rice straw mulching) treatment (Table 6). This result was similar to those of Duraisami *et al.* (2005) (Appendix IV).The result was in accordance to that of Younis *et al.*(2012).

Significant variation was found in case of days from transplanting to curd initiation due to application of different levels GA_3 (Table 7). Maximum days (52) were required in G_0 (control) treatment and minimum days were required (41.22) in G_2 (75 ppm GA_3 applied) treatment. Roy and Nasiruddin (2011) and Kaur and Mal. (2018) reported similar result in case of GA_3 applied to cabbage and cauliflower cultivation respectively (Appendix IV).

Significant interaction effect was observed in combination of mulching and GA_3 applied. Minimum days for curd initiation (38.67) was recorded in M_2G_2 treatment combination (straw mulching and 75 ppm GA_3 application) treatment combination and maximum days (52) was required was recorded in case of M_0G_0 (control) treatment (Table 8) (Appendix IV).

4.9 Curd weight (g)

Curd weight varied significantly in different types of mulching applied. Highest curd (736.2 g) curd weight was recorded from M_2 treatment (rice straw mulching). However, lowest (604.6 g) curd weight (g) was recorded from that of control treatment (M_0) (Table 6) (Appendix IV). Significant variation was observed in case of different levels GA3 application in cauliflower. Highest (716.4 gm) curd weight per plant was obtained from G2 (75ppm GA3) and the lowest (628.9 gm) was recorded from (G0) control treatment (Table 7) (Appendix IV). A significant interaction effect was found between different types of mulching and different level of GA3 applied to cauliflower on the curd weight. However, maximum (778.5 g) curd weight was reported from treatment combination of M2G2 (straw mulching and 75ppm GA3 application) and the minimum (547 g) from treatment combination of M0G0 where no mulching and GA3 were applied (Table 8) (Appendix IV)

4.10 Curd yield plot^{-1} (kg)

A significant variation was found on the curd yield per plot due to the application of different mulch materials on cauliflower production. Highest curd yield per plot (8.83 kg) was recorded from M2 (rice straw mulching) treatment and minimum (7.26 kg) was found from the control (M0) treatment (Table 6) (Appendix IV). Kosterna (2014) observed that all kinds of straw significantly increase the yield of broccoli.

The curd yield was also varied significantly by the application of different levels GA3. Maximum (8.60 kg) curd yield per plot was obtained from G2 (75ppm GA3) and the minimum (7.547 kg) was recorded from the control (G0) treatment (Table 7) (Appendix IV). Attallah *et al.* (2012) reported that GA3 increase the fresh weight of cauliflower.

Interaction effect of different types of mulching and GA3 was significant in case curd yield per plot. The highest value (9.34 kg) was found from treatment combination M2G2 (straw mulching and 75ppm GA3 application) and the lowest (6.567 kg) from the control (M0G0) treatment (Table 8) (Appendix IV).

4.11 Curd yield ha^{-1} (ton)

Due to different types of mulching applied to cauliflower, curd yield per ha varied significantly. Highest yield/ha (27.27 t/ha) was calculated from M2 treatment which was rice straw mulching. On the other hand, lowest yield/ha (22.39 t/ha) was obtained from M0 (control) treatment (Table 6) (Appendix V).

The effect of GA3 at different levels on the curd yield/ha was also significant. Highest curd yield/ha (26.53 t/ha) was recorded from treatment G2 (75ppm GA3) and lowest yield was recorded (23.29 t/ha) from the control (G0) treatment (Table 7). This result support to those of Raghubanshi *et al.* (2013) (Appendix V).

The interaction between mulching and GA3 at different levels were also significant among different treatments. However, the highest value was (28.83 t/ha) from treatment combination of M2G2 (straw mulching and 75 ppm GA3 application) and the lowest (20.26 t/ha) from the control (M0G0) treatment combination (Table 8) (Appendix V).

Jadon *et al*. (2009) found that diameter of curd (cm),weight of curd per plant (kg), weight of the head per plant (kg), length of head per plant (cm),yield (q/ha) and dry weight of curd per 100 g of fresh weight of cauliflower was increased by application of mulch and GA_3. Similar result was found by Salim *et al*. (2008).

Table 6. Effect of mulching on crown initiation, curd weight, yield/plot and yield/ha of cauliflower

Treatment	Crown initiation	Curd weight (g)	Yield/plot (kg)	Yield/ ha (ton)
M_0	50.83 a	604.60 c	7.26 c	22.39 c
M_1	47.00 b	685.10 b	8.22 b	25.37 b
M_2	43.00 c	736.20 a	8.83 a	27.27 a
LSD (0.05)	0.65	5.49	0.06	0.20
CV%	1.64	0.96	0.97	0.96

M_0: Control, M_1 : Black polythene, M_2 : Rice straw

Table 7. Effect of different level of GA_3 on crown initiation, curd weight, yield/plot and yield/ha of cauliflower

Treatment	Crown initiation	Curd Weight (g)	Yield/plot(kg)	Yield/ ha(ton)
G_0	52.00 a	628.9 d	7.547 d	23.29 d
G_1	49.33 b	669.8 c	8.037 c	24.81 c
G_2	41.22 d	716.4 a	8.597 a	26.53 a
G_3	45.22 c	686.2 b	8.233 b	25.41 b
LSD (0.05)	0.75	6.34	0.08	0.24
CV%	1.64	0.96	0.97	0.96

G_0: Control, G_1 : 50 ppm, G_2 : 75 ppm, G_3 : 100 ppm

Table 8. Combination effect of mulching and different level of GA_3 on crown initiation, curd weight, yield/plot and yield/ha of cauliflower

Treatment	Crown initiation	Curd Weight (gm)	Yield/Plot (kg)	Yield/ha (ton)
M_0G_0	52.00 a	547.0 i	6.56 i	20.26 i
M_0G_1	51.00 b	602.6 h	7.23 h	22.32 h
M_0G_2	44.67 f	642.5 f	7.71 f	23.80 f
M_0G_3	47.67 d	626.4 g	7.51 g	23.20 g
M_1G_0	51.00 b	633.6 fg	7.60 fg	23.47 fg
M_1G_1	49.33 c	687.3 e	8.24 e	25.46 e
M_1G_2	40.33 h	728.2 c	8.73 c	26.97 c
M_1G_3	45.33 ef	691.2 e	8.29 e	25.6 e
M_2G_0	46.00 e	706.0 d	8.47 d	26.15 d
M_2G_1	44.67 f	719.5 c	8.63 c	26.65 c
M_2G_2	38.67 i	778.5 a	9.34 a	28.83 a
M_2G_3	42.67 g	740.8 b	8.89 b	27.44 b
LSD $_{(0.05)}$	1.31	10.98	0.13	0.41
CV%	1.64	0.96	0.97	0.96

M_0: Control, M_1 : Black polythene, M_2 : Rice straw
G_0: Control, G_1 : 50ppm, G_2 : 75ppm, G_3 : 100ppm

4.12 Dry weight of leaf

In case of rice straw mulching (M2), highest dry matter (6.38%) of leaf was recorded than other mulching treatment. Whereas, lowest dry matter (5.16%) were recorded in case M0 treatment (Table 9) (Appendix V). Different levels of GA3 caused significant variation in case of dry matter of leaf. Maximum dry matter (6.23%) was found from G_2 (75 ppm GA_3) treatment and minimum (5.16%) from that of G0 i.e. control (Table 10) (AppendixV). Dry matter of leaf variation was significant due to interaction effects of mulching and GA_3 application. Highest dry matter of leaf was (6.78%) recorded from M_2G_2(straw mulching and 75 ppm GA_3) treatment and the lowest value (4.27%) was obtained from treatment M0G0 i.e. no mulching and GA3 application(control) (Table 11) (AppendixV).

4.13 Dry weight of root

Highest dry matter of root (20.47%) was found from M2 where rice straw mulching was applied. On the contrary, lowest value (12.78%) was recorded from M0 treatment (Table 9) (Appendix V).

GA3 application at different level caused significant variation in case of dry matter of root in cauliflower cultivation. GA3 at 75ppm resulted in maximum dry matter of root (20.37%) than other treatment. However, minimum (12.87%) dry matter was found in G0 treatment (Table 10) (Appendix V).

Due to interaction effect of mulching and GA3, root dry matter varied significantly. M2G2 (straw mulching and 75ppm GA3) treatment combination represented highest value (24.70%) whereas M0G0 i.e. no mulching and GA3 application (control) treatment provided lowest value (9.79%) in case of dry matter of root (Table 11) (Appendix V).

4.14 Dry weight of curd

Significant variation was observed in case dry matter of curd due to different types of mulching in cauliflower. Maximum dry matter (6.74%) was found in case of M2 (rice straw mulching) treatment while minimum (4.90%) was recorded from M0 (control) treatment (Table 9) (Appendix V).

Different levels of GA3 caused significant variation in case of dry matter of curd. Highest curd dry matter (6.25%) was obtained from G2 (75 ppm) treatment whereas lowest value (5.35%) was recorded from G0 treatment (Table 10) (Appendix V).

The combined effect of mulching and GA3 was significant on curd diameter. Highest curd dry matter (7.25%) was obtained from M2G2 (straw mulching and 75 ppm GA3 application) treatment combination whereas lowest dry matter (4.25%) was recorded from M0G0 treatment combination where zero mulching and GA3 were applied (Table 11) (Appendix V).

Table 9. Effect of mulching on crown initiation, curd weight, yield/plot and yield/ha of cauliflower

Treatment	Dry weight of leaf (%)	Dry weight of root (%)	Dry weight of curd (%)
M_0	5.16 c	12.78 c	4.90 c
M_1	5.67 b	16.16 b	5.82 b
M_2	6.38 a	20.47 a	6.74 a
LSD (0.05)	0.27	0.97	0.34
CV%	5.68	7.02	7.06

M_0: Control, M_1 : Black polythene, M_2 : Rice straw

Table10. Effect of different level of GA_3 on crown initiation, curd weight, yield/plot and yield/ha of cauliflower

Treatment	Dry weight of leaf (%)	Dry weight of root (%)	Dry weight of curd (%)
G_0	5.16 c	12.87 d	5.35 c
G_1	5.61 b	15.56 c	5.69 bc
G_2	6.23 a	20.37 a	6.25 a
G_3	5.92 ab	17.07b	5.99 ab
LSD (0.05)	0.32	1.13	0.40
CV%	5.68	7.02	7.06

G_0 : Control, G_1 : 50 ppm, G_2 : 75 ppm, G_3 : 100 ppm

Table 11. Combination effect of mulching and different level of GA_3 on crown initiation, curd weight, yield/plot and yield/ha of cauliflower

Treatment	Dry weight of leaf (%)	Dry weight of root (%)	Dry weight of curd (%)
M_0G_0	4.27 g	9.79 f	4.25 i
M_0G_1	5.01 f	12.11 e	4.82 hi
M_0G_2	5.87 cd	16.31 d	5.39 fgh
M_0G_3	5.47 def	12.89 e	5.16 gh
M_1G_0	5.14 ef	12.93 e	5.55 efg
M_1G_1	5.68 cde	15.54 d	5.69 defg
M_1G_2	6.06 bc	20.10 c	6.11 cde
M_1G_3	5.78 cd	16.05 d	5.93 cdef
M_2G_0	6.08 bc	15.87 d	6.26 bcd
M_2G_1	6.15 bc	19.05 c	6.57 abc
M_2G_2	6.78 a	24.70 a	7.25 a
M_2G_3	6.51 ab	22.27 b	6.88 ab
LSD (0.05)	0.55	1.96	0.70
CV%	5.68	7.02	7.06

M_0: Control, M_1 : Black polythene, M_2 : Rice straw
G_0 : Control, G_1 : 50 ppm, G_2 : 75 ppm, G_3 :100 ppm

CHAPTER V

SUMMARY AND CONCLUSION

The field experiment was conducted at the Horticultural Farm of Sher-e-Bangla Agricultural University, Dhaka. To investigate the effects of mulching and GA_3 on growth and yield of cauliflower with their different concentrations during the period from October 2017 to February 2018. The experiment consists of three different concentrations of mulch viz. control, black polythene, rice straw and four different concentrations of GA_3 viz. control, 50ppm, 75ppm and 100ppm. 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 (1m x 1m) and 9 plants were accommodated in each plot with a spacing of 60 cm x 45 cm. Seedlings were transplanting in the field on 22 November, 2017. From each plot, 5 plants were randomly selected for collection of data. The treatment of the field experiment comprised two factors namely (a) three different concentrations of mulch and (b) four different concentration of GA_3. Data on different growth, yield contributing characters and yield were recorded to find out best combination of mulch and GA_3 for higher yield of cauliflower.

In case of mulch application the highest plant height at 30 DAS (39.80 cm), 45 DAS (53.49 cm) and 60 DAS (67.25 cm), the maximum number of leaves per plant at 30 DAS (13.08), 45 DAS (21.33) and 60 DAS (19.42), the maximum leaf length (41.33 cm); breadth (21.11 cm), the maximum stem length (18.26 cm); diameter (2.05 cm), the maximum canopy (57.81), the earliest crown initiation (43 days), the maximum curd weight (736.2 g), the highest yield/plot (8.83 kg) and yield/ha (27.27 ton), the maximum dry weight of leaf (6.23%), root (20.47%) and curd (6.74%) were recorded from the rice straw that is M2 treatment.

On the other hand, the lowest plant height at 30 DAS (31.57 cm), 45 DAS (39.52 cm) and 60 DAS (51.58 cm), the lowest number of leaves per plant at 30 DAS (7.25), 45 DAS (11.83) and 60 DAS (15.08), the lowest leaf length

(23.92 cm); breadth (12.34 cm), the lowest stem length (7.81 cm); diameter (0.87 cm), the lowest canopy (42.68), the delay crown initiation (50.83 days), the lowest curd weight (604.6 g), the lowest yield/plot (7.25 kg) and yield/ha (22.39 ton), the lowest dry weight of leaf (5.16%), root (12.78%) and curd (4.90%) were recorded from the control that is M_0 treatment.

In case of GA_3 application the highest plant height at 30 DAS (37.73 cm), 45 DAS (49.66 cm) and 60 DAS (63.41 cm), the maximum number of leaves per plant at 30 DAS (12.89), 45 DAS (20.89) and 60 DAS (24.11), the maximum leaf length (35.89 cm); breadth (20.09 cm), the maximum stem length (17.04 cm); diameter (1.87 cm), the maximum canopy (53.05), the earliest crown initiation (41.22 days), the maximum curd weight (716.4 g), the highest yield/plot (8.59 kg) and yield/ha (26.53 ton), the maximum dry weight of leaf (6.23%), root (20.37%) and curd (6.25%) were recorded G2 treatment.

On the other hand, the lowest plant height at 30 DAS (32.33 cm), 45 DAS (42.79 cm) and 60 DAS (55.64 cm), the lowest number of leaves per plant at 30 DAS (6.778), 45 DAS (11.56) and 60 DAS (11.33), the lowest leaf length (29.11 cm); breadth (13.22 cm), the lowest stem length (9.69 cm); diameter (1.106 cm), the lowest canopy (46.68), the delay crown initiation (52 days), the lowest curd weight (628.9 g), the lowest yield/plot (7.54 kg) and yield/ha (23.29 ton), the lowest dry weight of leaf (5.16%), root (12.87%) and curd (5.35%) were recorded from the G2 treatment.

In case of combined effect of mulch and GA_3 the highest plant height at 30 DAS (42.17cm), 45 DAS (58.09cm) and 60 DAS (71.07cm), the maximum number of leaves per plant at 30 DAS (15.67), 45 DAS (25.33) and 60 DAS (27.33), the maximum leaf length (45 cm); breadth (25.04 cm), the maximum stem length (22.43 cm); diameter (2.64 cm), the maximum canopy (62.02), the earliest crown initiation (38.67 days), the maximum curd weight (778.50%), the highest yield/plot (9.34 kg) and yield/ha (28.83 ton), the maximum dry weight of leaf (6.78%), root (24.70%) and curd (7.25%) were recorded from the rice straw and 75ppm GA3 that is M_2G_2 treatment combination.

On the other hand, the lowest plant height at 30 DAS (28.39 cm), 45 DAS (35.71 cm) and 60 DAS (48.96 cm), the lowest number of leaves per plant at 30 DAS (5), 45 DAS (8.33) and 60 DAS (10), the lowest leaf length (20.67 cm); breadth (10.08 cm), the lowest stem length (5.01 cm); diameter (0.62 cm), the lowest canopy (40.06), the delay crown initiation (57 days), the lowest curd weight (547 g), the lowest yield/plot (6.567 kg) and yield/ha (20.26 ton), the lowest dry weight of leaf (4.27%), root (9.79%) and curd (4.25%) were recorded from the control treatment that is M_0G_0 treatment combination.

CONCLUSION

On the basis of results in previous chapter, it may be concluded that mulch and GA_3 application had significant effect on growth and yield of cauliflower. Thus, application of rice straw and GA_3 (75ppm) was found to be the most appropriate treatment for increasing growth and curd yield. Therefore, for increasing the production of cauliflower both rice straw and 75 ppm GA_3 may be used.

REFERENCES

Ahmed, A., Masoum, A.and Koto, A. (1991). Effects of different mulch materials on soil temperature and yield of cauliflower. *Emir. J. Agric. Sci.* 3: 67-79.

Ahmed, M. S., Farag, A. A., Mohamed A. A.,Radwan, H. A., El-Marsafy, M.Y. and Hashem, F. A. (2015). Utilization of rice straw in tomato production under different levels of water requirements. *Egypt. J. Agric. Res*.93 (5).

Ahmed,N.U.,Mahmud,N.U.,Hossain,A.,Zaman,A.U.,Halder,S.C.(2017). *Int. J. Nat. and Soci*. Sci.4(2):07-13.

Ali, M. A., Hossain, M. M., Zakaria, M. P., Hossain, T., Naznin, A.and Islam,M. M. (2015). Effect of GA3 on quality seed production of onion in Bangladesh. *Eco-friendly Agril. J*. 8(03): 47-50.

Balakrishnao, M., Arunprasath, A. (2018). Impact of plant growth regulators and organic fertilizer on growth and biochemical composition of *Trigonella foenum-graceum* L. *Int. J. Bot. Stud*. 3(3): 24-28.

BBS, 2015.Year Book of Agricultural Statistics of Bangladesh, Statistics Division, Ministry of Planning, Govt. of the People's Republic of Bangladesh.p. 58.

Bhardwaj, R. L. (2013). Effect of mulching on crop production under rainfed condition - a review. *Agri. Reviews*, 34 (3): 188-197.

Booij, R. (1988).Effect of growth regulators on curd diameter of cauliflower. *Sci. Hort*. 38(1–2): 23-32.

Chaurasiy, J.,Meena, M. L.,Singh, H. D.,Adarsh, A. and Mishra, P. K. (2014). Effect of GA_3 and NAA on growth and yield of cabbage (*Brassica oleracea* var. Capitata l.) Cv. Pride of india. *The Bioscan*. 9(3): 1139- 1141.

Chowdhury, M. S., Hasan, Z.,Kabir,K., Jahan, M. S. and Kabir, M. H.(2014). Response of okra (*Abelmoschusesculentus*L.) to growth regulator organic manures. *The Agricul*. 12(2): 56-63.

FAO. 2016. Production year book. Food and Agriculture Organization of the United Nations, Rome, Italy.55(7): 429-432.

Ferdous, J., Datta, A. and Anwar, M. (2017). Plastic mulch and microorganism effects on yield and yield components of cauliflower and tomato in inland and coastal regions of Bangladesh. *J. Crop Impr*.31(3): 261-279.

Filho, R. S., Santos, R. H. S., Tavares, W., Wilcken, C. F.,Serrão, J. E.,Zanuncio, J. C. (2014). Rice-Straw Mulch Reduces the Green Peach Aphid, *Myzuspersicae* (Hemiptera: Aphididae) Populations on Kale, *Brassica oleracea* var. acephala (Brassicaceae). Plants. *PLOS ONE*, 9(4):41-74.

Halter, L., Habegger, R. and Schnitzler, W.H. (2005). Gibberellic acid on artichokes (*cynarascolymus*l.) cultivated in Germany to promote earliness and to increase productivity. *Acta. Hort*. 681:75-82.

Islam, M.A., Rahim, M.A. and Iqbal, T. M. T. (2015). Effect of irrigation and mulching on growth and yield of ginger. Bangladesh. *Agron. J*. 18(1): 27-36.

Islam, M.A., Siddiqua, A. and Kashem, M.A. (1993). Effect of growth regulators on growth yield and ascorbic acid content of cabbage. *Bangladesh j.Agril. Sci*. 20(1): 21-27

Jadon, R. S., Lekhi, R., Sharma, S. and Sharma, R. (2009). Effect of Gibberelic acid, IBA and NAA as Foliar Spray on the Growth, Yield and Quality of Cauliflower (*Brassica oleracea* var. botrytis L.). Agriculture: Towards a New Paradigm of Sustainability ISBN: 978-93-83083-64-0.

Job, M., Rusia, D. K. Dinmani, K. and Singh, V. K. (2018). Effect of drip irrigation and plastic mulch on yield, water use efficiency of cauliflower. *J. of Pharma and Phytoche*. SP1:2556-2560.

Karim, M.R., Mondal, M. F. and Rashid, M. H. A. (2011). Effects of NPKS and mulching on growth and yield of garlic. *J. Bang. Soc. Agric. Sci.* Technol. 8 (1&2):119-124.

Kaur, P. and Mal, D. (2018). Effect of foliar spray of NAA and GA3 on the growth, curd formation and yield of cauliflower (*Brassica oleracea*. var. botrytis). *J. Pharmacog and Phytoche*. 7(3): 2805-2807.

Knavel, F. E. and Mohr, H. C. (1997). Distribution of roots of four different vegetables and paper and polythene mulches. *Proc Am Soc. Hort. Sci*., 91: 589-597

Kosterna, E. (2014). Soil mulching with straw in Broccoli cultivation for early harvest. *J. of Eco. Engi*. 15(2).

Luitel, B. P., Lee, T. J. andKan, W. H. (2015). Fruit set and yield enhancement in tomato (*Lycopersicon esculentum*Mill.) using gibberellic acid and 2,4-Dichlorophenoxy acetic acid spray. Prot. *Hort. and Plt. Factory*. 24(1): 27-33.

Meena, M. K.,Aravindakshan, K., Dhayal, M., Singh, J. and Meena, S. L. (2018). Effect of Biofertilizers and Growth Regulators on Growth Attributes of Cauliflower (*Brassica oleracea* var. botrytis L.) cv. PusaPaushja. *Int. J. Curr. Microbiol.App. Sci*. Special Issue-7: 885-890.

Meena, R.K., Dhaka, R.S., Meena, N.K. and Meena, S., Effect of Foliar Application of NAA and GA3 on growth and yield of okra (*Abelmoschus esculentus* L.) cv. ArkaAnamika, *Int. J. Pure App. Biosci*. 5(2): 1057-1062.

Mohanta, H. C., Hossain, M. M., Islam, M.S., Salam, M.A., and Saha, S.R. (2015). Effect of Plant Growth Regulators on Seed Yield of Carrot. Ann. Bangladesh. *Agric*. 19: 23-31.

Moursy, F. S., Mostafa, F. A., Solieman, N. Y. (2015). Polyethylene and rice straw as soil mulching: Reflection of soil mulch type on soil temperature, soil borne diseases, plant growth and yield of tomato. Gl. *J. Adv. Res*. **2**(10): 1497-1519.

Olasantan, F. O. (1985). Effects of intercropping, mulching and staking on growth and yield of tomatoes. *Exp. Agri*.21(02):13 –44.

Patil, S. S., Kelkar, T. S. and Bhalerao, S. A. (2013). Mulching: a soil and water conservation practice. Res. *J. Agriculture and Forestry Sci*. 1(3): 26-29.

Patil, A.A., Maniur, S.M. and Nalwai, U.G. (1987). Effect GA3 and NAA on growth and yield of cabbage. South Indian Hort., 35(5): 394-395.

Rahman, M. S.,Md. Islam, A.,Haque, M. S. and Md. Abdul Karim, M. A. 2004.

Effects of planting date and gibberellic acid on the growth and yield of garlic (*Allium sativum*L.). Asi. *J. Pt. Sci*.3: 344-352.

Rahman, M., Nahar, M., Sahariar, M. and Karim, M. (2015). Plant growth regulators promote growth and yield of summer tomato (*Lycopersicon esculentum* Mill.). *Progressive Agri*. 26(1): 32-37.

Rahman,M.A.,Imran,M.,Ikrum, M.,Rahman, M. H. and Rabbani, M. G. (2016). Effects of Planting Date and Growth Hormone onGrowth and Yield of Cauliflower.J.Envi. *Sci. & Nat. Res*.9(2):143-150.

Razzaque, M. A. and Alib, M. A. (2009). Effect of mulching material on the yield and quality of Potato Varieties Under no tillage condition of ganges tidal flood plain soil. Bangladesh. *J. Sci. Ind. Res.* 44(1):51-56.

Roy, R and Nasiruddin, K. M. (2011). Effect of Different Level of GA3 on growth and yield of cabbage. *J. Environ. Sci. & Nat. Res*.4(2): 79-82.

Sałata, A., Gruszecki, R. and Dyduch, J. (2013). The effect of gibberellic acid GA3 on morphological features of artichoke (*Cynarascolumus*L.). Modern Phytomorp.4: 87–90.

Salim, M. M., R., Khan, A. S., Sarkar, M. A., Hossain, M. A. and Hussain, M. J. (2008). Growth and yield of cauliflower as influenced by polythene mulching. *Int. J. Sustain Crops Prod*. 3(6): 38-40.

Salim, M. M. R., Khan, A. S. M. M. R., Sarkar, M. A., Hossain, M.A. and Hussain, M. J. (2008). Growth and Yield of Cauliflowers as Influenced by Polyethylene Mulching. *Int. J. Sustain. Crop Prod*. 3(6):38-40.

Sarangi, S. K.,Saikia, U. S., Lama, T. D. (2010). Effect of rice (*Oryza sativa*) straw mulching on the performance of rapeseed (*Brassica campestris*) varieties in rice–rapeseed cropping system. *Ind. J. Agri. Sci*.80(7):603- 605.

Shreen. Y. Attallah. and Abbas, H. S. (2012). Effect of Gibberllic Acid on Earliness of Cauliflower Curd Initiation under Assuit Conditions. Assiut*J. of Agric. Sci*., 43(1):48-56.

Singh, H. N., Vishwakarma, G. and Singh, J. (2016). Effect of Gibberellic acid and

nitrogen on yield and marketability of cabbage (*Brassica oleracea* var. capitata L.) cv. pride of India. *J. Pharma and Phytoche*. 7(3): 900- 903.

Singh, M., Rana,D. K.,Rawat, J. M. S. and Rawat, S. S. (2011). Effect of GA3 and kinetin on growth, yield and quality of sprouting broccoli (*Brassica oleracea*var. italica). *J. of Hort. and Fores*. 3(9): 282-285.

Sweeney, W. and Campbel, K. L. (1987). Tomato yield and nitrogen recovery as influence by irrigation method, nitrogen source and mulch. *Hort Sci.*, 22(1): 27-29

Sudesh, J. and Khetarpaul, N. (2011). Importance of vegetables in human nutrition and health. In: Rana, M. K. (ed.) Fundamentals of vegetables Production, New India Publishing Agency. New Delhi. p70.

Teame, G., Tsegay, A. and Abrha, B., (2017). Effect of organic mulching on soil moisture, yield and yield contributing components of sesame (*Sesamum indicum* L.). *Int. J. Agro*.2017: 31-37.

Verma, S., Sengupta, S., Agarwal, B. K.,Jha,K.K.,Mishra,S., Rajak, R. and Rani, V. (2018). Foliar application of boron, urea and GA3 influences earliness of curd production in broccoli (*Brassica oleracea* var. italica). *Int. J. Agri. Sci*. 14 (1): 149-153.

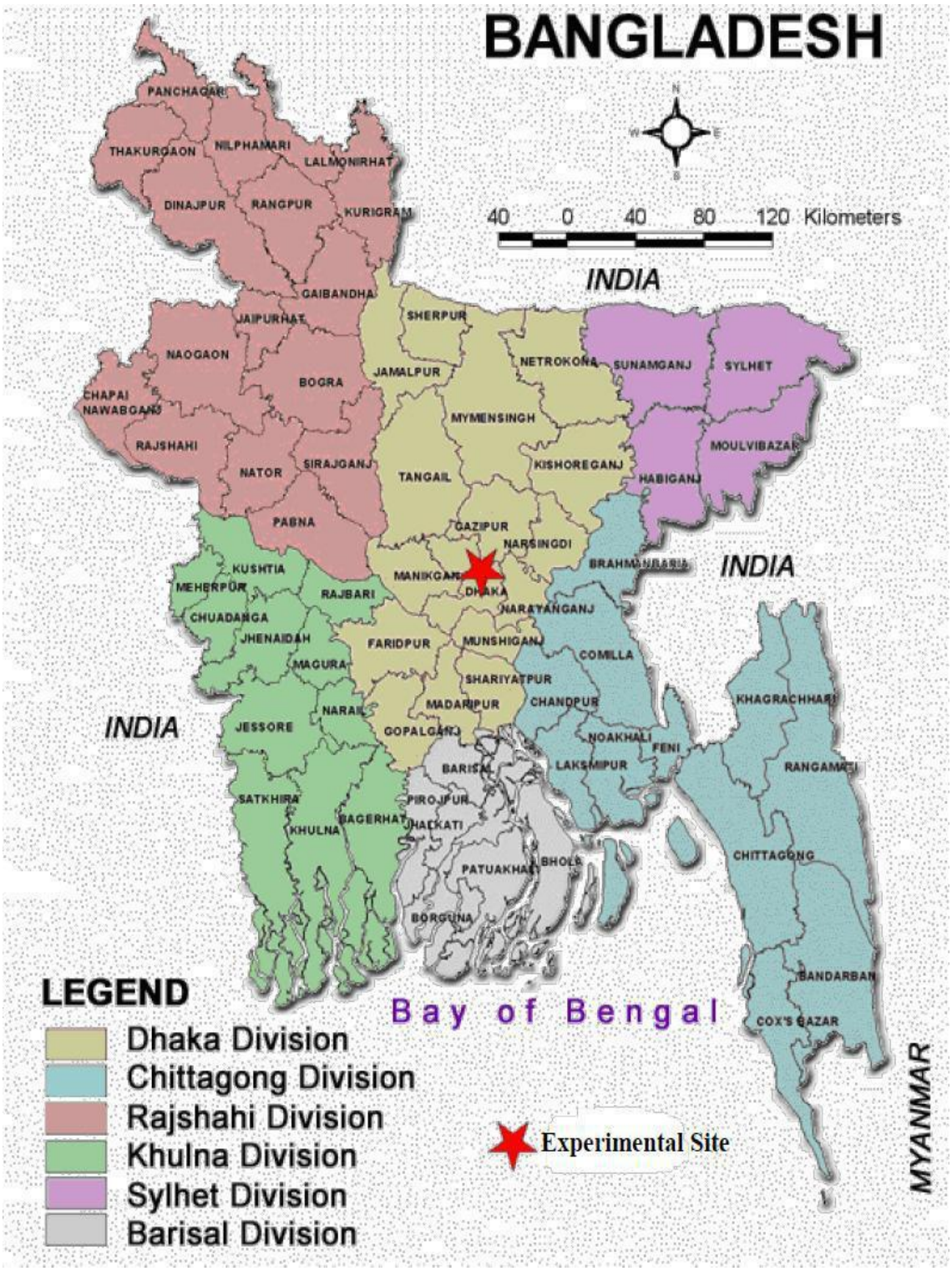
Vishwakarma, S., Bala, S., Kumar, P., Prakash, N.,Kumar, V., Singh, S. S. and Singh, S. K. (2017). Effect of nitrogen, naphthalene acetic acid and Gibberellic acid on growth, yield and quality of broccoli (*Brassica oleracea*var. italica L.) Cv. 'Sante'. *J. Pharmaco and Phytochem*. 9(4): 188-194.

Wang, T. and Yang, X. (2008). The effects of gibberellins on inflorescence differentiation, photosynthesis characteristics and quality in broccoli. *Northern Hort*. 01: 10-12.

Younis, A., Bhatti,M. Z. M.,Riaz, A., Tariq, U.,Arfan, M., Nadeem, M. and Ahsan, M. (2012). Effect of different types of mulching on growth and flowering of *Freesia alba*Cv. Aurora. Pak. *J. Agri. Sci*. 49(4): 429-433.

APPENDICES

Appendix I. Map showing the experimental site under study



Appendix II. The mechanical and chemical characteristics of soil of the experimental site as observed prior to experimentation.

Particle size constitution:

Sand	40%
Silt	40%
Clay	20%
Texture:	Loamy

Appendix III. The mechanical and chemical characteristics of soil of the experimental site as observed prior to experimentation.

Chemical composition:

Constituents	:	0-15 cm depth
P^H	:	6.4
Total N (%)	:	0.07
Available P (µ gm/gm)	:	18.49
Exchangeable K (meq)	:	0.07
Available S (µ gm/gm)	:	20.82
Available Fe (µ gm/gm)	:	229
Available Zn (µ gm/gm)	:	4.48
Available Mg (µ gm/gm)	:	0.825
Available Na (µ gm/gm)	:	0.32
Available B (µ gm/gm)	:	0.94
Organic matter (%)	:	1.4

Source: Soil Resources Development Institute (SRDI), Farmgate, Dhaka.

Appendix IV. Analysis of variance on plant height of cauliflower at different days after transplanting

Source of variation	Degrees of freedom	Mean square of plant height		
		30 days	45 days	60 days
Replication	2	25.988	36.820	75.493
Factor A	2	214.543	586.709	736.866
Factor B	3	43.930	77.433	96.655
AB	6	2.555	2.608	7.819
Error	22	2.089	3.310	2.141
*Significant at 0.05 level of probability				

Appendix V . Analysis of variance on leaf number of cauliflower at different days after transplanting

Source of variation	Degrees of freedom	Mean square of leaf number		
		30 days	45 days	60 days
Replication	2	42.583	56.444	100.333
Factor A	2	102.333	274.111	58.583
Factor B	3	62.769	148.519	279.333
AB	6	1.963	4.407	7.250
Error	22	1.311	0.384	1.848
*Significant at 0.05 level of probability				

Appendix VI. Analysis of variance on leaf length, leaf breadth, stem length and stem diameter of cauliflower at different days after transplanting

Source of variation	Degrees of freedom	Mean square of			
		Leaf length	Leaf breadth	Stem length	Stem diameter
Replication	2	63.528	21.134	9.833	0.320
Factor A	2	910.028	231.087	334.239	4.230
Factor B	3	77.222	77.509	89.269	0.982
AB	6	1.361	3.282	2.135	0.096
Error	22	1.073	0.622	2.488	0.032
*Significant at 0.05 level of probability					

Appendix VII. Analysis of variance on canopy, crown initiation, curd weight and Yield/plot of cauliflower at different days after transplanting

Source of variation	Degrees of freedom	Mean square of			
		canopy	Crown initiation	Curd weight	Yield/Plot
Replication	2	49.743	80.111	2877.916	0.417
Factor A	2	690.441	184.111	52780.714	7.596
Factor B	3	66.678	200.926	11980.686	1.724
AB	6	2.207	7.259	403.578	0.057
Error	22	2.433	0.596	42.070	0.06
*Significant at 0.05 level of probability					

Appendix VIII. Analysis of variance on yield/ha, dry weight of leaf, dry weight of root and dry weight of curd of cauliflower at different days after transplanting

Source of variation	Degrees of freedom	Mean square of			
		Yield/ha	Dry weight of leaf	Dry weight of root	Dry weight of curd
Replication	2	3.923	0.070	60.828	0.286
Factor A	2	72.429	4.540	178.556	10.102
Factor B	3	16.433	1.878	88.124	1.356
AB	6	0.552	0.147	2.178	0.060
Error	22	0.058	0.106	1.335	0.169
*Significant at 0.05 level of probability					