INFLUENCE OF GA_3 AND NITROGEN ON GROWTH AND YIELD OF CABBAGE

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This is to certify that the thesis entitled "**INFLUENCE OF GA_3 AND NITROGEN ON GROWTH AND YIELD OF CABBAGE**" 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 ANJUMAN ARA AKTHER, Registration No. 10-04084 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.

Dated: June, 16
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BY

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ABSTRACT

The effect of different levels of GA_3 and nitrogen were tested on the cabbage cultivar 'Atlas 70' in the Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka during November 2015 to March 2016. The experimental plot was laid out in Randomized Complete Block Design (RCBD) with three replications. The two-factorial experiment was consisted of three levels of GA_3; G_0 = 0 ppm, G_1 = 60 ppm and G_2 = 80 ppm and four levels of nitrogen; N_0= 0 kg/ha, N_1= 210 kg/ha, N_2= 240 kg/ha, N_3= 270 kg/ha. In case of gibberellic acid, the highest yield (87.87 t/ha) was obtained from G_1 and lowest yield (74.29 t/ha) was obtained from G_2. For nitrogen, the highest yield (85.41 t/ha) was obtained from N_2 and lowest yield (70.83 t/ha) was obtained from N_0. Among all treatments combinations G_1N_2 produced the highest yield (97.77 t/ha) and G_0N_0 produced lowest yield (68.88 t/ha). So, 60 ppm GA_3 and 240 kg N/ha may be used for cabbage cultivation.

LIST OF ABBREVIATED TERMS

ABBREVIATION	ELABORATIONS
%	Percent
@	At the rate
°C	Degree centigrade
AEZ	Agro-Ecological Zone
Anon.	Anonymous
ANOVA	Analysis of Variance
BARI	Bangladesh Agricultural Research Institute
BINA	Bangladesh Institute of Nuclear Agriculture
Cal.	Calorie
CV	Coefficient of Variation
DAT	Day After Transplanting
Df	Degrees of Freedom
DMRT	Duncan s Multiple Range Test
et al.	And others
g	Gram
i.e.	That is
J.	Journal
Ns	Non Significant
p^H	Hydrogen ion concentration
RCBD	Randomized Complete Block Design
RH	Relative humidity
SAU	Sher-e-Bangla Agricultural University
SRDI	Soil Resource Development Institute

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CHAPTER I

INTRODUCTION

Cabbage (*Brassica oleracea*var. *capitata*L.) belongs to the family Cruciferae and is biennial herbaceous in nature. It is one of the important vegetable crop in Bangladesh. The origin of cabbage is the Western Europe and north shores of the Mediterranean Sea (Chauhan, 1986).

Cabbage occupied an area of 11.33 thousand hectares of land during 1999-2000 growing season with a total production of 112 thousand metric tons in Bangladesh (BBS, 2000). Thus, the average yield was 9.39 t/ha. Growth regulators are organic compounds other than nutrients; small amount of which are capable of modifying growth (Leopold, 1963). Among the growth regulators auxin causes enlargement of plant cell and gibberellins stimulate cell division, cell enlargement or both (Nickell, 1982). Due to the diversified use of productive land, it is necessary to increase the food production, and gibberellic acid (GA_3) may be a contributor in achieving the desired goal. The production of cabbage can be increased by using GA_3. Cabbage was found to show a quick growth when treated with plant growth regulators (Islam *et al.,* 1993). Application of GA_3 stimulates morphological characters like plant height, number of leaves, head diameter, thickness of head as well as the weight of head. Application ofGA_3 with the environmental conditions play important role in modifying the growth and yield of cabbage.Cabbage was found to show a quick growth, early head formation and higher yield when treated with plant growth regulators especially GA3 and NAA (Dhengle*et al*., 2008; Yadav *et al*., 2000; Kumar *et al*., 1996).

Cabbage seedlings are transplanted from seedbed to the main field. The time between uprooting and establishment of young and tender seedlings in the field is very critical. Vegetables, like, cabbage, cauliflower and tomato respond well to plant growth regulators inminimizing the transplanting shock and being encouraged to a quick growth (Chhonkar and Jha, 1963).Lawand*et al*.(1986)

carried out an experiment to study the effects of spacing, nitrogen,phosphorus and potassium on yield and yield contributing characters of cabbage,cv.Golden Acre.They found 240 kg N/ha was good for cabbage yield.The crop needs good manuring for producing higher yield.Cabbage needs large quantities of nitrogen fertilizers.The optimum dose depends largely on soil type,growing conditions and environmental factors.

The health benefits of cabbage include frequent use as a treatment for constipation, stomach ulcers, headaches, obesity, skin disorders, eczema, jaundice, scurvy, rheumatism, arthritis, gout, eye disorders, heart diseases, aging, and Alzheimer's disease. One of their most important celebrated benefits to health is their powerful antioxidant quality. This means that cabbage and other similar vegetables scavenge free radicals from around the body, which can be very detrimental to overall health and are major contributors to things like cancer and heart disease.

Cabbage also has a number of anti-cancer compounds, like lupeol, sinigrin, and sulforaphane, which are known to stimulate enzyme activity and inhibit the growth of tumors, which can lead to cancer. One study, performed primarily on Chinese women, showed a significant reduction in breast cancer when cruciferous vegetables like cabbage were regularly added to their diet.

The research may inspire the growers to cultivate cabbage commercially as well as to improve health and economic status of peoples of Bangladesh. Our initiative was to use some elements such as GA_3 and nitrogen fertilizer by which we can improve the growth, yield and quality of cabbage.

However, considering the above circumstances, the present research was under taken with the following objectives:

1.To investigate the optimum level of gibberellic acid for growth and higher yield of cabbage.

2.To determine the optimum nitrogen fertilizer dose for growth and higher yield of cabbage.

3.To find out the suitable combination of gibberellic acid and nitrogen for ensuring better growth and higher yield of cabbage.

CHAPTER II

REVIEW OF LITERATURE

Cabbage is an important vegetable crop not only in Bangladesh but all over the world. Many research works have been conducted in relation to the present experiments in several parts of the world. But limited literatures are available in Bangladesh. Some of the important research works regarding the effects of different levels of nitrogen and GA_3 on the growth and yield of cabbage are reviewed in this chapter.

2.1 Effect of GA_3 on the growth and yield of cabbage

Nasiruddin and Roy (2011) conducted an experiment on the effect of GA_3 on growth and yield of cabbage. Single factor experiment consisted of four concentrations of GA_3, viz., 0, 25, 50 and 75 ppm. The results clearly revealed that 50ppm 0f GA_3produced the tallest plants, the highest diameter of cabbage head and the highest head yields.

Lendve*et al*. (2010) found that application of GA_3 50 ppm was found significantly superior over most of the treatments in terms of number of the leaves, plant spread, and circumference of stem, left area, fresh and dry weight of the plant, shape index of head, length of root, fresh and dry weight of root. Except treatment GA_3 75 ppm, which gave better results for days required for head initiation and head maturity.

Yu *et al*. (2010) conducted an experiment with '8398' cabbage (*Brassica oleracea*var. captata L.) plants with 7 true leaves and 'Jingfeng No. 1' cabbage plants with 9 true leaves were vernalized in incubator. Then, '8398' cabbage plants vernalized for 18 days and 'Jingfeng No. 1' cabbage plants vernalized for 21 days were treated by high temperature of 37^0C for 12 hours to explore the changes of endogenous hormone during devernalization in cabbage. The results showed that: GA_3 content had less changes, IAA content rose and ABA content decreased during devernalization. Compared with CK (vernalization period),

GA_3 and ABA content decreased significantly, whereas IAA content rose significantly when devernalization ended. Lower GA_3 and ABA content, and higher IAA content can benefit the accomplishment of devernalization.

A field experiment was conducted by Chauhan and Tandel (2009) during the *Rabi* season at Agronomy farm, N.M. College of Agriculture, Navsari Agricultural University, Navsari. Results showed that spray of GA_3 and NAA significantly influenced the performance of growth, yield and quality characters of cabbage. The best plant growth regulator treatments for growth, yield and quality characters of cabbage was GA_3 100 mg l-1 foliar spray at 30 and 45 days after transplanting (DAT) followed by NAA 100 mg l-1 foliar spray at 30 and 45 DAT.

The effect of GA_3 and/or NAA (both at 25, 50, 75 or 100 ppm) on the yield and yield parameters of cabbage (cv. Pride of India) was investigated by Dhengle and Bhosale (2008) in the field at Department of Horticulture, college of Agriculture, Parbhani. The highest yield was obtained with GA3 at 50 ppm followed by NAA at 50 ppm (332.01 and 331.06 q/ha, respectively) Combinations and higher concentrations of plant growth regulators proved less effective.

Moyazzama (2008) carried out an experiment to find out the effect of different concentration of GA_3 and potassium on the growth and yield of cabbage at Sher-e-Bangla Agricultural University Farm in Dhaka. She applied GA_3 at 0, 65, and 85 ppm. The maximum plant height and diameter of head was obtained from 85 ppm of GA_3.

Kar *et al.*(2003) conducted an experiment on the effect of variety and growth regulators on growth and yield of cabbage(*Brassica oleraceae* var. *capitata*) at the Horticulture Farm of Bangladesh Agricultural University, Mymensingh, Bangladesh during October 2002 March, 2003. The highest gross and marketable yield of cabbage were obtained from the plants sprayed with 50 ppm NAA (Naphthalene Acetic Acid).

The in vitro propagation of shoot tips and the quality of explants of cabbage were significantly affected by the different concentrations of BA and NAA in the culture media reported by Liao *et al*. (2003). A higher rate of shoot proliferation with better quality plantlets were obtained when the medium contained more than 0.8 mg BA/litre and less than 0.5 mg NAA/litre. The effects of kinetin and zeatin on propagation efficiency was better than the combination of both treatments when used in similar concentrations. Heat shock treatment (450 for 2 hour) stimulated the proliferation of shoots.

The effects of growth retardants hexaconazole (Hex) and diniconazole (Din), on the height control of cabbage plug seedling were investigated by Park *et al*. (2002) Hex at 5 mg/litre did not affect growth compared to the control. Din treatments reduced the growth of the plants compared to the control treatment, and decreased leaf number of seedlings more than Hex. Din at rates more than 100 mg/litre resulted in extreme dwarfing and unhealthy seedlings. Leaf length and width increased a little 30 days after treatment, indicating that the dwarfing effect of the compounds was temporary. Rooting rate was 92.5% in the control, and 95% in plots treated with hexaconazole at 500 mg/litre.

Yadav, *et al.* (2000) conducted an experiment on the effects of NAA at 50, 100 and 150 ppm, gibberellic acid at 50, 100 and 150 ppm and succinic acid at 250, 500 and 750 ppm, applied at 2 spraying levels (1 or 2 sprays at 30 and 60 days after transplanting), on growth and yield of cabbage cv. Golden Acre. The maximum plant height (28.4 cm) and plant spread (0.187 m^2) resulted from 2 sprays with gibberellic acid at 150 ppm. The highest number of open leaves (23.6) and yield (494.78 q/ha) was obtained in the treatment with 2 sprays of gibberellic acid at 100 ppm. Leaf area was highest in 2 sprays of 500 ppm succinic acid.

Vijoy and Kumar (2000) observed that 30 days old Cauliflower (cv. Pant Subhra) seedling were transplanted into experimental plots and treated with 50 or 100ppm GA_3, 5 or 10ppm IBA, or 100 or 2000ppm NAA at 15 and 30 days

of growth. The results clearly revealed that GA_3 produced the tallest plants, the largest curds and the highest curd yields.

Dharmender*et al.* (1996) conducted an experiment with growth regulators and found that GA_3 and/or NAA (both at 25, 50 or 75 ppm) On the yield of cabbages (ev. Pride of India) was investigated in the field at Jobner, Rajasthan, India. yield was observed following treatment with. 50 ppm GA_3followed by 50 ppm NAA. Combinations and higher concentration of plant growth regulators proved less effective and were uneconomic in comparison to the control.

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

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

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

Muthoo*et. al*. (1987) reported that foliar application of different concentrations of GA_3, NAA and Mo (in various combination or separately) increased the average fresh weight and dry weight of leaves and curd and yield. Among individual application, $GA_3$was the best for vegetative growth and Mo followed by NNA for curd growth and yield.

Mishra and Singh (1986) conducted an experiment in two season trials with Snowball-16 cauliflower N and/or GA_3 were applied 15 and 45 days after transplanting found that 1% N plus 50 ppm GA_3gave the highest yield (301.48 t/ha), whereas Bo had less effect.

Islam (1985) conducted an experiment at the Bangladesh Agriculture University Farm, Mymensingh and applied various growth regulators (CCC, GA_3, NAA and IBA) 30 days after transplanting of 32-days-old seedlings and reported that CCC decreased the plant height, size of loose leaves, diameter of cabbage head and finally the yield. GA_3increased the plant height of the plant, number of loose leaves per plant, size of leaf and finally the yield.

Yabuta*et al.* (1981) reported that application of GA_3had significantly increased marketable weight, petiole length and number of leaves and height of many leafy vegetables but decreased the leaf area.

Kato and Sooen (1980) observed that leaf petiole epinasty in cabbage in cabbage appeared to be controlled by the hormone balance at the epical region of the stem. They also reported that applied NAA induced a downward movement of the wrapper leaves of decapitated plants and the plants with the entire heads and in the leaves of young seedlings but GA_3induced the upward movement of leaves.

Abdalla *et al.* (1980) conducted an experiment with the cauliflower varieties and the plant were treated with different concentrations of IBA (5-40ppm), GA_3 (10-80ppm) or NNA (120-160ppm) 4 weeks after transplanting and twice more at fortnightly intervals. NNA at 160 ppm gave the height yield with regard to card diameter, weight and color. Similar results were obtained from plants treated with GA_3 at 80 ppm and NNA at 40 ppm.

Badawi and EL-Sahhar (1979) conducted an experiment at the experimental station of the Faculty of Agriculture, Cairo University, Egypt. They sprayed 0, 50, 100 and 200 ppm GA_3 and 0, 10, 20 40 ppm IBA after 4 and 8 weeks of transplanting to determine the extent of stimulating effect of different concentration of GA_3 and IBA on cabbage. In the most cases, treatments showed a decline in both diameter and height of edible head. They found higher edible head weight (5.21 kg) was obtained with GA_3(50 ppm) applied 4 weeks after transplanting.

Zee (1978) applied Gibberellic acid once or twice as 10 or 20 ppm spra on seedling of cabbage at transplanting or 10 or 20 days after transplanting, plants reached edible maturity 53 days after transplanting when treated with 20 ppm GA_3. Plant fresh weight and dry weight were considerably enhanced by a 20 ppm GA_3 spray applied 10 days after transplanting. Transplanting 30 days after sowing delayed harvest and reduced plant weight, regardless of GA_3treatment.

Chauhan and Bordia (1971) carried out an investigation using Drumhead variety of cabbage to assess the effects of Gibberellic acid (GA_3) at 5, 10, 15, 25, 50, 100 ppm, Beta-napthoxy-acetic acid (NOA) at 5, 10, 15, 25, 50, 100ppm and 2,4-Dicholorophenoxy-acetic acid (2,4-D) at 0.25, 0.5, 1.0, 2.0, 2.5 ppm as pre sowing seed treatment on the growth and yield of cabbage and mentioned that none of the treatments affected the height of the plants and the time taken for head formation. Maximum weight of head (1.72 kg) was obtained with 50 ppm GA_3as against 0.81 kg under control.

Chauhan and Singh (1970) found that 2 sprays of 15 ppm GA_3 at 2 and 3 weeks after cabbage transplanting increased earliness, yield and quality.

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

Srivastava (1960) reported the beneficial effects of GA_3, NOA and other plant growth regulators as pre-sowing seed treatments of many vegetable crops. He concluded that the application of GA_3 or 2,4-D at appropriate concentration as pre-sowing seed treatment may be quite beneficial in obtaining increased yield.

2.2 Effect of different levels of nitrogen on the growth and yield of cabbage

Pramanik (2007) carried out an experiment to find out the effect of different levels of nitrogen and phosphorus on the growth and yield of cabbage at Sher-e-Bangla Agricultural University Farm in Dhaka. Nitrogen was applied at 0, 200, 260 and 320 kg/ha. The maximum plant height and diameter of head was obtained from 260 kg of nitrogen per hectare.

Khan *et al.* (2002) conducted an experiment to evaluate the influence of N_2, P_2O_5 on the growth and marketable yield of cabbage. All three nutrients were given in five different combinations with or without FYM. Results showed that N_2, P_2O_5 and K_2O @ 160:90:60 kg ha^{-1} alone with FYM @ 15-20 t ha^{-1} gave the maximum total weight of 1641 g in T_5 followed of T_4 as 1459 g given N_2, P_2O_5, K_2O @ 120:90:O kg ha^{-1} with FYM @ 15-20 t ha^{-1}, whereas in the control treatment, no fertilizer it was found 1004. As far as weight of edible portion is concern it was significant amount all treatments, in T_5 it was found as 1099 g followed by T_4 as 929 g, the minimum weight of edible portion was obtained in

control treatment,With no fertilizers as 597 g. Although, plant with maximum height was found in T_5, but it was found non-significant among all treatments. Data on the girth indicates that it was significant among all treatments. Maximum girth was obtained in T_5 as 41.69, followed as 39.46 in T_3. On the whole it was observed that application of N, P_2O_5 and K_2O @ 160:90:60 along with FYM @ 15-20 t ha^{-1} gave the desirable results in term of growth and marketable yield of cabbage.

Wang and Li (2004) carried out an experiment on a vegetable field with Peking cabbage (*Brassica pekinensis*lour. rupr.), cabbage (*Brassica chinensis var. oleiferamakino and nemoto*), green cabbage (*Brassica chinensis*L.), spinach *(Spinaciaoleracea*L.), and rape (*Brassica campestris*L.) to study the effects of nitrogen (N) forms and rates, and phosphorus (P) fertilization on their growth and nitrate accumulation. The results indicated that application of ammonium chloride, ammonium nitrate, sodium nitrate, and urea significantly increased the yields and nitrate concentrations of Peking cabbage and spinach.

Parmar *et al.*(1999) reported higher yields in cabbage with increased nitrogen rates. The application of 200 kgha-1 N produced significantly higher yield over 150kg ha-1 N but at par with 250 kg ha-1 N. This was attributed to the fact that higher nitrogen levels favored the growth of plants with larger leaf area and it was more usefully utilized in head formation. Similar observations on cabbage were made by Ghanti*et al.*(1982), where yield contributing characters such as head diameter and gross mass of heads and number of marketable heads increased with increase in the levels of nitrogen up to 200 kgha-1 Gupta(1987) observed significantly higher cabbage yields at 150 kgha-1N than yields at 0,50 and 100kg ha-1 N yet at par with yield at 200 kg ha-1 N.

Everaarts and De Moel(1998) reported increasing uniformity with increasing amounts of nitrogen applied. In cabbage production uniformity of heads is important. Increase in relative core length was observed when nitrogen

application rate increased, whereas dry matter content of the heads decreased.This was associated with softer head tissue at higher nitrogen availability,thereby having less physical resistance to stalk elongation. The lower the relative core length, the better the head quality(AalbersbergandStolk,1993).

Hossain (1998) studied the effect of different planting time, spacing and nitrogen level on the growth and yield of cabbage at the Horticulture Farm of the Bangladesh Agricultural University, Mymensingh. The experiment consisted four levels nitrogen viz.0, 50 150 and 250 kg/ha. The maximum plant height, diameter of head, thickness of head, number of lateral roots, gross yield (108.60 ton/ha), marketable yield (79.33 ton/ha) were obtained from 250 kg/ N/ha.

According to Dixit (1997) the effects on N (0, 40, 80, 120 or 160 kg/ha) on the growth of cabbages, cv. Pride of India was investigated in Himachal Pradesh, India. Yield increasing with increasing N rate (from 136.8 to 175.1 q/ha after addition of 0 and 160 kg N/ha respectively).

Bhuiyan (1996) carried out an experiment to find out the effect of different levels of nitrogen and their time of application on the growth and yield of cabbage at horticulture farm, Bangladesh Agricultural University, Mymenshing in Bangladesh. There were 6 levels of nitrogen (0, 75, 150, 225 and 300 kg N/ha). He found that different levels of nitrogen had significantly influenced on growth and yield of cabbage. Yield contributing characters and yield such as plant height, diameter and thickness of the head were maximum at a rate 150 kg N/ha. The highest gross yield (79.62 ton/ha) was achieved by the application of 150 kg N/ha compared to the lowest yield at 28.88 ton/ha case of 0 kg N/ha.

An experiment was conducted by Gopal and Lal (1996) to find out the effect of nitrogen and spacing on yield and quality of cabbage cv. Golden Acre, in India. They used different levels of nitrogen 0, 50, 75 or 100 kg/ha. Growth (number of leaves, height of plant and weight of head) increased with increasing rates of

N. The highest yield (254.85 q/ha) was observed at the rate of 100 kg N/ha compared with 168.73 q/ha in control.

Malik *et al.* (1996) studied the effect of nitrogen and spacing on growth and yield of cabbage cv. Pussa Drum Head at Mohanpur in India. They applied N fertilizer at the rate 0, 40, 80 or 120 kg/ha on a sandy loam soil during the winter season. Yield increased with increasing rate of N application (57.76 and 331.46 g/ha with 0 and 120 kg/ha, respectively). Highest net profit and cost: benefit ratio were obtained at 120 kg N/ha and at the closer spacing.

Balvoll (1994) conducted trials over 3 years, the hybrid cultivars Erdeno (vigorous), Apex (which has considerably less free [outer] leaf area than other cultivars) and Bartolo (intermediate growth). In addition to a basic dressing of 180-200 kg N/ha, some plots received one or 2 applications of 77 kg N/ha as a top dressing. The plants were spaced 30, 40 or 50 cm apart in rows 43 cm apart. Each kg of N top dressing gave a yield increase of 130 kg/ha, regardless of the cultivar or spacing. The closest spacing resulted in a higher yield/ha than the widest spacing, with no marked difference in response between the cultivars. Erdeno showed most variation, with a standard deviation in headweight of 500-600 g and a coefficient of variation of about 30% compared with 300-400 g and about 27% respectively, for the other cultivars. Plants were grown on a 3-row bed system. In 2 of the years the row direction was E-W and in these years the row in the bed facing S gave a lower yield, probably because it received greater exposure to the sun than did the other 2 rows. The difference in yield response between rows was lowest at the highest level of N top dressing.

Jiaswal*et al.* (1992) carried out an experiment on effect of nitrogen levels, method of application and spacing on growth and productivity of cabbage. N was applied at the rate of 125, 250 or 375 g/ha. Highest yield (770.77g/ha) 10 was obtained with 375 kg N/ha applied under foliar application at 4, 5, 6 or 7 weeks after transplanting at spacing 30x20 cm.

An experiment was conducted by Hill (1990) in Australia to study the effect of plant spacing and nitrogenous fertilizer on the yield and plant conformation of Chinese cabbage. There were 6 levels of N (0, 50, 100,200,300 or 400 kg n/ha) in the experiment. He found the maximum marketable yield of 126.6 and 123.6 t/ha with the N-rates of 200 and 300 kg/ha, respectively and the yield decreased when the N-rate was increased to 400kg/ha. He also noted damage due to soft rot which was severe at the highest N- rate and contributed to the reduced yield.

Khadir*et al*. (1989) carried out an experiment to study the effect of different levels of urea fertilizer and plant spacing on growth and yield of cabbage. The different nitrogen levels were 0, 138 and 276 kg/ha. They found that the mean head weight, diameter and yield were greater at the maximum nitrogen level. They obtained increased leaf number/plant, vegetative growth and maximum yield from 276 kg N/ha.

Singh and Naik (1988) studied the response of cabbage to plant spacing, nitrogen and phosphorus levels, at Rachi, India. It was found that the thickness of marketable head and head weight of cabbage were the maximum at the rate of 180 kg N/ha.

An experiment, Prabhakar and Srinivas (1987) used three nitrogen levels (0, 75 and 150 kg/ha) and found that individual head yield was increased with increasing nitrogen up to 150 kg/ha (1,76 t/ha), compared with 1.04 t/ha with 75 kg N/ha and 0.23 t/ha in the control.

In a 3 years replicated trials was conducted by Khurana *et al.* (1987) to investigate the effect of nitrogen 'and spacing on cabbage cv. Pride of India and found that the highest head yield and the average head weight were produced by 60 kg nitrogen per hectare in four splits.

Farooque and Mondal (1987) reported that the higher levels (336 kh/ha) of nitrogen increased the marketable yield of cabbage.

Lawande*et al.* (1986) carried out an experiment to study the effects of spacing, nitrogen, phosphorus and potassium on yield and yield contributing characters of cabbage, cv. Golden Acre. They found 240 kg N/ha was good for cabbage yield.

Csizinszky and Schyster, (1985) conducted experiments to investigate the effect of N on the yield of cabbage with 2 years trail in Florida. The experiments were conducted ill spring and autumn-winter. They observed that the high N-rate (257 kg/ha) increased head size in both seasons, but increased marketable yields in the spring.

Peck(1981)observed decreases in percent dry mass of the heads, increased number of burst heads and increased tip burn in the heads with increasing fertilizer nitrogen rate. It was therefore concluded that high nitrogen fertilizerdecreased the quality of cabbage heads.

It was reported by Batsei*et al.* (1979) that nitrogen at the rate of 240 kg per, hectare produced the highest yield of cabbage on irrigated soil.

Thomson and Kelly (1957) mentioned that cabbage is a heavy feeder of nitrogen. They also noted that in moist soil of California, 56-112 kg of nitrogen per hectare is considered adequate fertilization for cabbage 308 kg N/ha. The higher dose reduced proportionately bigger head weights. SimiliarlyVleck and Polack (1977) found that application of 140 kg N/ha was effective for raising cabbage yields, but the maximum number of outer leaves and yield were produced by 80 kg N/ha.

Man and Sandhu (1956) carried out an experiment on the nitrogen requirement of cabbage in India. They found the optimum dose of nitrogen is about 168 kg/ha, which gave the maximum number and larger size of outer leaves, bigger and heavier heads. The maximum sizes of marketable higher yield of head were also produced by the treatment.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at the farm Sher-e-Bangla Agricultural University (SAU) during the period of November 2015 to March 2016 with a view to find out the optimum levels of GA_3 and nitrogen fertilizer application for cabbage cultivation.The materials used and methodologies adopted for research work are elaborately described in this chapter in logical sequence.

3.1 Experiment site

The experiment was conducted at the Horticulture Research Farm of Sher-e-Bangla Agricultural University (SAU), Dhaka. It was located in 24.09^0N latitude and 90.26^0E longitudes. The altitude the location will be 8 m from the sea level as per the Bangladesh Metrological Department, Agargaon, Dhaka-1207.

3.2 Soil of experiment site

The experiment site belongs to the Modhupur Tract (UNDP, 1988) under AEZ No. 28 and the selected plot of the land was medium high in nature with adequate irrigation facilities and remained fallow during the previous season. The soil texture of the experimental was sandy loam. The nutrient condition of the farm soil under the experimental plot with in a depth 0-20 cm were collected and analyzed in SRDI, Dhaka, and result have been presented in Appendix I.

3.3 Climate and weather

The research site is situated in subtropical zone, the climate is characterized by heavy rainfall during the months from April to September (Kharif season) and scantly rainfall during the rest month of the year (Rabi season)March.Information regarding average monthly the maximum and

minimum temperature, rainfall and relative humidity and sunshine hour as recorded by the weather yard, Bangladesh Meteorological Department (Climate Division), Agargaon, during the period of study has been presented in Appendix II.

3.4 Test Crop

The cabbage (*Brassica oleraceae*var*capitata)* cultivar 'Atlas-70 was used as the test crop in the research. The seeds were collected from Siddique Bazar, Dhaka.

3.5 Treatment of the research

The research consisted of two factors:

Factor A : 3 levels of Gibberellic acid

a.G_0 = 0(control)
b.G_1 = 60 ppm
c. G_2 = 80 ppm

Factor B : 4 levels of Nitrogen

a. N_0 = 0 (control)
b. N_1 = 210 kg/ha
c. N_2 = 240 kg/ha
d. N_3 = 270 kg/ha

There were 12 (3 × 4) treatments combination such as G_0N_0, G_0N_1, G_0N_2, G_0N_3, G_1N_0, G_1N_1, G_1N_2, G_1N_3, G_2N_0, G_2N_1, G_2N_2 and G_2N_3.

3.6Seed bed preparation

Seed bed for raising cabbage seedlings was made on 15 October,2015. Seedlings were raised in 3 m × 1 m bed. For making seed bed the soil was properly ploughed and converted into loose friable and dried masses. Thus, a good tilth was obtained. Weeds,stubbles and dead roots were removed from the seed bed. The surface of thebed was made smooth and well leveled.

3.7 Raising of seedlings

Seeds were sown in the seed bed on 17 October,2015. Seeds were then covered with finished light soil. They were also provided by polyethylene bags to protect the young seedlings from scorching sunshine and rainfall. Light

watering, weeding was done as and when necessary to provide seedlings of a good condition for growth.

3.8 Design of the experiment

The double factorial research was laid out in the Randomized Complete Block Design (RCBD) with three replications.

3.9 Layout of the experimental plot

The total area of the research plot was 291 m^2 with length 29.1 m and width 10 m. The total area was divided into three equal blocks. Each block was divided into 12 plots where 12 treatments combination were allotted at random. There were 36 unit plots altogether in the research. The size of each plot was 2 m × 1.8 m. The distance maintained between two blocks and two plots were 1.0 m and 0.5 m, respectively. Seedlings were transplanted on the plots with 60 cm x 40 cm spacing. 15 seedlings were accommodated in each unit plot. The layout of the research is shown in Figure 1.

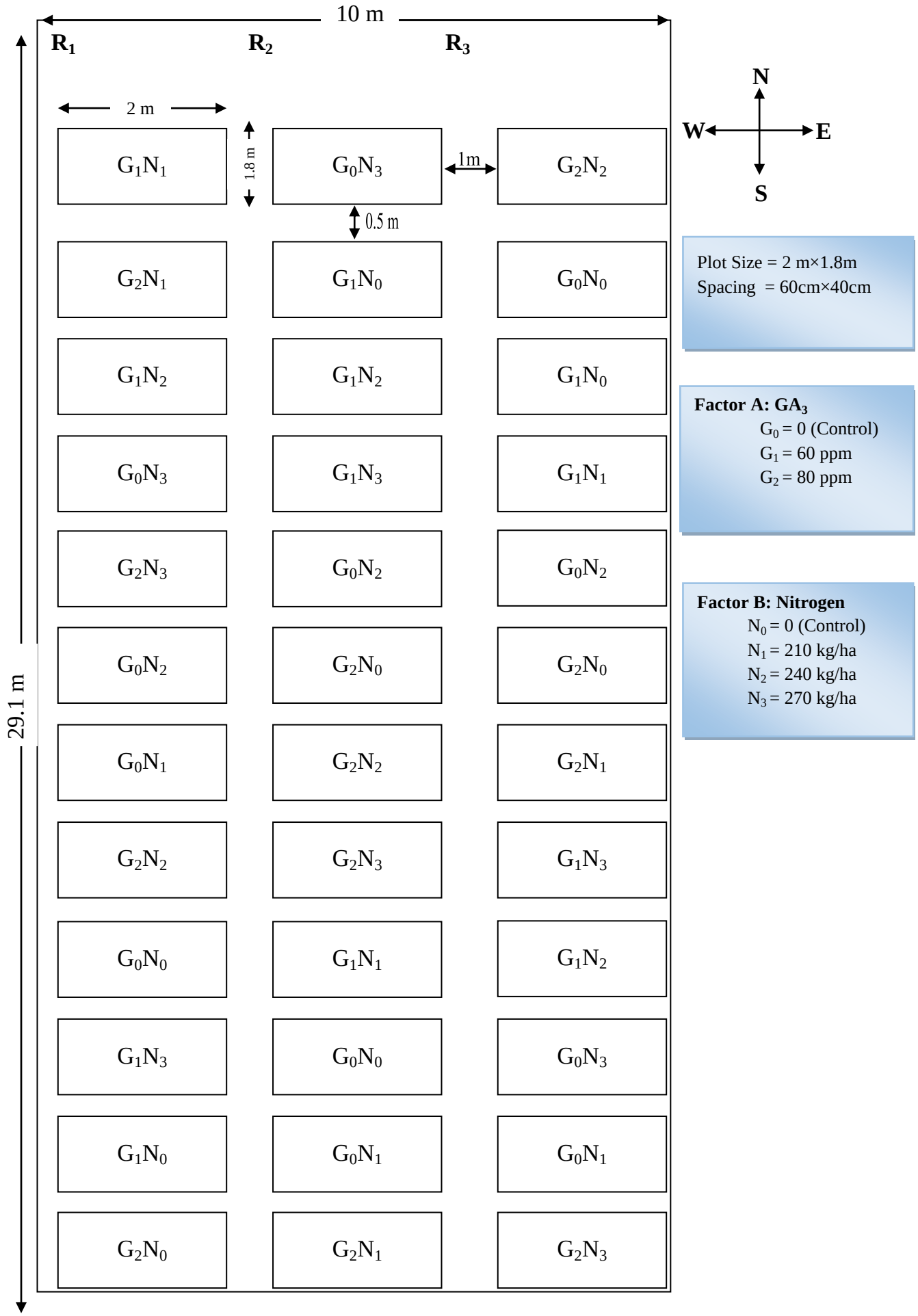

Fig 1. Layout of the experimental plot

3.10 Cultivation procedure:

3.10.1 Land preparation

The selected plot of the research was opened in the 2nd week of November 2015 with a power tiller. 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 removed from the field. Finally, a good tilth was achieved.

3.10.2 Application of manure and Fertilizers

Manure and fertilizers were applied according to Fertilizer RecommendationGuide 2005, BARC as presented below-

Name of fertilizers and manure	**Quantity (kg/ha)**
Urea	As per treatment
TSP	200
MoP	250
Cow dung	10 ton/ha

Full doses of cow dung, TSP and MoP were applied during final land preparation. The total amount of urea was applied in three installments at 20, 40 and 60 days after transplanting.

3.10.3 Collection, preparation and application of growth regulator

Plant growth regulator Gibberellic Acid (GA_3) was collected from Hatkhola Road, Dhaka. A 1000 ppm stock solution of GA_3 was prepared by dissolving 1 g of it in a small quantity of ethanol prior to dilution with distilled water in one litre of volumetric flask. The stock solution was used to prepare the required concentration for different treatment i.e. 60 ml of this stock solution was diluted in 1 litre of distilled water to get 60 ppm GA_3 solution. In a similar way, 80 ppm stock solutions were diluted to 1 litre of distilled water to get 80 ppm solution. Control solution also prepared only by adding a small quantity of

ethanol with distilled water. GA_3 as per treatment were applied at three times 15, 35 and 55 days after transplanting by a mini hand sprayer.

3.10.4 Transplanting of seedlings

The seed bed was watered before uprooting the seedling to minimize the root damage. Care was taken so that root damage was minimum and some soil should remain with the roots.The seedling 30 days old and having 5-6 true leaves were transplanted on 17 November in plots. Transplanting was done in the afternoon to the research plot and a light irrigation was given after transplanting. During transplanting of seedling, 60 cm x 40 cm spacing were followed. 15 plants were transplanted in each unit plot. The seedlings were watered immediately after transplanting. To protect from scorching sunshine and unexpected rain, banana leaf sheath pieces were used over the transplanted seedlings. Shading and watering were continued until the seedlings were well established and it required for 6 days. A number of treated seedlings were planted on the border of the experimental plots for gap filling.

3.10.5 Intercultural Operations

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 establishment of the cabbage seedlings.

3.10.5.1 Gap filling

The transplanted seedlings in the research 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 boll 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.

3.10.5.2 Weeding

The hand weeding was done in 20, 40 and 45, 60 days after transplanting to keep the plots free from weeds.

3.10.5.3 Earthing up

At the time of earthing up the plants were supported with soil to avoid topplingdown of the plant during the head formation.

3.10.5.4 Irrigation

Light watering was given by a watering can at every morning and afternoon after transplanting. Following transplanting and it was continued for a week for rapid and well establishment of the transplanted seedlings. Beside this a routine irrigation was given at 3 days intervals.Care was taken to avoid water stress from the time of head formation to the head maturity period.

3.10.5.5 Pest and disease control

Few plants were damaged by mole crickets and caterpillars which fed on the leaf epidermis and later made holes just after transplanting. In the leaves spraying with Ripcord @ 2ml per litre was done to control them. Sometime, adult Cabbage borer female laid eggs on the growing point or on the olderleaves. Some plants were infected by Alternaria leaf spot disease caused by *Alternaria brassicae*. To prevent the spread of Alternaria leaf spot disease, Rovral 50 WP @ 20 g/10 liter of water was sprayed.

3.11 Harvesting

The head cabbage was first harvested on 07 February 2015 at 80 DAT. Harvesting in completed 80-90 Days. When the plants formed compact

heads,the harvesting of the crop was done plot wise after testing the compactness of the cabbage head by hand. The compact head showed comparatively a hard feeling. A sharp knife was used to cut the head. at the base of the plant.

3.12 Parameter assessed

1. Plant height
2. No.of loose leaves
3. Leaf breadth
4. Canopy
5. Weight of head
6. Head diameter
7. Length of root
8. Fresh Weight of root
9. Dry matter (%) of root
10. Dry matter (%) of leaves
11. Yield (kg/plot)
12. Yield (t/ha)

3.13 Data collection:

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

3.13.1 Plant height

The height of the plant was measured at 30,45,60 DAT with meter scale from the ground level to the tip of the longest leaf and was recorded in centimeter (cm).

3.13.2 Number of loose leaves per plant

The number of leaves per plant was counted at 30,45,60 DAT and at harvest.

3.13.3 Breadth of large leaf

Breadth of large leaf was measured at 45 and 60 DAT in cm with a meter scale and was expressed in centimeter (cm).

3.13.4 Canopy

The canopy was measured at 60 days after transplanting.

3.13.5 Length of root

The distance from the base to the top of the root was measured after harvest ofthe plant in centimeter (cm) with the help of a scale to determine the length of root.

3.13.6 Fresh weight of root

The fresh weight of cabbage root was recorded from the average of 5 plants in gram (g).

3.13.7 Dry weight of root

The dry weight of 100gm root was recorded in gram(g).

3.13.8 Diameter of head

Diameter of head was measured in cm with a scale as the horizontal distancefrom one side to another side.It was done after sectioning the head vertically at the middle position.

3.13.9 Fresh weight of head per plant

The fresh weight of head per plant was recorded excluding the stem, roots andloose leaves at harvest in kilogram(kg).

3.13.10 Dry matter content of head per plant

First the fresh weight of head was recorded, and then 100 g of head were takenfrom central portion of each head and dried in an oven at 70^0Cfor 72 hoursafter sun drying for two days.

3.13.11 Yield (kg/plot)

The yield per plot was measured by totaling the head yield of each unit plot

separately during the period from first to final harvest and was recorded in kilogram (kg).

3.13.12 Yield (t/ha)

The yield per hectare was calculated out from per plot yield data and their average was taken. It calculated by the following formula,

$$\text{Yield per hectare (ton)} = \frac{\text{Area of plot in square meter x 1000}}{\text{Yield per plot (kg) x 10000}}$$

3.14 Statistical analysis

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

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was laid out to find the influence of GA_3 and phosphorus fertilizer on growth and yield of cabbage. The analysis of variance (ANOVA) of the data on different growth and yield parameters are presented in Appendices III-V. The results have been shown and discusses with the help of different tables and graphs and also possible interpretations given under the following sub-headings:

4.1 Plant height (cm)

Significant variation was performedof different concentrations of gibberellic acid on plant height of cabbage applied at 30, 45 and 60 DAT (Appendix III). At 30, 45 and 60 DAT, the tallest plant (25.42, 31.66 and 40.48 cm, respectively) was recorded from G_1 (60 ppm GA_3) which was followed by 24.34 and 36.90 cm, respectively to G_2 (80 ppm GA_3) at 30 DAT and 60 DAT; and 27.90 cm for G_0 (0 ppm) at 60 DAT (Fig. 2). Nasiruddin and Roy (2011) reported that application of GA_3 increased the plant height of cabbage and it was revealed that 50ppm 0f GA_3 produced the tallest plants. Moyazzama (2008) reported that the maximum plant height was obtained from 85 ppm of GA_3. Yadav *et al.* (2000) found the maximum plant height (28.4 cm) resulted from two sprays with gibberellic acid at 150 ppm.

Different levels of nitrogen fertilizer showed significant variation for plant height of cabbage at 30, 45 and 60 DAT (Appendix III). The tallest plant (24.23, 29.88 and 38.64 cm, respectively) was recorded from N_2 (240 kg Urea per hac) at 30, 45 and 60 DAT. The shortest plant height was observed at 22.32, 28.22 and 36.48 cm, respectively fromN_0 (0 Kg Urea)(Fig. 3). Pramanik (2007) reported that the maximum plant height was obtained from 260 kg of nitrogen per hectare. Bhuiyan (1996) reported that plant height was maximum at a rate 150 kg N/ha.

Combined effect of different concentrations of gibberellic acid and nitrogen fertilizer showed significant differences on plant height of cabbage at 30, 45 and 60 DAT (Appendix III and Table

2). The tallest plant (27.23, 33.00 and 40.00 cm, respectively) at 30, 45 and 60 DAT and was obtained from G_1N_2 (60 ppm GA_3 + 240 kg urea), while the shortest plant 18.76 cm from the combination G_oN_o at 30 DAT; 25.63 cm from the combination G_0N_1 at 45 DAT; and 30.97 cm from the combination G_2N_2 at 60 DAT, respectively.

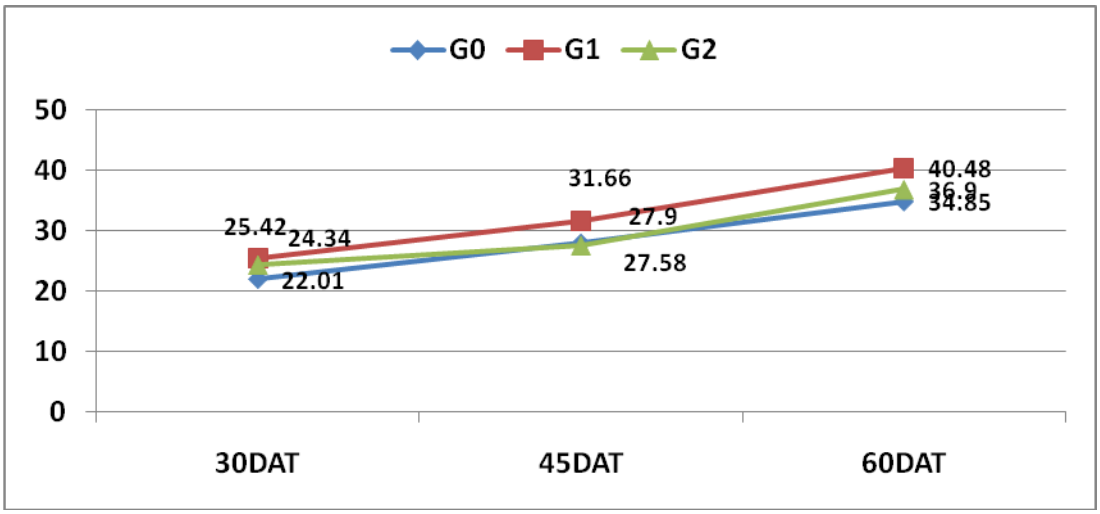

Figure 2. Effect of different levels of gibberellic acid on plant height of cabbage at different days after transplanting.

G_0 = 0 ppm,
G_1 = 60 ppm
G_2 = 80 ppm

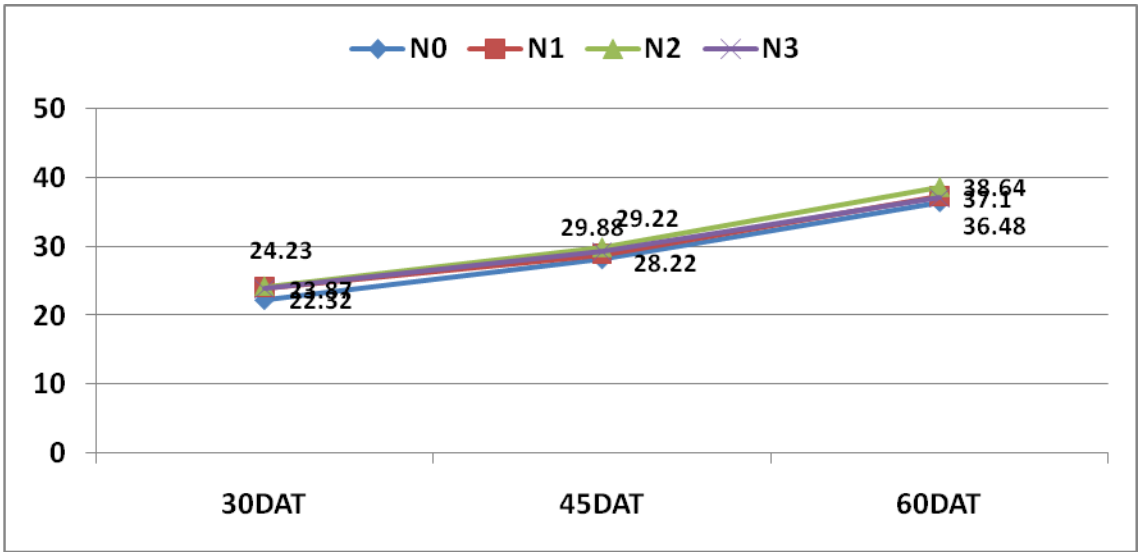

Figure 3. Effect of different levels of nitrogen on plant height of cabbage at different days after transplanting

N_0 = 0 kg/ha
N_1 = 210 kg/ha
N_2 = 240 kg/ha

N_3 = 270 kg/ha

Table 1: Combined effect of gibberellic acid and different levels of nitrogen on plant height of cabbage at different days after transplanting

Combinations	Plant height (cm)		
	30 DAT	**45 DAT**	**60 DAT**
G_0N_0	18.76 g	27.66 de	36.30 bcd
G_0N_1	20.83f g	25.63 e	33.67 defg
G_0N_2	18.96 g	28.66 cd	33.97 def
G_0N_3	24.23 bcde	29.66 bcd	32.30 fg
G_1N_0	25.16 abc	31.00 abc	37.97 abc
G_1N_1	23.56 cdef	32.00 ab	36.97 bc
G_1N_2	27.23 a	33.00 a	40.00 a
G_1N_3	24.70 abcd	30.66 abc	38.90 ab
G_2N_0	22.10 def	26.00 e	32.13 fg
G_2N_1	26.73 ab	28.00 de	35.23 cde
G_2N_2	25.56 abc	29.00 cd	30.97 g
G_2N_3	21.76 ef	27.33 de	32.97 efg
CV%	7.71	5.15	9.72
LSD (0.05)	1.33	1.533	2.74

Gibberellic acid:
G_0 = 0 ppm
G_1 = 60 ppm
G_2 = 80 ppm

Nitrogen:
N_0 = 0 kg/ha
N_1 = 210 kg/ha
N_2 = 240 kg/ha
N_3 = 270 kg/ ha

4.2 Number of loose leaf

Significant variation was recorded on number of leaves per plant due to application of different concentrations of GA_3 at 30, 45, 60 DAT excepting at harvest (Appendix III). The maximum number of leaves per plant (12.58, 15.40 and 17.90), at 30, 45 and 60 DAT was found from G_1. GA_3 concentration G_2 produces the highest number of leaves per plant (12.74) at harvest (Figure 3). The minimum number of leaves (10.81, 16.68 and 12.25) were obtained from concentration G_0 at 30, 60 and at harvest, respectively. Lendve *et al*. (2010) reported maximum number of leaves with 50 ppm GA_3. Yadav *et al.* (2000) reported the highest number of open leaves (23.6) was obtained in the treatment with two sprays of gibberellic acid at 100 ppm.

Significant variation was observed for different levels of nitrogen fertilizer in terms of number of leaves per plant of cabbage at 30, 45, 60 DAT at harvest (Appendix III). At 30 and 60 DAT, the maximum number of leaves per plant 11.99 and 16.36) was counted from N_1 which was statistically similar (11.57 and 11.42) at 30 DAT for N_2 and N_3 respectively; and 16.25 and 16.06 at 60 DAT for N_3 and N_0. Highest number of leaves per plant (15.08 and 13.23) at 45 DAT and at harvest for nitrogen level N_3. The minimum number (11.11 and 14.20) at 30 DAT and 45 DAT was found for N_o, 15.97 at 60 DAT for N_2 and 11.71 at harvest for N_1 respectively (Figure 5).

Different concentrations of gibberellic acid and nitrogen fertilizer showed significant differences due to their combined effect on number of leaves per plant of cabbage at 30, 45, 60 DAT and at harvest (Appendix III). At 45 and 60 DAT, the maximum number of leaves per plant (16.33 and 17.30) was recorded from G_1N_3; at 30 DAT, the maximum number of leaves per plant (13.00) was observed from G_1N_1; at harvest, the maximum number of leaves per plant (15.00) was obtained from G_2N_3. The minimum number of leaves per plant (10.00 and 13.60) at 30 DAT and 45 DAT was found from G_0N_0; leaf number 15.86 at 60 DAT from G_0N_3 and leaf number 11.90 at harvest from G_0N_1 (Table 2).

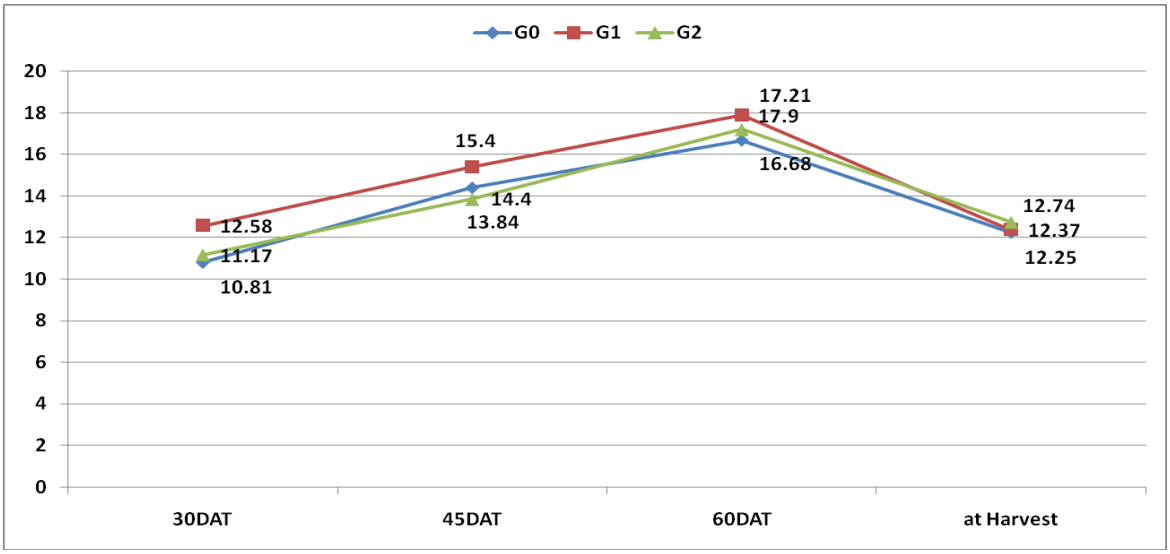

Figure 4. Effect of different levels of gibberellic acid on number of loose leaf of cabbage at different days after transplanting

G_0 = 0 ppm,
G_1 = 60 ppm
G_2 = 80 ppm

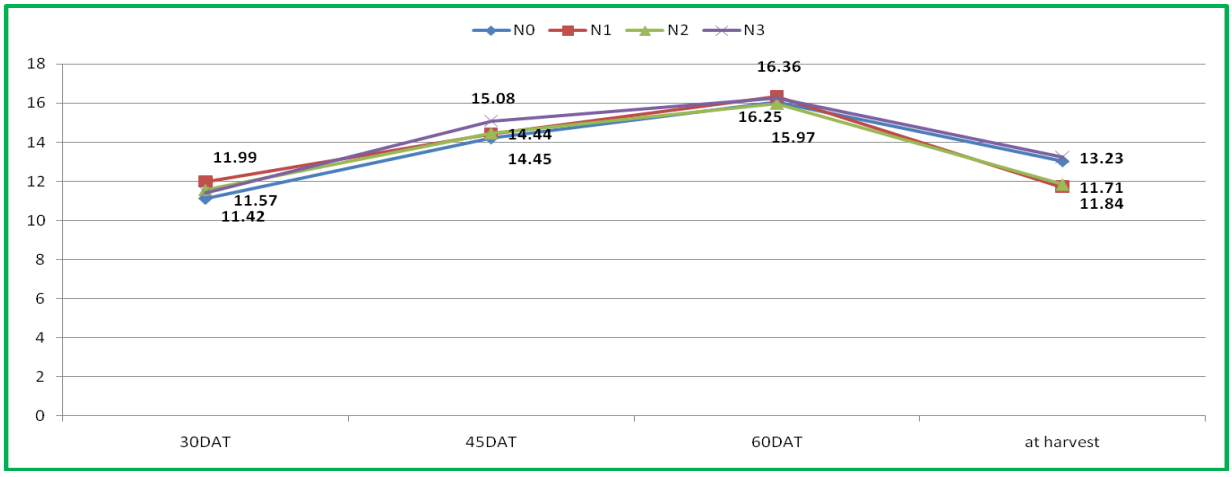

Figure 5. Effect of different levels of nitrogen on number of loose leaf of cabbage at different days after transplanting.

N_0 = 0 kg/ha
N_1 = 210 kg/ha
N_2 = 240 kg/ha
N_3 = 270 kg/ha

Table 2: Combined effect of gibberellic acid and different levels of nitrogen on number of loose leaf of cabbage at different days after transplanting

Combinations	Number of loose leaves			
	30 DAT	**45 DAT**	**60 DAT**	**At harvest**
G_0N_0	10.00 f	13.60 cd	16.53 abc	13.03 b
G_0N_1	11.60 cd	14.66 bc	15.93 bc	11.90 c
G_0N_2	11.70 bcd	15.13 abc	16.13 abc	12.10 c
G_0N_3	11.00 def	14.20 bcd	15.86 bc	11.96 c
G_1N_0	12.76 ab	15.00 abc	16.40 abc	13.20 ab
G_1N_1	13.00 a	14.86 abc	17.16 ab	12.23 c
G_1N_2	12.33 abc	15.40 ab	16.33 abc	11.33 cd
G_1N_3	11.83 bcd	16.33 a	17.30 a	12.73 c
G_2N_0	10.26 ef	14.00 bcd	15.26 c	12.86 c
G_2N_1	11.06 def	13.80 cd	16.00 abc	11.00 d
G_2N_2	10.40 ef	12.83 d	15.46 c	12.10 c
G_2N_3	11.13 de	14.73 bc	15.60 c	15.00 a
CV%	5.79	6.73	7.75	12.31
LSD (0.05)	1.11	1.75	1.34	1.29

Gibberellic acid:
G_0 = 0 ppm
G_1 = 60 ppm
G_2 = 80 ppm

Nitrogen:
N_0 = 0 kg/ha
N_1 = 210 kg/ha
N_2 = 240 kg/ha
N_3 = 270 kg/ha

4.3 Leaf breadth (cm)

Leaf breadth varied significantly for application of different concentrations of GA_3 (Appendix IV). The maximum leaf breadth (19.80 and 23.33 cm) at 45 DAT and 60 DAT was obtained from G_1, which was statistically similar (19.78 and 23.04 cm) at same days after transplanting with G_2. The minimum (18.81 and 22.72 cm) at 45DAT and 60 DAT was obtained from G_0 (Table 3).

Different levels of nitrogen showed significant variation on leaf breadth (Appendix IV). The maximum leaf breadth (20.28 and 23.15 cm) at 45 DAT and 60 DAT was observed in N_3 and the minimum (18.48 and 21.46 cm) was obtained from N_0 (Table 3). The increasing of Nitrogen level increases the leaf breadth of cabbage.

The combined effect of GA_3 and nitrogen was significantly varied on leaf breadth (Appendix IV). The maximum leaf breadth (21.60 and 24.23 cm) at 45 DAT and 60 DAT was recorded from the treatment combination of G_1N_3 which was statistically similar to G_2N_2 (21.20 cm) at 45 DAT and G_oN_1 (23.66 cm) at 60 DAT. The treatment combination of G_0N_0 (control) gave the minimum (17.13 and 21.06 cm) leaf breadth at 45 DAT and 60 DAT (Table 4). From the results it was found that both GA_3 application and dose favored for maximum leaf breadth of plant growth.

Table 3. Effect of gibberellic acid and nitrogen levels on leaf breadth of cabbage at different days after transplanting

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

Table 4: Combined effect of gibberellic acid and nitrogen levels on leaf breadth of cabbage at different days after transplanting

Combinations	Leaf breadth (cm)	
	45 DAT	**60 DAT**
G_0N_0	17.13 c	21.06 bc
G_0N_1	20.33 abc	23.66 ab
G_0N_2	19.20 abc	21.73 abc
G_0N_3	18.60 abc	22.50 abc
G_1N_0	20.20 abc	20.33 c
G_1N_1	18.26 abc	21.13 bc
G_1N_2	19.13 abc	22.00 abc
G_1N_3	21.60 a	24.23 a
G_2N_0	18.13 bc	23.00 abc
G_2N_1	19.13 abc	22.66 abc
G_2N_2	21.20 ab	21.73 abc
G_2N_3	20.66 ab	22.73 abc
CV%	10.24	6.65
LSD (0.05)	3.37	2.69

Gibberellic acid:
G_0 = 0 ppm
G_1 = 60 ppm
G_2 = 80 ppm

Nitrogen:
N_0 = 0 kg/ha
N_1 = 210 kg/ha
N_2 = 240 kg/ha
N_3 = 270 kg/ha

4.5 Canopy (cm)

Canopy of plant varied significantly at different days after transplanting (DAT) due to application of different concentrations of GA_3 (Appendix V). At 60 DAT the maximum plant canopy (54.13 cm) obtained from G_1, while the minimum (52.98 cm) was recorded from G_0. The effect of GA3 application on canopy of plant was best at the concentration of 60 ppm. Lendve *et al*. (2010) reported maximum canopy of plant was obtained from 50 ppm GA_3. Yadav, *et al.* (2000) found the maximum plant canopy (0.187 m^2) resulted from two sprays with gibberellic acid at 150 ppm.

Different levels of nitrogen showed insignificant variation on plant canopy at different days after transplanting (DAT) (Appendix V). The maximum plant canopy (55.60 cm) was observed in N_1 and the minimum (53.17 cm) was found from both N_0 and N_2 at 60 DAT (Table 5). Nitrogen upto 210 kg/ha gradually increase the growth of cabbage plant. Khadir*et al.* (1989) obtained increased plant growth from 276 kg N/ha. Pramanik (2007) reported that the maximum canopy of plant was obtained from 260 kg N/ha.

The variation was found for combined effect of GA_3 and nitrogen on plant canopy at different DAT. The maximum plant canopy (57.06 cm) was recorded from the treatment combination of G_2N_1 (210 kg/ha N with GA_3 at 80 ppm), which was statistically similar with the combination G_1N_1 (56.40 cm), G_1N_o (55.13 cm) and G_1N_3 (54.93 cm). The treatment combination of G_0N_0 (control) gave the minimum (51.33 cm) plant canopy (Table 6) at 60 DAT. From the results it was found that both GA_3 and nitrogen levels influence the plant growth that means canopy.

Table 5. Effect of gibberellic acid and nitrogen levels on canopy of cabbage at 60 DAT

GA_3	Canopy (cm) (60DAT)	Nitrogen	Canopy (cm) (60DAT)
G_0	52.98 b	N_0	53.17 b
G_1	54.13 a	N_1	55.60 a
G_2	55.06 ab	N_2	53.17 b
CV%	5.19	N_3	54.28 ab
LSD (0.05)	1.91	CV%	5.19
		LSD (0.05)	2.21

Table 6: Combined effect of gibberellic acid and nitrogen levels on canopy of cabbage at 60 DAT

Combinations	Canopy (cm) (60DAT)
G_0N_0	51.33 c
G_0N_1	53.33 abc
G_0N_2	52.93 bc
G_0N_3	54.33 abc
G_1N_0	55.13 abc
G_1N_1	56.40 ab
G_1N_2	53.80 abc
G_1N_3	54.93 abc
G_2N_0	53.06 bc
G_2N_1	57.06 a
G_2N_2	52.80 bc
G_2N_3	53.60 abc
CV%	5.19
LSD (0.05)	2.83

Gibberellic acid:
G_0 = 0 ppm
G_1 = 60 ppm
G_2 = 80 ppm

Nitrogen:
N_0 = 0 kg/ha
N_1 = 210 kg/ha
N_2 = 240 kg/ha
N_3 = 270 kg/ha

4.6 Weight of head (kg)

Fresh weight of head varied significantly for different concentrations of GA_3 (Appendix V). The maximum fresh weight of head (2.10 kg) was obtained from G_1, while the minimum (1.78 kg) was recorded from G_2 (Table 7). The effect of GA_3 application on fresh weight of head was optimum at the concentration of 60 ppm. Chauhan and Bordia (1971), and Badawi and Sahhar (1979) found maximum yield for 50 ppm GA_3.

Different nitrogen levels showed significant variation on fresh weight of head (Appendix V). The maximum head weight (1.97 kg) was observed from N_3 and the minimum (1.89 kg) was found in both N_0 and N_1 (Table 7). Nitrogen levels upto 270 kg/ha gradually increase the head weight of cabbage plant. Singh and Naik (1988) found that 180 kg N/ha performed the highest yield.

The variation was found for combined effect of GA_3 and nitrogen levels on fresh weight of head. The maximum head weight (2.38 kg) was recorded from the treatment combination of G_1N_2 which was statistically similar to G_1N_1, G_1N_o and G_0N_3, while the treatment combination G_0N_0 (control) gave the minimum (1.68 kg) fresh weight of head(Table 8). From the results it was found that both GA_3 and nitrogen levels influence the cabbage yield which was ensured by maximum fresh weight of head. Zee (1978) reported that plant fresh weight was considerably enhanced with the application of 20 ppm GA_3.

4.7 Head diameter (cm)

Head diameter varied significantly for the application of different concentrations of GA_3 (Appendix V). The maximum head diameter (22.45 cm) was obtained from G_1, while the minimum (19.30 cm) was recorded from G_0 (Table 7). The effect of GA_3 application on head diameter was the best at the concentration of 60 ppm. Nasiruddin and Roy (2011) reported that the maximum head diameter was obtained from 50 ppm GA_3.Moyazzama (2008) reported that the maximum diameter of head was obtained from 85 ppm of GA_3.

Different levels of nitrogen showed significant variation on head diameter (Appendix V). The maximum head diameter (20.98 cm) was observed in N_3 which was followed by N_1 (20.65 cm)

and the minimum (20.34 cm) was found in N_0(Table7). Nitrogen upto 270 kg/ha gradually increase the head size of cabbage plant. Pramanik (2007) reported that the maximum diameter of head was obtained from 260 kg of nitrogen per hectare. Hossain (1998) obtained maximum head diameter from 250 kg N/ha. Ghanti*et al.* (1982) reported that head diameter increase in the levels of nitrogen up to 200 kgha-1.Bhuiyan (1996) reported that diameter of the head was maximum at a rate 150 kg N/ha.

The variation was found for combined effect of GA_3 application and nitrogen levels on head diameter. The maximum head diameter (24.00 cm) was recorded from the treatment combination of G_1N_2 which was statistically similar to G_1N_1 (23.13 cm) and G_1N_3 (22.03 cm), while the treatment combination of G_oN_3 (18.66 cm) gave the minimum head diameter which was statistically similar to G_2N_2 (18.80 cm) (Table 8). From the findings it was revealed that both GA_3 application and nitrogen levels influence the yield which ensured by the maximum head diameter.

Table 7. Effect of gibberellic acid and nitrogen levels on weight of head and head diameter of cabbage

GA_3	**Weight of head (kg)**	**Head diameter (cm)**
G_0	1.88 b	19.30 b
G_1	2.10 a	22.45 a
G_2	1.78 b	20.01 b
CV%	9.91	6.17
LSD (0.05)	0.20	1.25
Nitrogen		
N_0	1.89	20.34 c
N_1	1.89	20.65 b
N_2	1.94	20.37 a
N_3	1.97	20.98
CV%	11.47	6.17
LSD (0.05)	0.028	0.29

Gibberellic acid:
G_0 = 0 ppm
G_1 = 60 ppm
G_2 = 80 ppm
Nitrogen:
N_0 = 0 kg/ha
N_1 = 210 kg/ha
N_2 = 240 kg/ha
N_3 = 270 kg/ha

Table 8: Combined effect of gibberellic acid and nitrogen levels on weight of head and head diameter of cabbage

Combinations	Weight of head (kg)	Head diameter (cm)
G_0N_0	1.68 c	19.36 d
G_0N_1	1.91 b	18.86 d
G_0N_2	1.99 abc	20.30 cd
G_0N_3	2.07 abc	18.66 d
G_1N_0	2.11 ab	20.66 bcd
G_1N_1	2.12 ab	23.13 ab
G_1N_2	2.38 a	24.00 a
G_1N_3	2.01 abc	22.03 abc
G_2N_0	1.77 bc	21.00 bcd
G_2N_1	1.78 bc	19.96 cd
G_2N_2	1.88 bc	18.80 d
G_2N_3	1.98abc	20.30 cd
CV%	9.91	6.17
LSD (0.05)	0.40	2.50

Gibberellic acid:
G_0 = 0 ppm
G_1 = 60 ppm
G_2 = 80 ppm

Nitrogen:
N_0 = 0 kg/ha
N_1 = 210 kg/ha
N_2 = 240 kg/ha
N_3 = 270 kg/ha

4.8 Fresh weight of root (g)

Fresh weight of root was varied significantly for different concentrations of GA_3 (Appendix V). The maximum fresh weight of root (22.66 g) was obtained from G_1, while the minimum (18.12 g) was recorded from G_0 (Table 9). The effect of GA_3 on fresh weight of root was best at the concentration of 60 ppm which was followed by 80 and 0 ppm. Lendve*etal*. (2010) reported maximum fresh weight of root was observed from 50 ppm GA_3. Moyazzama (2008) reported that the maximum fresh weight of root was obtained from 85 ppm GA_3.

Different nitrogen levels showed significant variation on fresh weight of root (Appendix V). The maximum fresh weight of root (20.52 g) was observed in N_2 which was statistically similar to N_3 (20.40 g) and the minimum (19.73 g) was found from N_0 (Table 9). Nitrogen upto 240 kg/ha gradually increase the root growth of cabbage plant. Pramanik (2007) reported that the maximum fresh weight of root was obtained from 260 kg N/ha.

The variation was found for the combined effect of GA_3 application and nitrogen levels on fresh weight of root. The maximum fresh weight of root (24.00 g) was recorded from the treatment combination of G_1N_2 which was statistically similar to G_1N_o (23.00 g) and G_1N_3 (22.66 g), while the treatment combination of G_0N_0 gave the minimum (16.86 g) fresh weight of root (Table 10). From the results it was reported that both GA_3 application and nitrogen levels influence the plant growth which ensured maximum fresh weight of root.

4.9 Length of root (cm)

Due to application of different levels of GA_3 and nitrogen showed significant variation on length of root on cabbage (Appendix V). The maximum length of root (19.55 cm) was obtained from G_1, while the minimum (15.42 cm) was recorded from G_0 (Table 9). The effect of GA_3 on length of root was best at concentration of 60 ppm which was followed by 80 and o ppm.

Different nitrogen levels showed significant variation on fresh weight of root (Appendix V). The maximum length of root (17.15 cm) was obtained from N_1 , while the minimum (16.23 cm) was recorded from N_0 (Table 9).The effect of nitrogen on length of root was best at 210 kg/ha.

The variation was not found for the combined effect of GA_3 and nitrogen on length of root (Appendix V). The maximum length of root (23.33 cm) was recorded from the treatment combination of G_1N_3 which was statistically similar to G_1N_2 (22.23 cm), G_1N_0 (20.05 cm) and G_2N_3 (16.86 cm), while the treatment combination of G_0N_0 gave minimum (16.70 cm) length of root (Table 10). From the results, it was reported that both GA_3 application and nitrogen levels influenced the plant growth which ensured maximum length of root.

Table 9. Effect of gibberellic acid and nitrogen levels on fresh weight of root and length of root of cabbage

GA_3	**Fresh weight of root (g)**	**Length of root (cm)**
G_0	18.12 c	15.42 b
G_1	22.66 a	19.55 a
G_2	19.79 b	16.40 b
CV%	8.01	9.82
LSD (0.05)	1.36	1.46
Nitrogen		
N_0	19.73 a	16.23b
N_1	20.12 a	17.15 a
N_2	20.52 a	16.88 a
N_3	20.40	16.46 a
CV%	8.01	9.82
LSD (0.05)	0.77	2.62

Gibberellic acid:
G_0 = 0 ppm
G_1 = 60 ppm
G_2 = 80 ppm

Nitrogen:
N_0 = 0 kg/ha
N_1 = 210 kg/ha
N_2 = 240 kg/ha
N_3 = 270 kg/ha

Table 10: Combined effect of gibberellic acid and nitrogen levels on fresh weight of root and length of root of cabbage

Combinations	Fresh weight of root (g)	Length of root (cm)
G_0N_0	16.86 h	16.50 f
G_0N_1	19.80 defg	18.06 def
G_0N_2	17.33 gh	18.23 ef
G_0N_3	18.50 efgh	18.90 cdef
G_1N_0	23.00 ab	20.05 abc
G_1N_1	21.00 bcde	20.73 bcd
G_1N_2	24.00 a	22.23 ab
G_1N_3	22.66 abc	23.33 a
G_2N_0	21.33 abcd	18.00 ef
G_2N_1	19.56 efgh	19.56 bcde
G_2N_2	20.23 cdef	17.50 c
G_2N_3	18.03 fgh	10.86 abc
CV%	8.01	9.82
LSD (0.05)	2.73	2.73

Gibberellic acid:
G_0 = 0 ppm
G_1 = 60 ppm
G_2 = 80 ppm

Nitrogen:
N_0 = 0 kg/ha
N_1 = 210 kg/ha
N_2 = 240 kg/ha
N_3 = 270 kg/ha

4.10 Dry matter percent of root

Significant variation was observed on dry matter content of 100g root of cabbage for different gibberellic acid concentration under the present study (Appendix V). The highest dry matter content of 100g root (17.20%) was found from G_1, while the lowest dry matter content of 100g root (15.80%) was recorded from G_0 (Table 11). Lendve *et al*. (2010) reported that maximum dry weight of root was obtained from 50 ppm GA_3.

Different levels of nitrogen fertilizer showed significant variation for dry matter content of 100g root of cabbage (Appendix V). The highest dry matter content of 100g root (20.15%) was found from N_2, whereas the lowest dry matter content of 100g root (15.45%) was recorded from N_0 (Table 11).

The interaction effect of different concentrations of gibberellic acid and nitrogen fertilizer showed significant differences on dry matter content of 100g root of cabbage (Appendix V). The highest dry matter content of 100g root (20.56%) was recorded from G_1N_2 and the lowest dry matter content of 100g root (15.56%) was found from G_0N_0 (Table 12).

4.11 Dry matter percent of leaf

Significant variation was recorded for dry matter content of 100g leaf of cabbage for different concentrations of gibberellic acid under the present study (Appendix V). The highest dry matter content of 100g leaf (7.22%) was recorded from G_1 which was followed by G_2 (6.26%), while the lowest dry matter content of 100g leaf (5.54%) was found from G_0 (Table 11). Chauhan *et al*. (2009) agreed to the findings of the present study.

Different nitrogen levels showed significant variation for dry matter content of 100g leaf of cabbage (Appendix V). The highest dry matter content of 100g leaf (6.56%) was found from N_2 which was followed (6.17%) by both N_1 and N_3, whereas the lowest dry matter content of 100g leaf (6.08%) was found from N_0.

Significant difference was observed on dry matter content of 100g leaf of cabbage due to combined effect of different concentrations of gibberellic acid and nitrogen fertilizer

(AppendixV). The highest dry matter content of 100g leaf (8.26%) was recorded from G_1N_2 and the lowest dry matter content of 100g leaf (4.53%) was found from G_0N_0 (Table 12).

Table 11. Effect of gibberellic acid and nitrogen levels on dry matter percent of root and matter percent of leaf of cabbage

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

Gibberellic acid:
G_0 = 0 ppm
G_1 = 60 ppm
G_2 = 80 ppm

Nitrogen:
N_0 = 0 kg/ha
N_1 = 210 kg/ha
N_2 = 240 kg/ha
N_3 = 270 kg/ha

Table 12: Combined effect of gibberellic acid and nitrogen levels on dry matter percent of root and matter percent of leaf of cabbage

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

Gibberellic acid:
G_0 = 0 ppm
G_1 = 60 ppm
G_2 = 80 ppm

Nitrogen:
N_0 = 0 kg/ha
N_1 = 210 kg/ha
N_2 = 240 kg/ha
N_3 = 270 kg/ha

4.12 Yield (kg/plot)

Yield per plot varied significantly for application of different concentrations of GA_3 (Appendix V). 31.637 kg cabbage was obtained as highest yield/plot from G_1 (60 ppm of GA_3), while 26.750 kg cabbage was found as lowest yield/plot from G_2 (80 ppm of GA_3) (Table 13). The best effect of GA_3 application on yield per plot was obtained from the concentration of 60 ppm. Badawi and Sahhar(1979) reported that plants treated with GA_3 (50 ppm) showed significantly greater yield per plot than untreated controls. Chauhan and Bordia (1971)revealed that a gradual increase in the yield per plot with 50 ppm of GA_3.

Significant variation was observed for different levels of nitrogen on yield per plot (Appendix V). Yield per plot was highest (30.75 kg) in nitrogen dose N_2 (240 Kg/ha) and it was followed by 28.65 kg in N_1 (210 kg/ha), while the lowest yield per plot (25.50 kg) was found in N_0 (control) (Table 13). The best effect of nitrogen application on yield per plot was obtained from the dose of 240kg/ha. Singh and Naik (1988) reported that 180 kg N/ha performed the highest yield.

The combined effect of GA_3 and nitrogen was found significant variation on yield per plot. The treatment combination $G_1N_2$was produced the maximum yield/plot (35.20 kg), while the treatment combination G_0N_0 was performed the lowest yield/plot (24.80 kg) (Table 14). From the results it was found that 60 ppm of GA_3 and 240 kg N favored highest yield per plot.

Table 13. Effect of gibberellic acid and nitrogen levels on yield/plot of cabbage

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

Gibberellic acid:
G_0 = 0 ppm
G_1 = 60 ppm
G_2 = 80 ppm
Nitrogen:
N_0 =0 Kg/ha
N_1- 210 kg/ha
N_2 = 240 Kg/ha

N_3 = 270 Kg/ha

4.13 Yield (t/ha)

Significant variation was observed on yield/ha (ton) for application of different concentrations of GA_3 (Appendix V). The highest yield/ha (87.876 ton) was obtained from G_1 (60 ppm GA_3), while the lowest (74.296 ton) was found from G_2 (80 ppm) (Figure 5).Maximum yield/ha was found by Nasiruddin and Roy (2011) and it was revealed that 50ppm 0f GA_3 produced highest yield. Significantly the highest yield (104.66 t/ha) was found from the treatment of 50 ppm GA_3 was found by Roy *et al*. (2010). Yadav *et al.* (2000) reported the highest yield (494.78 q/ha) was obtained in the treatment with two sprays of gibberellic acid at 100 ppm.Dharmender*et al.* (1996) reported high yield was observed from the treatment with 50 ppm GA_3.

Nitrogen showed significant variation in different levels on yield/ha (Appendix V). The highest yield/ha (85.41 ton) was obtained from N_2 (240 Kg/ha) and the lowest (70.83 ton) was found from N_0 (Control) (Figure 6). Gupta (1987) observed significantly higher cabbage yields at 150 kg/ha N. The highest yield/ha was obtained from nitrogen doses 180 kg/ha which was reported by Singh and Naik (1988). Parmar *et al.* (1999) reported higher yields was observed from application of 200 kgha-1 N.Bhuiyan (1996) reported that highest gross yield (79.62 ton/ha) was achieved by the application of 150 kg N/ha compared to the lowest yield at 28.88 ton/ha case of 0 kg N/ha.

The interaction of GA_3 with nitrogen was found significant on yield/ha. The maximum yield (97.77 ton) was noted from the treatment combination of G_1N_2 (60 ppm GA_3 with 240 Kg N/ha), while the treatment combination of G_0N_0 (Control) gave the minimum (68.88 ton) yield (Table 14). From the present findings it was revealed that 60 ppm GA_3 with 200 kg N/ha favored for obtaining higher yield of cabbage.

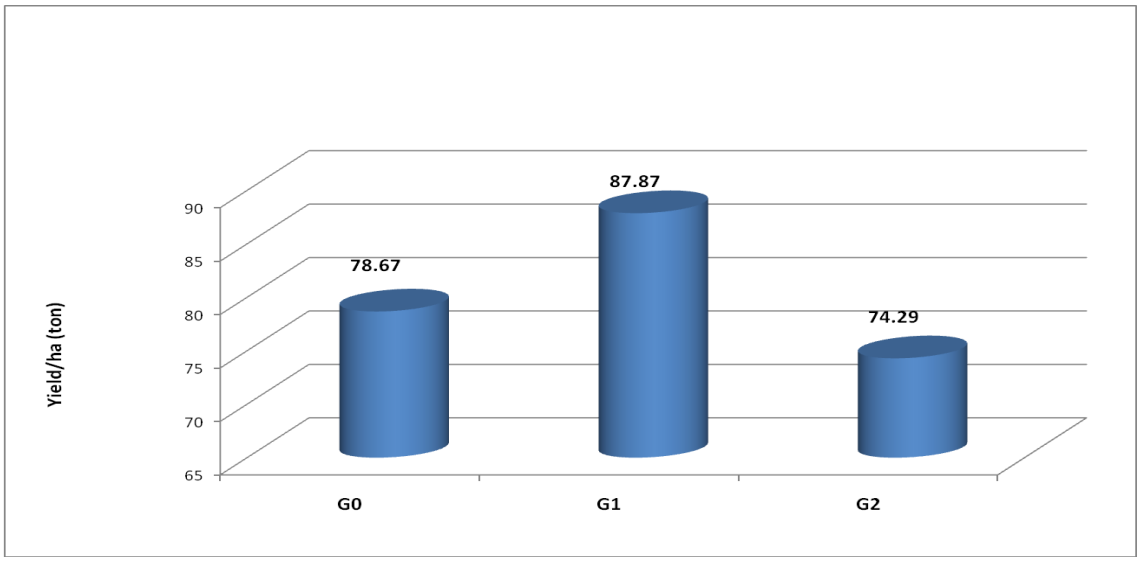

Figure 5. Effect of gibberellic acid on yield (t/ha) of cabbage

Gibberellic acid:
G_0 = 0 ppm
G_1 = 60 ppm
G_2 = 80 ppm

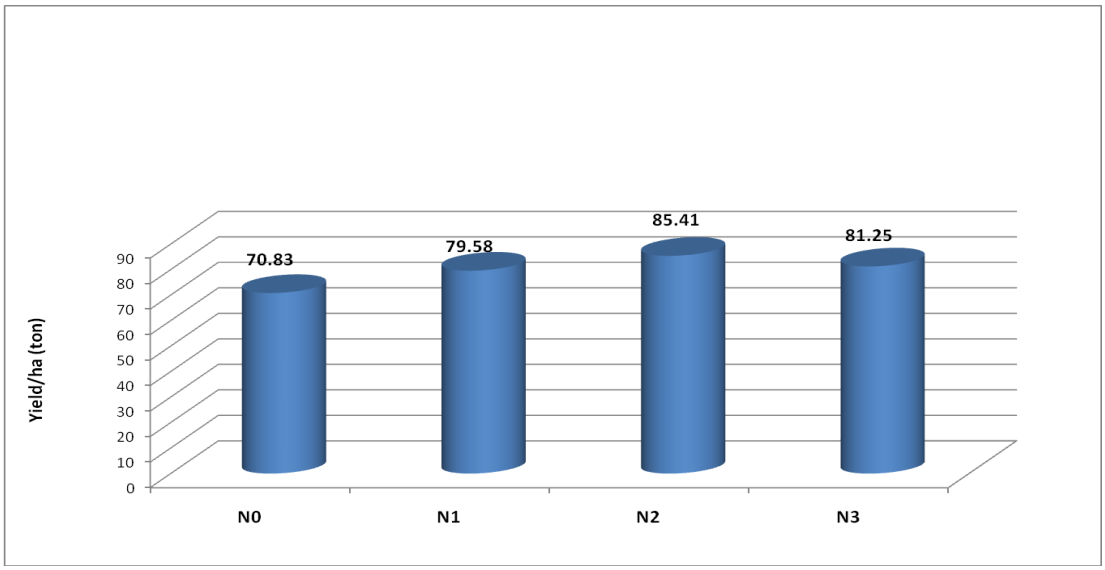

Figure 6. Effect of nitrogen levels on yield (t/ha) of cabbage

Nitrogen:
N_0 = 0 kg/ha
N_1 = 210 kg/ha
N_2 = 240 kg/ha
N_3 = 270 kg/ha

Table 14: Combined effect of gibberellic acid and nitrogen levels on yield (kg/plot) and yield (t/ha) of cabbage

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

Gibberellic acid:
G_0 = 0 ppm
G_1 = 60 ppm
G_2 = 80 ppm

Nitrogen:
N_0 = 0 kg/ha
N_1 = 210 kg/ha
N_2 = 240 kg/ha
N_3 = 270 kg/ha

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was carried out in the Horticultural farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207 during the period from October 2015 to February 2016 to find out the growth and yield of cabbage influenced by GA_3 and nitrogen. The experiment consisted of two factors Factor A : different doses of GA_3 such as G_0 = control, G_1 = 60 ppm and G_2 = 80 ppm; Factor B : different doses of nitrogen such as N_0 = control, N_1 = 210 kg/ha, N_2 = 240 kg/ha and N_3 = 270 kg/ha. Data on different growth and yield contributing characters were recorded.

The highest plant (40.48 cm) was recorded from $G_1$and the minimum (34.85 cm) was recorded from G_0 at 60 DAT. The maximum number of leaves per plant (17.90) at 60 DAT was found from G_1 and the minimum (16.68) was recorded from G_0. The maximum leaf breadth (23.33 cm) at 60 DAT was obtained from G_1 and the minimum (22.72 cm) at 60 DAT was obtained from G_0. At 60 DAT,the maximum plant canopy (55.06 cm) obtained from G_2, while the minimum (52.98 cm) was recorded from G_0. The maximum fresh weight of head (2.10 kg) was obtained from G_1, while the minimum (1.78 kg) was recorded from G_0. The maximum head diameter (22.45 cm) was obtained from G_1, while the minimum (19.30 cm) was recorded from G_0. The maximum fresh weight of root (22.66 g) was obtained from G_1, while the minimum (18.12 g) was recorded from G_0. The highest dry matter (%) of root (17.20) was found from G_1, while the lowest dry matter (%) of root (15.80) was recorded from G_0. The highest dry matter (%) of leaf (7.22) was recorded from G_1 while the lowest dry matter (%) of leaf (5.54) was found from G_0. Highest yield (31.63kg/plot) was obtained from G_1 of cabbage, while lowest yield (26.750 kg/plot) was found from G_0. The highest yield (87.87t/ha) was obtained from G_1, while the lowest (74.29 t/ha) was found from G_2.

The highest plant (38.64 cm) was recorded from N_2 and lowest plant height was observed at 36.48 cm fromN_0 at 60 DAT. At 60 DAT, the maximum number of leaves per plant (16.36) was counted from nitrogen dose N_1. The minimum number (15.97) was found from N_2 at 60 DAT. The maximum leaf breadth (23.15 cm) at 60 DAT was observed in N_3 and the minimum (21.46 cm) was obtained from N_0. The maximum plant canopy (55.60 cm) was observed in N_1 and the minimum (53.17 cm) was found from both N_0 and N_2 at 60 DAT. The maximum head weight (1.97 kg) was observed from N_3 and the minimum (1.89 kg) was found in both N_0 and N_1. The maximum head diameter (20.98 cm) was observed in $N_3$and the minimum (20.34 cm) was found in N_0. The maximum fresh weight of root (20.52 g) was observed in N_2 and the minimum (19.73 g) was found from N_0. The highest dry matter (%) of root (20.15) was found from N_2, whereas the lowest dry matter (%) of root (15.45) was recorded from N_0. The highest dry matter (%) of leaf (6.56) was found from N_2, whereas the lowest dry matter (%) of leaf (6.08) was found from N_0. Yield was the highest (30.75 kg/plot) in nitrogen dose N_2, while the lowest yield (25.50 kg/plot) was found in N_0. The highest yield (85.41 t/ha) was obtained from N_2 and the lowest (70.83 t/ha) was found from N_0.

The maximum (40.00 cm) plant height was recorded from the treatment combination of G_1N_2 and the minimum (30.97 cm) was recorded from the treatment combination of G_2N_2 at 60 DAT. At 60 DAT, the maximum number of leaves per plant (17.30) was recorded from G_1N_3. The minimum number of leaves per plant (15.26) was found from G_2N_0 at 60 DAT. The maximum leaf breadth (24.23 cm) at 60 DAT was recorded from the treatment combination of G_1N_3. The treatment combination of G_0N_0 (control) gave the minimum (21.06 cm) leaf breadth at 60 DAT. The maximum plant canopy (57.06 cm) was recorded from the treatment combination of G_2N_1. The treatment combination of G_0N_0 gave the minimum (51.33 cm) plant canopy at 60 DAT. The maximum head weight (2.38 kg) was recorded from the treatment combination of G_1N_2,

while the treatment combination G_0N_0 gave the minimum (1.68 kg) fresh weight of head. The maximum head diameter (24.00 cm) was recorded from the treatment combination of G_1N_2, while the treatment combination of G_oN_3 (18.66 cm) gave the minimum head diameter. The maximum fresh weight of root (24.00 g) was recorded from the treatment combination of G_1N_2, while the treatment combination of G_0N_0 gave the minimum (16.86 g) fresh weight of root. The highest dry matter (%) of root (20.56) was recorded from G_1N_2 and the lowest dry matter (%) of root (15.56) was found from G_0N_0. The highest dry matter (%) of leaf (8.26) was recorded from G_1N_2 and the lowest dry matter (%) of leaf (4.53) was found from G_0N_2. The treatment combination G_1N_2 was produced the maximum yield (35.20 kg/plot), while the treatment combination G_0N_0 was performed the lowest yield (24.80 kg/plot). The maximum yield (97.77 t/ha) was noted from the treatment combination of G_1N_2, while the treatment combination of G_0N_0 gave the minimum (68.88 t/ha) yield.

Conclusions

Among the combinations of different levels of gibberellic acid and nitrogen fertilizer 60 ppm GA_3 and 240 kg N/ha induced the superior growth, yield contributing characters and yield of cabbage.

Considering the situation of the present experiment, further studies in the following areas may be suggested:

1. Such study may be trialed in different agro-ecological zones (AEZ) of Bangladesh for exploitation of regional adaptability and other performances,
2. Some higher levels of GA_3 and nitrogen may be included in future program for more confirmation of the results.

REFERENCES

Abdalla, I. M., Helal, R. M. and Zaki, M. E. (1980). Studies on the effect of some growth regularors on yield and quality of cauliflower. *Ann. Agric. Sci*., **12**: 199-200.

Badawi, M. A. and EL-Sahhar, K. F. (1979). Influence of some growth substances on different characters of cabbage. *Egypt. J. Hort*., **6** (2): 221-235.

Balvoll, G. (1994). Res. with cultivars, nitrogen manuring and plant spacings in ` abed system for winter cabbage.*NorskLandbruksforsking*. **8**(1): 65-73.

BARC. (2005). Fertilizer Recommendation Guide. 111p.

Batsei, S.I.,Polyakov, A.A. and Nedel, R.F. (1979). Effect of organic mineral fertilizers on the yield and quality of irrigated late white cabbage. *Khimiya V. Sel. Skonhhozyistve*., **17** (3): 18-20.

BBS,(2000). Monthly Statistical Bulletin of Bangladesh Bureauof Statistics, Ministry of planning, Govt. of the people'srepublic of Bangladesh, Dhaka. 2000, 136.

Bhuiyan, S. M. (1996). Effect of different levels of nitrogen and their time of application on the growth and yield of cabbage. *Hort. Abstr*., **42**(1): 1078.

Chauhan, K. S. and Bordia, N. S. (1971). Effect of gibberellic acid, beta-naphthoxy acetic acid and 2, 4-dichlorophenoxy acetic acid as pre-sowing seed treatment on growth and yield of cabbage (*Brassica oleracea*var. *capitata*L.). *Indian J. Hort.,* **28**: 57-59.

Chauhan .(1986).Vegetable production in India. Ram Prasad and sons, India. 131-140pp.

Chauhan U. M. and Y. N. Tandel. (2009). Effect of plant growth regulators on growth, yield and quality of cabbage (*Brassica oleracea*var. capitata L.) cv. Golden Acre. *The Asian J. Hort.,* **4**(2): 512-514.

Chauhan, K. S. and Singh, R. (1970). Response of cabbage on foliar application of gibberellic acid and urea.

Chauhan, K. S. and Bordia, N. S. (1971). Effect of gibberellic acid, beta-naphthoxy acetic acid and 2, 4-dichlorophenoxy acetic acid as pre sowing seed treatment on growth and yield of cabbage (*Brassica oleracea*var. *capitata*L.). *Indian J. Hort.*, **28**: 57-59. *an J. Hort*., **27**: 68-70.

Chhonkar, V. S. and R. N. Jha. (1963). The use ofstarter solutions and plant growth regulatorsin transplanting of cabbage and theirresponse on growth and yield, *Indian J.Hort.,* **20**(2):122-128.

Chhonkar, V. S. and Singh, R. (1985). Effect of NAA and 2, 4-D on growth, yield and quality of cabbage (*Braicaoleracea*var. *capitata*L.). *Indian J. Hort*., **22**: 322-329.

Csizinszky, A.A. and Schyster, D.J. (1985). Response of Cabbage to insecticide schedule, plant spacing and fertilizer rates. *J Amer. Soc. Hort.* Sci., **110**(6): 888-893.

Dharmender, K., Guja, K. D., Paliwal, R. and Kumar, D. (1996). Yield and yield attributes of cabbage as influenced by GA_3 and NAA. *Crop Res. Hisar*., **12**(l): 120-122.

Dhengle, R. P. and Bhosale, A. M. (2008). Effect of plant growth regulators on yield of cabbage (*Brassica oleraceae var. capitata). Interl. J. Plant Sci.,* **3**(2): 376-378.

Dixit, S.P. (1997). Effect of nitrogen and farmyard manure on the productivity of cabbage in a hot temperature; hills zone of Himachal Pradesh. *Ann. Agrill. Res*., **18**(2): 258-261.

Everaarts, A. P. and De Moel, C. P. (1998).Growth, development and yield of white cabbage in relation to the time of planting, Vollegrond, lelystad,132:50.

Farooque,A.M.and Mondal,M.F.(1987).Effect of spacing and level of nitrogen on growth and yield of cabbage.*Bangladesh Hort.,***15**(2):1-4.

Gopal, L. and Lal, G. (1996). Effect of nitrogen and spacing on yield and quality of cabbage. *Ann. Bot*., **12**(2): 242-244.

Gomez, K.A. and Gomez, A. A. (1984). Statistical Procedure for Agricultural Research, 2nd end., John Wiley and Sons, Singapore, 28-192.

Ghanti,P.,Sounda,G.,Jana,P.K. and Som, M. G. (1982).Effect of levels of nitrogen, phosphorus and spacing on yield characters of cabbage.*Veg. Sci.* **9**: 1-4.

Hill, T.R. (1990). Effect of plant spacing and nitrogenous fertilizer on the yield and plant conformation of Chinese cabbage. *Australian J. Eapcri. Agric*., **30**(3): 437-439.

Hossain, A. T. Z. (1998). Effect of different planting time, spacing and nitrogen on growth and yield of cabbage. *Ann. Agrill. Res*., **14**(2):1-4.

Islam, M,A., Siddique A.,andKashem M.A. (1993).Effect of growthregulators on the growth, yield and ascorbic acidcontent of cabbage. *Bangladesh J. Agril. Sci*., 20(1):21-27.

Islam, M. T. (1985). The effect of some growth regulators on yield and biomass production in cabbage. *Panjab Veg. Grower.*, **20**: 11-16.

Jaiswal, N.K., Khare., Sharma, B.K. and Shrivastava, S.S. (1992). Effect of nitrogen levels, methods of application and spacing on growth and productivity of cabbage. *Advances in Hort. And Forestry*., **2**: 158-164.

Kar, A. K., Islam, M. K.,Maniruzzaman, M. and Khatun,K.(2003). Effect of Plant growth regulators(PGR) on growth and yield of two cabbage varieties. *Bangladesh J. Online.,* p.807-811.

Kato, T. and Sooen, A. (1980). Physiological studies of head formation on cabbage. *J. Jap. Soc. Hort. Sci*., **48**(4): 426-434.

Khadir, G.A., Marazat, S.K. and Doun, S.A. (1989). Effect of different levels of urea fertilizer and plant spacing on growth and yield of cabbage. *Dirasat*. **16**(9): 88-105.

Khan, R., Ahmed, S., Khan, S., Ahmed, F., Zaman, M. and Khan , B. A. (2002). Effect of Different Levels of Nitrogen, Phosphorus and Potassium on the Growth and Yield of Cabbage. *Asian J. of Plant Sci.*, **1:** 548-549.

Khurana, S.C., Thakral, K.K., Sing, G.r. and Nuldita, M.L. (1987). Effect of nitrogen and spacing on cabbage cv. Pride of India. *Haryana J. Hort. Sci*., **16** (314): 274-277.

Kumar, D., Gujar, K. D. and Singh, K. (1996). Effect of GA and NAA on growth, chlorophyll content and maturity of cabbage. Crop Research (Hisar). 12(1): 116-119.

Lawande, K.E., Bhore, D.P., Kale P.N. and Patil, J.D. (1986). Effects of spacing, nitrogen, phosphorus and potassium on yield and yield contributing characters of cabbage. *J. Maharashtra. Agril. Univ*., **11**(2): 192-196.

Lendve, V. H., Chavan, S. D., Barkule, S. R. and Bhosale, A. M. (2010). Effect of foliar application of growth regulators on growth of cabbage cv. Pride of India. *The Asian J. Hort*., **5**(2): 475-478.

Leopold, A. C. (1963). Auxins and Plant Growth,Berkeley and Los Angeles, University of California Press. 5p.

Liao, F.X., Pan, R.C. and He, X.M. (2003). Effect of plant growth regulators and heat shock on shoot-tip culture in *Brassica campestris*L. *Acta Hort. Sinica*. **30**(2): 224-226.

Malik, S.C., Biswajit, B. Bhattacharya, B. (1996). Effect of different levels of nitrogen and different spacing on growth and yield of cabbage. *Environment and Ecology*., **14** (2): 304-306.

Man, K.S and Sandhu, B.B. (1956). On the nitrogen requirement of cabbage. *Indian J. Hort*., **12**: 188-195.

Mishra, H. P. and Singh, B. P. (1986). Studies on the nutrients and growth regulator interaction in “Snowball-16" cauliflower. *Prog. Hort*., **18** (1-2): 77-82.

Moazzama, K. (2008). Effect of different doses of GA_3 and potassium on growth and yield of cabbage. MS Thesis. Dept. of Hort., SAU, Dhaka. pp.24-47.

Muthoo, A. K., Kumar, S. and Maurya, A. N. (1987). Studies on the effect of foliar application of GA_3, NAA and molybdenum on growth and yield of Cauliflower (*Braicaoleracea*var. capitata L.). *Haryana J. Hort. Sci*., **16** (1-2): 115-120.

Nasiruddin, K. M. and Roy, R. (2011). Effect of different level of GA_3 on growth and yield of cabbage. *J. Environ. Sci. & Natural Resources*, **4**(2):79-82.

Nickell, L.G. (1982). Plant growth regulators. Springer-VerlagBerlin Heidelberg, New York, 1-3.

Parmar, H. C.,Maliwal,G. L.,Kaswala,R. R.andPatel, M, L. (1999).Effect of irrigation, nitrogen and spacing on yield ofcabbage.*IndianJ.Hort.***56**(3);256-258.

Park, Y.B., Ko, S.B. and Moon, J.S. (2002). Effectiveness of growth regulators on height control of cabbage plug seedlings. *Korean J. Hort. Sci. Tech*. **20**(3): 221-224.

Patil, A. A., Maniur, S. M. and Nalwadi, U. G. (1987). Effect of GA3 and NAA on growth and yield of cabbage. *South Indian Hort*., **35** (5): 393-394.

Peck,N.H.(1981).Cabbageplantresponsetonitrogenfertilization.*Agron.J.***73**:679-684.

Pendey, S. N. and Sinha, B. K. (1987). Physiology. Revised edition. Vikash Publishing House Pvt. Ltd., New Delhi- 110014. pp444-445.

Pramanik , S. (2007). Effect of nitrogen and phosphorus on the growth and yield of cabbage. MS Thesis. Dept. of Hort., SAU, Dhaka. pp.21-42.

Prabhakar, B. S. and Srinivas, K. (1987). Response of cabbage to spacing and fertilization. *Indian J. Agron*., **21**(1):113.

Rashid, M. M. (1993). Sabjibiggan. Bangla Academy, Dhaka. pp189-196.

Singh, R.V. and Naik, L.B. (1988). Repose of cabbage to plant spacing nitrogen and phosphorus levels. *Indian .J. Hort. Sci*., **39** (2): 1026-1028.

Srivastava, R. P. (1960). Effect of treatment on tomato seeds with plant regulators. *J. Sci. Res. BHU*., **11**(l): 80-85.

Thompson, H. C. and Kelly, W. C. (1957). Cole Crops. Vegetable Crops. McGraw Hill Book Co., New York. pp278-279.

Vijoy, K. N. R. and Kumar, V. (2000). Effect of plant growth regulators on cauliflower cv. Plant subhra. *Orisa J. Hort*., **28**(1):65-67.

Vleck, F. and Polack, J. (1977).Effect of the principle plant nutrients on Cabbage yield and quality. Zahradnictvi.**4** (314): 153-160 [cited from Hort.,Abstr.,**50** (6): 4193, 1980.

Wang, Z. and Li, S. (2004). Effects of Nitrogen and Phosphorus Fertilization on Plant Growth and Nitrate Accumulation in Vegetables. *J. of Plant Nutrition*., **27**(3):539-556.

Yabuta , T., Sumuki, Y., Asoc, K. and Hayashi, T. (1981). Effect of foliar spray of plant hormones on yield and quality of cabbage. *J. jep.soc. Hort. Sci*., **50**(3) :360-364.

Yadav, R. L., Dhaka, R. S. and Fageria, M. S. (2000). Effect of GA_3, NAA and succinic acid on growth and yield of cabbage. *Haryana J. Hort. Sci.*,**29** (3/4):269-270.

Yu, X. H., Li, W. P., Jiang, X. M., Liu, D. and Zhang, Y. (2010). Changes of endogenous hormone during devernalization in cabbage. *China Veg*. **20**: 38-41.

Zee, S. Y. (1978). The effect of GA_3 on plant growth before and after transplanting. *Acta. Hort*., 185-189.

APPENDICES

Appendix I. Characteristics of the soil of research field analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of the soil of experimental field

Morphological features	**Characteristics**
Location	Horticulture Field , SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained

B. Physical and chemical properties of the initial soil

Characteristics	**Value**
% Sand	27
% Silt	43
% Clay	30
Textural class	Silty-clay
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	13
Exchangeable K (me/100 g soil)	0.1
Available S (ppm)	33

Source: SRDI, 2013

Appendix II. Monthly record of air temperature, relative humidity and rainfall of the experimental site during the period from October, 2015 to February, 2016

Month	Air temperature (°C)		Relative humidity (%)	Rainfall (mm)
	Maximum	Minimum		
October,2015	29.18	18.25	81.10	38
November,2015	28.79	18.55	82.52	83.1
December,2015	25.33	14.50	84.07	0.00
January,2016	21.72	10.18	83.63	Trace
February,2016	26.78	15.50	75.20	26.10

Source: Bangladesh Meteorological Department (Climate and weather division) Agargaon, Dhaka - 1212

Appendix III. Analysis of variance of the data on plant height and number of loose leaves of cabbageas influenced by different levels of gibberellic acid and nitrogen

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

AppendixIV.Analysis of variance of the data on leaf breadth and leaf length of cabbage as influenced by different levels of gibberellic acid and nitrogen

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

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

Appendix V. Analysis of variance of the data on yield contributing characters of cabbage as influenced by different levels of gibberellic acid and nitrogen

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

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