INFLUENCE OF LIMING AND FOLIAR APPLICATION OF GA_3 ON GROWTH AND FLOWERING OF GLADIOLUS

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INFLUENCE OF LIMING AND FOLIAR APPLICATION OF GA_3 ON GROWTH AND FLOWERING OF GLADIOLUS

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CERTIFICATE

*This is to certify that the thesis entitled, **'Influence of Liming and Foliar Application of GA_3 on Growth and Flowering of Gladiolus"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment 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 **Tahrima Taslim**, Registration number: **08-02785** 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 duly been acknowledged.

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TO

MY BELOVED PARENTS

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INFLUENCE OF LIMING AND FOLIAR APPLICATION OF GA_3 ON GROWTH AND FLOWERING OF GLADIOLUS

BY

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ABSTRACT

An experiment was conducted to evaluate the growth and flower production of gladiolus as influenced by lime and GA_3 at Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka during November 2014 to March 2015. The experiment consisted of two factors where Factor A: three levels of lime i.e. L_0: 0, L_1: 2.5 and L_2: 5.0 t ha^{-1} and Factor B: four levels of GA_3 *viz.*, G_0: 0, G_1: 150, G_2: 200 and G_3: 250 ppm respectively. The experiment was laid out in Randomized Complete Block Design with three replications. Liming and GA_3 showed significant variation on most of the parameters. In case of lime, the highest no. of spike (327,000 ha^{-1}) and corm (13.6 t ha^{-1}) was recorded from L_1 and the lowest (319,000 ha^{-1}) and (13.1 t ha^{-1}) from L_0. For GA_3 the highest no. of spike (340,000 ha^{-1}) and corm (14.2 t ha^{-1}) was recorded from G_2 while the lowest (308,000 ha^{-1}) and (12.3 t ha^{-1}) from G_0. For interaction effect the highest no. of spike (350,000 ha^{-1}) and corm (15 t ha^{-1}) was recorded from L_1G_2 while the lowest (308,000 ha^{-1}) and (11.8 t ha^{-1}) from L_0G_0. The highest benefit cost ratio (2.64) was from L_1G_2 and the lowest (2.10) from L_2G_0. So, 2.5 ton lime ha^{-1} with 200 ppm GA_3 was found best for growth and flowering of gladiolus.

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LIST OF ABBREVIATION AND SYMBOL

Abbreviations		Expansion
@	=	At the rate of
AEZ	=	Agro–Ecological Zone
Agric.	=	Agriculture
Agril.	=	Agricultural
ANOVA	=	Analysis of variance
BARC	=	Bangladesh Agricultural Researcher Council
BARI	=	Bangladesh Agricultural Research Institute
BAU	=	Bangladesh Agricultural University
BBS	=	Bangladesh Bureau of Statistics
cm^2	=	Centimeter Square
CRD	=	Completely randomized design
CV (%)	=	Co–efficient of Variance
DAP	=	Days After Planting
DMRT	=	Duncan Multiple Range Test
et al.	=	and Others
FAO	=	Food and Agriculture Organization
G	=	Gram
HRC	=	Horticulture Research Centre
IAAS	=	Institute of Agriculture and Animal Science
LSD	=	Least significant difference
m^2	=	Square Meter
Max.	=	Maximum
Min.	=	Minimum
MP	=	Murate of Potash
NS	=	Non Significant
Ppm	=	Parts per million
RCBD	=	Randomized Complete Block Design
SAU	=	Sher-e-Bangla Agricultural University
SRDI	=	Soil Resources Development Institute
TSP	=	Triple Super Phosphate
UNDP	=	United Nations Development Program
Viz.	=	Namely

CHAPTER I

INTRODUCTION

Gladiolus (*Gladiolus grandiflorus* L.) is an herbaceous annual flower belongs to the family Iridaceae, is one of the most popular bulbous flowering plant (Bose and Yadav, 1989). The term gladiolus deriving from the Latin word gladiolus, meaning a sword, on account of the sword like shape of its foliage, however, previously it was the name of 'iris' which ancient Greeks used to call as 'xiphion' (Lehri *et al.*, 2011). Gladiolus is now grown as a cut flower widely in Europe, particularly in Holland, Italy and Southern France (Butt, 2005). It is a very popular cut flower in Bangladesh. It is also known as the Sword Lily, due to its sword shaped leaves. Gladiolus seems to be originated in South Africa and its development started only at the beginning of the 18th century. It was introduced from India around the year 1992 (Mollah *et al*., 2002). Gladiolus is a very colorful decorative flower which is grown in herbaceous border, bed, rockery, pot and also for cut flower (Bose and Yadav, 1989).

Gladiolus is a popular cut flower for its attractive spikes having floret of huge forms, dazzling colors, varying sizes and long durable quality as cut flower. It is frequently used in landscape, bedding, bouquets, flower arrangement etc. (Arora, 2007). It is also used as cut flower in different social and religious ceremonies. It has been appropriately providing a symbol of glamour and perfection (Singh *et al*., 2012). It gained popularity in many parts of the world owing to its unsurpassed beauty and economic value (Chadha and Choudhuary, 1986). Gladiolus is one on the most famous and popular cut flower for their majestic spikes, which contain attractive, colorful, elegant and delicate florets (Saeed *et al.*, 2013). The aesthetic value of gladiolus in the daily life is increasing with the advancement of civilization for the spikes owing to its elegance and long vase life and spikes are most popular in flower arrangement and preparing bouquets (Mukhopadhyay, 1995).

The production of gladiolus is mainly concentrated in few districts of Bangladesh such as Jessore, Jhenaidha, Satkhira, Dhaka, Mymensingh, Cox's Bazar, Chittagong and Rangpur. But very recently the flower production area appears to have increased significantly and estimated area of around 10,000 ha and the annual trade at wholesale level to be worth 500-1000 million taka in Bangladesh although which was much lower compared other countries of the world (Khan, 2009). The low yield of gladiolus in Bangladesh however is not an indication of low yielding potentially of this crop but of the fact that the low yield may be attributed to a number of reasons, viz. unavailability of quality seeds of high yielding varieties, land for production based on light availability, fertilizer management, pest infestation, improper irrigation facilities. Different management practices influence the production and quality of gladiolus flower as well as its corm and cormels (Khanna and Gill, 1983).

Lime as a source of calcium carbonate was used for crop and flower production in our country due to increase the fertility status of soil. Azman *et al.* (2014) reported that the low pH had adverse affect on plant growth while Kamruzzaman *et al.* (2013) reported that the application of dolochun ($CaCO_3$) was used as the liming material and showed statistically identical yield compared to chemical fertilizer. Farzana and Dadlani (2014) reported that soi pH should be 6.5 to 7.5 for proper growth and flowering of gladiolus. Reddy *et al*. (2014) also found that the vegetative and floral traits of Gladiolus are promoted with foliar application of calcium nitrate and calcium carbonate. Anonymous (2013) also reported that the dolomite powder is a material widely used in agriculture, flower gardening and house gardening and plant growing. Liming of acidic soils enhance the activities of beneficial microbes in the rhizosphere and hence improve root growth by the fixation of atmospheric nitrogen because neutral pH allows more optimal conditions for free living N fixation (Stephen *et al.*, 2011). Application of lime at an appropriate rate brings several chemical and biological changes in the soils, which are beneficial or helpful in improving crop yields and quality on acid soils (Fageria and Baligar, 2008).

Normal plant growth and development are regulated by naturally produced chemicals or endogenous plant hormones. Their role can often be substituted by application of synthetic growth regulating chemicals, which are becoming extremely important and valuable in the commercial control of crop growth in both agriculture and horticulture (Nickell, 1982). PGRs are also other important factors for maximizing the crop and flower production. The application of plant growth regulators is one of the most important factors in improving the growth, yield and flower quality. PGR are organic compounds, other than nutrients, which in small amount promote, inhibit or otherwise modify any plant physiological processes. Use of PGRs, has tremendous potentialities in flower production in Bangladesh (Saha, 2005). Among different PGRs gibberellic acid (GA_3) enhance the growth, development and yield of gladiolus at different concentrations with also the application of lime (Vijai *et al*., 2007). GA_3 increases the height of plants, number of flowers and induce early flowering. Studies indicated that the application of GA_3 can affect the growth and development of gladiolus flowers (Chopde *et al*., 2011).

There is a scope of increasing flower yield, quality of flower, corm and cormel production of gladiolus with the application of lime and GA_3. Considering the present situations and above facts therefore, the present study was undertaken with the following objectives-

i) to study the effect of lime on growth, flowering, corm and cormel production of gladiolus;

ii) to study the effect of GA_3 on growth, flowering, corm and cormel production of gladiolus; and

iii) to determine the suitable combination of lime and GA_3 for better production of gladiolus.

CHAPTER II

REVIEW OF LITERATURE

Gladiolus is one of the important cut flower in Bangladesh and as well as many countries of the world. A very few studies on the related to growth, flower, corm and cormel production due to application of liming and GA_3 have been carried out in our country as well as many other countries of the world. So the research work so far done in Bangladesh is not adequate and conclusive. Nevertheless, some of the important and informative works and research findings related to the influence of liming and GA_3 on growth, flower, corm and cormel production of gladiolus reviewed under the following headings:

2.1 Influence of liming on gladiolus

Athanasea *et al.* (2013) conducted an experiment under soil acidity to highlighting the most causes of soil acidification, lime quality and lime requirement at Sub–Sahara Africa. Soil acidity affects crops in many ways and its effects are mostly indirect, through its influence on chemical factors such as aluminum (Al) and manganese (Mn) toxicity, calcium (Ca), phosphorus (P) and magnesium (Mg) deficiencies and biological processes. The application of lime believed to enhance soil health status through improving soil pH, base saturation, Ca and Mg. It reduces Al and Mn toxicity and increases both P uptake in high P fixing soil and plant rooting system.

Anonymous (2013) reported that the dolomite powder is a material widely used in agriculture, flower gardening and house gardening and plant growing. The dolomite powder is the most valuable agricultural lime for a wide range of agricultural plants and houseplants like potato, beet, Lucerne, clover, buckwheat, onion, carrot, violet, orchid, Cape primrose etc. The dolomite powder neutralizes the soil acidity and enriches it with potassium, magnesium and other microelements valuable for plants. It is necessary to measure the soil acidity with ph–meter to decide if there is a need to add the dolomite powder to the soil. The normal soil acidity for houseplants is

6.5 pH, for garden plants – from 5.5 to 7.5 ph depending on the plant. If the acidity is less than values above, i.e. the soil are acid, the dolomite powder may help to normalize the soil for the plant to grow.

Liming acidic soils enhance the activities of beneficial microbes in the rhizosphere and hence improve root growth by the fixation of atmospheric nitrogen because neutral pH allows more optimal conditions for free–living N fixation (Stephen *et al.*, 2011). Application of lime at an appropriate rate brings several chemical and biological changes in the soils, which are beneficial or helpful in improving crop yields on acid soils (Fageria and Baligar, 2008). They also reported that the calcium released from applied lime in soil has been reported to enhance plant resistance to several plant pathogens, including *Erwinia phytophthora*, *R. solani*, *Sclerotium rolfsii*, and *Fusarium oxysporum*.

Kisinyo *et al.* (2005) reported that the soil acidity and phosphorus (P) deficiency are the major cause of acidic or poor *Leucaena leucocephala* establishment in tropical soils. A greenhouse experiment was conducted to determine the effects of lime (L) as $CaCO_3$ and phosphorus (P) as TSP on soil pH, P availability, leucaena nodulation, shoot growth, P and N contents. Both L and P had significant effects on P availability, shoot, weight, P and N, and nodule number, weight and N. Lime significantly ($P<0.05$) increased soil pH. Phosphorus decreased it, though not significantly. Based on the results, it is clear that acidity, P deficiency and poor nodulation limit leucaena establishment and growth in acid soils.

Gillman *et al.* (1998) reported that the 'Royal Red' was grown in pine bark amended with 0, 0.4. 0.8. 1.6 or 3.2 Ibs/yd) dolomitic lime. Growth characteristics, responded quadratically to dolomitic lime with those plants receiving 2.4 kg m^{-1}) having the greatest shoot and root dry weights and inflorescence numbers. Plants grown in 3.2 Ibs/yd had the greatest shoot lengths. Although all dolomite lime amendments was tested improved growth of Buddleia davidii 'Royal Red'. The incorporation of 1.6 Ibs/yd produced growth and Inflorescence quantity.

2.2 Influence of GA_3 on gladiolus

Sajjad *et al.* (2015) carried out an experiment to enhance the sprouting of multiple buds and evaluate its effects on other growth parameters. Result revealed that the Gibberellic acid at 100 ppm concentration increased plant height to 105 cm compared to 97.60 cm in control plants, flowering percentage (84.67%), spike length (40.03 cm) and also boosted the corm weight (68.30 g).

Sajid *et al.* (2015) investigate the effect of foliar application of gibberellic acid and 6–benzyl aminopurine on growth, flowering, post harvest life and corm production of gladiolus cv. Traderhorn. First spray of BAP or GA_3 was applied 30 days and the second 60 days after planting at 0, 25, 50 or 100 mg L^{-1}. Results revealed that both the plant growth regulators increased plant height, stalk length, number of florets per spike, fresh weight of florets, vase life of spikes and diameter and weight of corms as compared to the control.

Sable *et al.* (2015) analyze the effect of plant growth regulators on growth and flower quality of gladiolus cv. 'H.B. Pitt'. In the present study it was found that the maximum height of the plant (59.43 cm), number of leaves (13.9), leaf area (64.8 cm^2) were recorded by treatment GA_3 200 ppm foliar spray while maximum number of florets $spike^{-1}$ (13.4), floret length (8.4 cm), length of spike (80.28 cm) and length of rachis (41.50 cm) were recorded with foliar spray of GA_3 at the rate of 200 ppm. However, maximum weight of floret (10.1 g), diameter of floret (9.5 cm) and girth of spike (2.60 cm) were produced by CCC 750 ppm foliar spray.

Aier *et al.* (2015) conducted an experiment on morphological, phenological and yield attributes of gladiolus cv. Red Candyman under Assam conditions due to gibberellic acid and benzyladenine. The results revealed that morphological characters were significantly influenced by GA_3 at 200 ppm which recorded the highest plant height, number of leaves per plant and leaf area. Significantly the minimum days to emergence of shoot, days to initiation of spike, days to full emergence of spike, days taken for first floret to show colour and days taken for first floret to open were also exhibited by GA_3 at 200 ppm. The treatment GA_3 at

250 ppm recorded the maximum duration of flowering. The treatment with GA_3 at 200 ppm exhibited maximum yield in terms of length of spike, length of rachis, number of florets per spike, diameter of floret, fresh weight, and dry weight of spike. On the other hand, BA at 250 ppm exhibited maximum economic yield in terms of number of spikes per corm and of corms per plant.

Singh *et al.* (2013) found that the different parameters *viz.* number of leaves per clump (130.17), height of plant (38.75 cm.), leaf area (37.86 cm^2) and weight of leaves per clump (256.79 g.) were found significant in the treatment T_8 where bulb dipped in GA_3 200 ppm + 12 hours. The minimum number of days to spike emergence (83.83), maximum spike length (98.58 cm^2) and spike weight (87.80 gm), higher number of florets per spike (32.89) and maximum number of spike per clump (3.00), length of inflorescence (34.75), diameter of rachis (0.68), length of basipetal floret (4.89), width of basipetal floret (3.42), duration of flowering of spike were maximum (13.75) and vase life was found maximum (8.75) was observed in treatment GA_3 200 ppm + 12 Hours (T_8). The treatment T_8 significantly affected the all above characters. The bulb production parameters revealed that GA_3 200 ppm + 12 hours soaking (T_8) were also significantly effect the number of bulbs per clump (9.08), number of bulblets per clump (7.58), bulb diameter (2.60 cm), weight of bulb per clump (196.33 gm.), weight of bulblets per clump (84.00 gm.) and fresh weight of bulb (18.88 gm).

Saeed *et al.* (2013) found that the GA_3 treatment significantly influenced the vase quality attributes and antioxidants capacity of gladiolus cut flowers. Gibberellic acid at 25 mg L^{-1} caused the longest time taken to open the floret and increased the floret opening, vase life duration and fresh weight.

Neetu *et al.* (2013) conducted an experiment with 4 different doses of GA_3 at 100 ppm, 200 ppm, 300 ppm and 400 ppm along with control on 5 cultivars of gladiolus viz., Archana, Gunjan, J.V. Gold, Sabnum and Snow Princes. The results revealed that maximum length of leaf and width of longest leaf were recorded when GA_3 was sprayed at 400 ppm on cvs. Sabnum and Gunjan.

However, maximum number of leaves plant^{-1} was registered with cv. Gunjan at 200 ppm GA_3. Among flowering parameters early spike emergence was noticed in cv. Sabnum when, GA_3 was sprayed at higher concentrations (300-400 ppm). In general, higher size of first and fifth floret was recorded with cv. J.V. Gold at 200-300 ppm GA_3. GA_3 at 300 ppm also exerted maximum length of spike, whereas maximum number of florets/spike was recorded with cv. Snow Princess when GA_3 was applied at 100-200 ppm.

Arshad (2013) conducted an experiment with corm size (3 levels) and plant growth regulator (seven levels) (G_0-Control, G_1-GA_3 100, G_2-GA_3 150, G_3-GA_3 200, G_4-BAP 50, G_5-BAP 100 and G_6-BAP 150 ppm, respectively). The results of the experiment showed that the corm size and plant growth regulators had significant effect on most of the parameters. Among all concentration of plant growth regulators, GA_3 at 200 ppm produced the highest yield per hectare (250,000 spikes) while control produced lowest yield (200,000 spikes). However, the treatment combination of large size corm and GA_3 at 200 ppm showed the best performance in respect of vegetative growth, flower and corm production in Gladiolus.

Islam *et al.* (2012) studied on plant emergence, growth and flower production of gladiolus among the different doses of GA_3 and Paclobutrazol. Three doese of gibberellic acid viz. 50, 100 and 200 ppm and Paclobutrazol viz. 20, 40 and 80 ppm including control treatments were used. It was found that GA_3 showed better performance than the Paclobutrazol while GA_3 200 ppm showed the best result in yield contributing characters such as reducing the number of days for 80% emergence, first spike initiation, 80% spike initiation, 80% harvest and increasing the number of tiller per hill, total number of spike per hill, length of spike and rachis, number of florets per spike and shelf life of flower production of gladiolus.

Dogra *et al.* (2012) conducted an experiment on the effect of gibberellic acid and plant geometry on growth, flowering and corm production in gladiolus cv. ‘Novalux’ under Jammu conditions. Four concentrations of GA_3 (0, 100, 200 and

300 ppm) and three levels of spacing were tested. Result revealed that different treatments of GA_3 significantly influenced the vegetative characters of gladiolus. Plant height (120.90 cm), number of leaves (9.37) and leaf width (5.41 cm) was recorded maximum at highest concentration of GA_3 i.e.300 ppm while minimum observations were recorded in control. All the flowering parameters were significantly influenced by the treatments of gibberellic acid. Early flowering (81.73 days), maximum spike length (96.03 cm), rachis length (68.55 cm) and floret diameter (9.55 cm) as recorded at 300 ppm GA_3 where as the highest number of florets per spike were observed at 200 ppm GA_3. Corm and cormel production was significantly affected by gibberellic acid. Corms treated with 300 ppm GA_3 produced largest corm of diameter 7.02 cm with maximum weight of 41. 99 g whereas highest number of corms per plant (1.65), cormels per plant (16.74) and heaviest cormel (11.04 g) was obtained at 200 ppm GA_3 followed by 300 ppm GA_3. In control, lowest yield contributing attributes like corm weight, number of cormels, weight of cormels and corm diameter were recorded.

Sharifuzzaman *et al.* (2011) evaluate the three different concentrations of gibberellic acid (GA_3), cycocel (CCC) and maleic hydrazide (MH) on the vegetative growth, yield and quality of chrysanthemum. GA_3 treated plants showed significant increase in plant spread, leave number and leave length. Irrespective of concentration, GA_3 also produced the higher number of sucker and flowers and CCC produced less. GA_3 also caused faster initiation of flowering and ACC and MH delayed it. Length of flower stalk significantly increased with GA_3. In this study, foliar application of 200 ppm GA_3 was the best for obtaining better growth of plants, maximum number of cut blooms with longer stalk as well as bigger flower size.

Chopde *et al.* (2011) conducted an experiment on the effect of growth regulators viz., GA_3 and NAA on growth and flowering of three varieties of gladiolus viz., Phule Neelrekha, Phule Tejas and Phule Ganesh. The results revealed that, effect of PGR was non–significant as regards leaves plant^{-1} and chlorophyll content of leaves. However, significantly early opening of first floret and 50% flowering and the maximum spike yield and spike quality parameters *viz.* length of spike, distance between two florets, longevity of flower on plant and length and width of florets were noted under the treatment of GA_3 150 ppm.

Hashemabadi and Zarchini (2010) evaluate effects of different levels of salicylic acid (SA) (50, 100, 150 and 200 mg L^{-1}), gibberellic acid (GA_3) (150, 200, 250 and 300 mg L^{-1}), and cycocel (CCC) (500, 1000, 1500 and 2000 mg L^{-1}) at pre–harvest stage on the quality, yield and vase life of cut rose (Rosa hybrida 'Poison'). Results showed that the effect of regulators has been significant at $P \leq 0.01$ level on fresh weight and flower height. The highest record of flower yield was obtained by application of 200 mg l L^{-1} GA_3 with 192 cut flowers per year per m^{-2}. The best treatment to increase the stem flower length was application of 300 mg L^{-1} GA_3 which produced longest cm stems (49.33).

Youssef and Gomaa (2008) found that the foliar application of GA_3 increased the plant height of *Dahlia pinnata* as compared with untreated plant (control) with superior for the highest concentration (300 ppm) as it gave 83.8 and 88.4 cm in the first and second seasons, respectively. However, the earliest flowering start was obtained by using the highest concentration of GA_3 (300 ppm). All treatments of GA_3 resulted in significant increments in the number of flowers/plant and the superiority was for the medium concentration (200 ppm) in both seasons. The increments of flower pedicel length were in parallel to the applied GA_3 concentrations, so the highest concentration (6 g L^{-1}) statistically scored the longest flower pedicel as it gave 27.0 and 25.0 cm in the first and second seasons, respectively. Similarly, the diameter of flower pedicel and head diameter were improved by using GA_3 treatments and the superiority were for the lowest rate of 100 ppm and 200 ppm, respectively at both first and second seasons.

Umrao *et al.* (2008) found that the application of GA_3 at all concentrations influenced growth and flowering of gladiolus. Maximum plant height (41.50 cm) was found with 150 mg L^{-1} being akin with 100 mg L^{-1} concentration (4 and 8) have also observed increase in plant height with GA_3 application. The earliest spike emergence in gladiolus was found in plants treated with 200 mg L^{-1} GA_3 being at par with 150 mg L^{-1} and spike emergence was 5-5.25 days earlier over control. The treatment with 150 mg L^{-1} GA_3 was found better for increasing spike length (36.00 cm). The placement and width of floret were increased at all levels of GA_3 over the control and were maximum at 100 mg L^{-1}.

Sharma *et al.* (2006) investigated the effect of gibberellic acid levels (0, 100, 200 and 300 ppm) on growth, flowering and corm yield in gladiolus (Red Beauty, Jester and Summer Face). Results revealed that cultivars and GA_3 significantly affected all the growth, flowering and corm yield parameters. Earliest sprouting (6.54 and 6.82 days) and maximum plant height (100.47 and 102.39 cm), number of leaves per plant (9.49 and 9.68), leaf length (85.00 and 82.80 cm), spike length (73.96 and 75.45 cm), number of florets per spike (18.01 and 16.46), rachis length (62.85 and 60.47 cm), floret length (13.01 and 12.83 cm), number of corms per plant (57.16 and 48.22) and vase life (14.33 and 13.70 days) were recorded with GA_3 at 200 ppm and 'Red Beauty' cultivar.

Maurya and Nagda (2006) conducted an experiment to investigate the effects of gibberellic acid (GA) at 50 and 100 ppm, Cycocel at 500 and 1000 ppm and NAA at 50 and 100 ppm on growth and flowering of gladiolus (*G. grandiflorus* cv. Friendship). Foliar application of GA at 100 ppm at 45 days after corm planting resulted in the highest height (104.5 cm), number of leaves (8.5 per plant), spike length (98.3 cm), number of florets (16.7 per spike), size of second florets (10.8 cm) and number of spikes per plant (1.73).

Kumer *et al.* (2005) conducted an experiment with daughter corms of gladiolus cv. Congo Song dipped in GA_3 (50, 100 and 150 ppm) and ehtrel (250, 500 and 750 ppm) separately for 24 hours both treated and untreated corms were planted in the field in Knapur, Uttar Pradesh, India. Data were recorded for number of leaves per plant, plant height, days to spike emergence, flowering duration, number of flowers per spike, spike length, number of corms per plant, corm diameter and corm weight. GA_3 and ethrel treatment in generally enhanced all parameters compared with the control. Such effect was more pronounced with the application of higher doses of growth regulators.

Verma (2003) studied to find out the optimum dose of nitrogen and gibberellic acid as foliar application for quality flower production in perpetual carnations. The treatments consisted seven levels of nitrogen (0, 200, 500 and 1000 ppm at weekly and fortnightly intervals), three levels of GA_3 (0, 50 and 100 ppm) and two cvs. (White Candy and Red Corso). The maximum plant height (65.94 cm) was recorded with nitrogen 1000 ppm per week and GA_3 100 ppm applied twice. GA_3 (50 ppm) produced buds of maximum size (1.83 cm). The maximum flower diameter (6.96 cm) was recorded with nitrogen 500 ppm per week and GA_3 50 ppm. Maximum stem length (58.25 cm) was recorded with nitrogen 1000 ppm per week and GA_3 100 ppm.

Gaur *et al.* (2003) investigated the effects of GA_3 and IAA, both applied at 25, 50, 100 or 200 ppm, on the growth, flowering and corm production of gladiolus cv. Eurovision, Uttar Pradesh, India. High GA_3 and low IAA concentrations improved plant height, number and size (width and length) of leaves and thickness and width of shoots; promoted earliness in spike emergence, colour break in the first floret and flowering; increased the length of spikes, number of florets per spike, size of florets and longevity of spikes; and increased the vase life of cut flowers and the number, weight and diameter of corms and cormels. The highest values for all parameters were recorded with GA_3 at 200 ppm

Prasad *et al.* (2002) conducted an experiment in Uttar Pradesh, India, to study the effect of gibberellic acid (at 0, 150 and 200 ppm) on the growth and flowering of gladiolus. GA_3 at 200 ppm increased plant height, leaf number, spike length, rachis length and floret number in Tropic Seas.

Misra *et al.* (2002) conducted an experiment during 2000-2001 in New Dehli, India on gladiolus cv. *Jester* to determine the effect of GA_3 (400 ppm). The number of leaves (7.66), per shoot leaf area (591 cm^2), plant height (76.33 cm), number of florets per spike (15.66), spike length (65 cm), and rachis (41.66 cm) were maximum in dipping + spraying at 40 + 65 + 90 days after planting (DAP) treatment. In addition, the days took 50% sprouting, size of corm at lifting, average weight of corm per plant, and propagation co-efficient increased with dipping + spraying at 40 + 65 + 90 DAP treatment.

Kirad *et al.* (2001) determine the effect of plant growth regulators (GA_3 at 50, 100 and 150 ppm; NAA at 25, 50 and 100 ppm; and cycocel at 2000, 4000 and 6000 ppm) on Gladioulus sp. cv. 'White Prosperity'. Plant growth regulators were applied by dipping for 12 h or spraying 40 days after planting. The earliest sprouting was obtained with GA_3 at 100 ppm. GA_3 at 100 ppm (dipping + spraying) resulted in the highest leaf number. The tallest plant resulted in the treatment with GA_3 @ 100 ppm (dipping + spraying).

Dutta *et al.* (2001) conducted an experiment at Pune, Maharashtra, India to determine the effects of gibberellic acid (GA_3) treatment on the corm germination of 10 gladiolus hybrids. Corms of each hybrid were cleaned prior to soaking in GA_3 solution at 100, 150 and 200 ppm and water for 24 h. GA_3 @ 200 ppm significantly increased the percentage of corm germination and reduced the number of days required for germination compared with other and control treatments. Seed corm germination values of 62.8 and 64.4% and 66.5% were obtained with GA_3 at 100, 150 and 200 ppm, respectively.

Khattab *et al.* (2000) conducted an experiment during 1997 and 1995 in Alexandria, Egypt, Gladiolus cv. Sancerre cormel were presoaked for 24 hours in gibberellic acid solutions at 0 or 100 ppm. A month after planting, plants were irrigated with diluted seawater at different concentrations (0, 5, 10, 15 or 20%). Each treatment was irrigated with non-magnetically or magnetically treated water. Generally, plant height, number of leaves, leaf area, leaf dry weight, corm volume, circumference and dry weight and number of cormels per plant were significantly reduced by saline treatments. Both GA_3 and magnetized seawater increased most of these characteristics. Using 5% magnetically treated seawater increased the values for plant height and corm volume and circumference than the control.

Prakash *et al.* (1999) investigated the effect of GA_3 on the floral parameters of gladiolus. Ten gladiolus cultivars were treated with 0, 100 and 150 ppm GA_3 and effects on flower parameters, *viz.* time of flowering, inflorescence length, spike length, floret length and number of florets per spike were studied. GA_3 treatment at 150 ppm followed by 100 ppm improved all the floral traits in gladiolus. Use of 150 ppm GA_3 in cv. Friendship produced the longest inflorescences and spikes with the highest number of florets per spike.

Karaguzel *et al.* (1999) carried out an experiment to study the effects of GA_3 on flowering and quality characteristics of gladiolus cv. 'Erovision'. Corms were soaked in solutions of 0 (control), 50 and 100 mg/l GA_3 kg^{-1} for 1 hour and were planted 5 days later (late autumn) at 49 corms/m^2 on 24 November. GA_3 at 100 ppm shortened the time from planting to harvest, and flowering percentage, the length of flowering stems and spikes, the number of flower per spike and diameter of flower stems.

Mukhopadhyay and Bankar (1996) conducted an experiment to investigate the influence of pre-planting soaking of corm with gibberellic acid that modifies growth and flowering of gladiolus cultiver 'Friendship'. Corms were soaked in solutions of 0, 10, 50, 100, 250 ppm GA_3 in the dark for 24 hours. Treatment with 10 ppm GA_3 advanced flowering by a few days. GA_3 increased the length of flower spike irrespective of concentration used. It also reduced the the number of cormel but increased cormel weight per plant.

Mahesh and Misra (1993) studied the effect of gibberellic acid (200, 500 and 1000 ppm) on gladiolus cv. Snow Princess. Significant changes in growth and flowering were obtained for many parameters. GA_3 at 200 ppm increased the plant height from 87.39 to 90.57 and 91.94 cm but the GA_3 at 1000 ppm increased the number of florets/spike from 10.19 to 10.67 and 10.66.

Misra *et al.* (1993) while working on implication of gibberellic acid on gladiolus corm cv. Sylvia at Kanpur, India and stated that GA_3 application at 0, 50, 100, 200, or 400 ppm enhanced vegetative growth, flowering and number of corm and cormel produced, but adversely affected individual corm weight. GA3 at 200, and 400 ppm reduced the duration of the whole spike. It was concluded that, apart from corm size, GA_3 at 100 ppm and 200 ppm gave encouraging results.

Arora *et al.* (1992) carried out an experiment to investigate the effects of GA_3 (5, 10, 25, 50, 75 or 100 mg/l) on growth and subsequent production of corm and cormel in 3 gladiolus cultivars (Aldebaran, Pusa Suhagin and Mayur). After treatment, corms were planted and observations were made on the number of days to sprouting, final diameter and weight of corms and number, diameter and weight of cormel production/corm. GA_3 at 100 mg/l accelerated sprouting of corms by 4.6, 3.2 and 4.8 days in Aldebran, Pusa Suhagin and Mayur, respectively. Corm weight and diameter were increased by 239.4 and 59.1% respectively, in Mayur when treated with GA_3 at 100 mg/l. Production of cormel was not significantly increased by GA_3 application although there was an increased in their diameter and weight.

Auge (1992) conducted an experiment with gladiolus cv. sylvia where corms were kept in GA_3 solutions for 24 hours in an attempt to find out the effect on growth and flowering. It was revealed that the GA_3 (as berelex at 0.5g/l) treated corms sprouted and flowered earlier than the control corms.

As per the above cited reviews, it may be concluded that the lime and GA_3 is important factors for flowering, corm and cormel production of gladiolus. The literature revealed that the influence of lime and GA_3 on flowering, corm and cormel production of gladiolus have not been studied well and have no definite conclusion for the production of gladiolus in the agro climatic condition of Bangladesh.

CHAPTER III

MATERIALS AND METHODS

The field experiment was conducted to find out the influence of liming and foliar application of GA_3 on growth and flowering of gladiolus. The materials and methods that were used for conducting the experiment have been presented in this chapter. It includes a short description of the location of experimental site, soil and climate condition of the experimental plot, materials used for the experiment, design of the experiment, data collection procedure and analysis.

3.1 Description of the experimental site

3.1.1 Experimental period

The experiment was conducted during the period from November 2014 to March 2015.

3.1.2 Experimental 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 of the location was 8 m from the sea level as per the Bangladesh Metrological Department, Agargaon, Dhaka-1207.

3.1.3 Climatic condition

The climate of experimental site is subtropical, characterized by three distinct seasons, the monsoon from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October. The monthly average temperature, humidity and rainfall during the crop growing period were collected from Weather Yard, Bangladesh Meteorological Department, and presented in Appendix I. During the experimental period the maximum temperature (31.4^0C) was recorded from March, 2015 and the minimum temperature (12.4^0C) from January, 2015, highest relative humidity (78%) was recorded from November, 2013, whereas the lowest relative humidity (64%) and highest rainfall (34 mm) was recorded in March, 2015.

3.1.4 Characteristics of soil

The soil of the experimental field belongs to the Tejgaon series under the Agroecological Zone, Madhupur Tract (AEZ- 28) and the general soil type is Shallow Red Brown Terrace soil. A composite sample was made by collecting soil from several spots of the field at a depth of 0-15 cm before the initiation of the experiment. The collected soil was air-dried, grind and passed through 2 mm sieve and analyzed at Soil Resources Development Institute (SRDI), Farmgate, Dhaka for some important physical and chemical properties. The soil was having a texture of silty clay with pH and organic matter 6.1 and 1.13, respectively. The results showed that the soil composed of 27% sand, 43% silt and 30% clay, which have been presented in Appendix II.

3.2 Experimental details

3.2.1 Planting materials

Corms of gladiolus (Yellow colour) were used as planting materials in this experiment.

3.2.2 Treatment of the experiment

The experiment was considered as two factors.

Factor A: Lime (3 levels)

i. L_0: 0 t ha^{-1} (control)
ii. L_1: 2.5 t ha^{-1}
iii. L_2: 5.0 t ha^{-1}

Factor B: Gibberellic acid GA_3 (4 levels)

i. G_0: 0 ppm (control)
ii. G_1: 150 ppm
iii. G_2: 200 ppm
iv. G_3: 250 ppm

There were on the whole 12 (3 × 4) treatment combinations such as L_0G_0, L_0G_1, L_0G_2, L_0G_3, L_1G_0, L_1G_1, L_1G_2, L_1G_3, L_2G_0, L_2G_1, L_2G_2 and L_2G_3.

3.2.3 Experimental design and layout

The experiment was laid out following Randomized Complete Block Design (RCBD) with three replications. An area of 16.5 m × 6.4 m was divided into three equal blocks. Each block was divided into 12 plots where 12 treatment combinations were allotted at random. There were 36 unit plots altogether in the experiment. The size of the each unit plot was 0.80 m × 0.75 m. The layout of the experiment is shown in Figure 1.

3.2.4 Preparation of the main field

The selected plot of the experiment was opened in the 1^{st} week of November 2014 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 planting the seed tubers. 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.

3.2.5 Application of manure and fertilizers

The sources of N, P_2O_5, K_2O as urea, TSP and MoP were applied, respectively. The entire amounts of TSP and MoP were applied during the final land preparation. Urea was applied in three equal installments at 15, 30 and 45 days after planting of corms. Well-rotten cowdung and lime (as per treatment) also applied during final land preparation. The amount of manures and fertilizers that were used in the experimental plot suggested by BARI, 2011 have been presented in Appendix III.

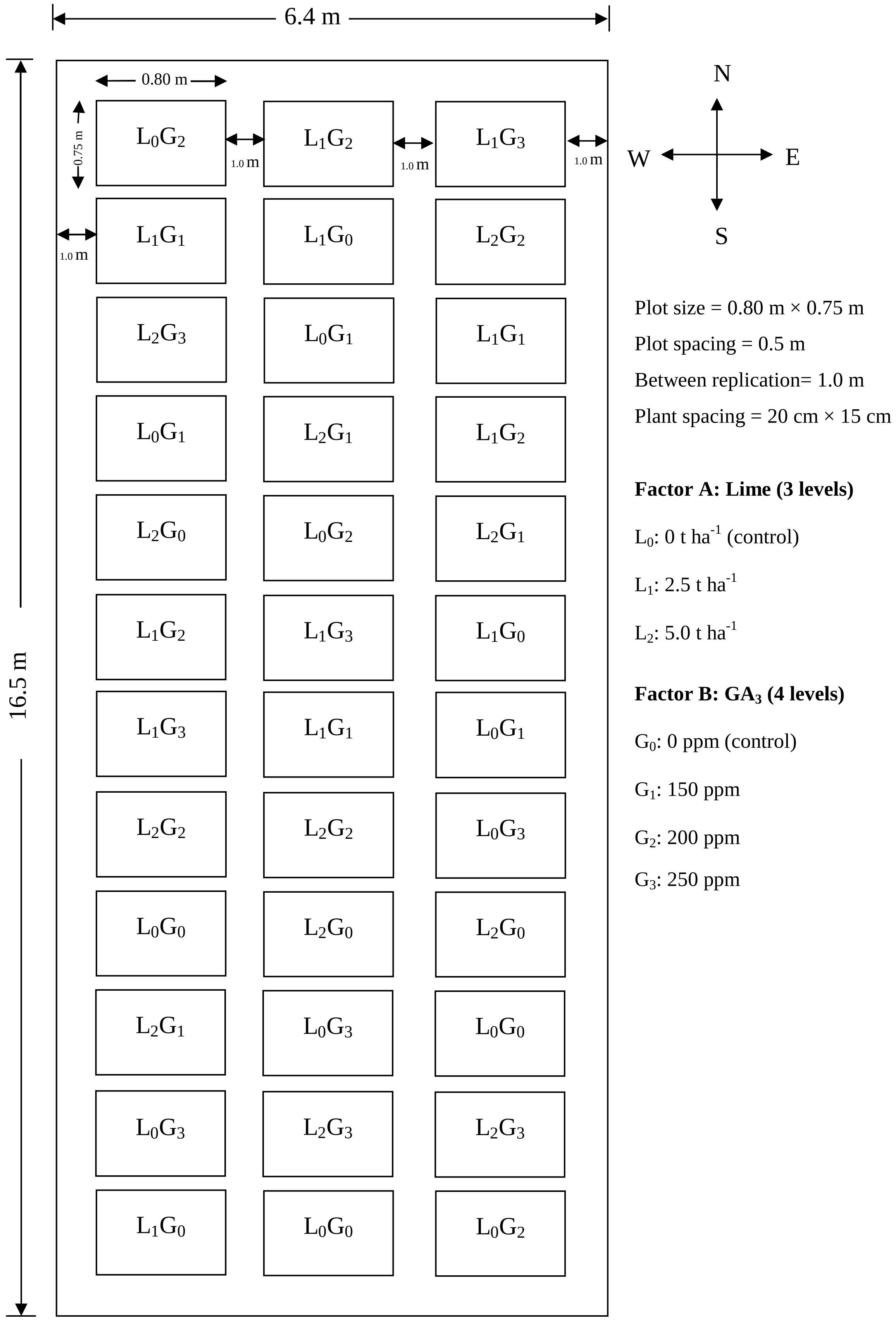

Figure 1. Layout of the experimental plot

3.2.6 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. 150 ml of this stock solution was diluted in 1 litre of distilled water to get 150 ppm GA_3 solution. In a similar way, 200 and 250 ppm stock solutions were diluted to 1 litre of distilled water to get 200 and 250 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 four times 15, 30 and 45 days after planting (DAP) by a mini hand sprayer.

3.3 Growing of crop

3.3.1 Collection of corms

Corms of gladiolus (Yellow colour) were collected from Horticulture farm of Sher-e-Bangla Agricultural University (SAU), Dhaka.

3.3.2 Planting of corms

The corms of gladiolus were planted at a depth of 5 cm in the experimental plots on 15 November, 2015. A spacing of 20 cm × 15 cm was used (BARI, 2011). Each plot accommodated 20 corms. The soil along the rows of corms was ridged up immediately after planting.

3.3.3 Intercultural operation

When the seedlings started to emerge in the beds it was always kept under careful observation. After emergence of seedlings, various intercultural operations, weeding, top dressing was accomplished for better growth and development of gladiolus seedlings.

3.3.3.1 Irrigation and drainage

Over-head irrigation was provided with a watering can to the plots once immediately after germination in every alternate day in the afternoon. Stagnant water was effectively drained out at the time of heavy rains.

Plate 1: Experimental plot

3.3.3.2 Weeding

Weeding was done to keep the plots free from weeds, easy aeration of soil, which ultimately ensured better growth and development. The newly emerged weeds were uprooted carefully after complete emergence of seedlings whenever it is necessary. Breaking the crust of the soil was done accordingly.

3.3.3.3 Top dressing

After basal dose, the remaining doses of urea were top-dressed in 3 equal installments. The fertilizers were applied on both sides of plant rows and mixed well with the soil by hand. Earthing up was done with the help of nirani immediately after top-dressing of fertilizer.

3.3.3.4 Plant Protection

For controlling leaf caterpillars Nogos @ 1 ml/L water was applied 2 times at an interval of 10 days starting soon after the appearance of infestation. There was no remarkable attack of disease in the field.

3.4 Data collection

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

3.4.1 Plant height

The height of plant was recorded in centimeter (cm) before initiation of rachis in the plants of experimental plot. The height was measured from the attachment of the ground level up to the tip of the growing point.

3.4.2 Days to flower anthesis

It was achieved by recording the days taken for flower anthesis of gladiolus from each unit plot.

3.4.3 Leaf area per leaf

Leaf area (LA) per leaf was determined from plant samples by using an automatic leaf area meter (Model LI-3100, Li-COR, Lincoln, NE, USA) immediately after removal of leaves from plants to avoid rolling and shrinkage. Leaf area was recorded before initiation of rachis in the plants of experimental plot.

3.4.4 Chlorophyll content

Leaves were 5 sampled plants from main gladiolus plant before initiation of rachis in the plants of experimental plot and a segment of 20 mg from middle portion of leaf was used for chlorophyll content was estimated on fresh weight basis extracting with 80% acetone and used double beam spectrophotometer (Model: U-2001, Hitachi, Japan) according to Witham *et al*. (1986).

3.4.5 Length of flower stalk

Length of flower stalk was measured from the base to the tip of the spike and expressed in centimeter.

3.4.6 Length of rachis

Length of rachis refers to the length from the axil of first floret upto the tip of the inflorescence and expressed in centimeter.

3.4.7 Number of florets spike^{-1}

All the florets of the spike were counted from 5 randomly selected plants and their mean was calculated.

3.4.8 Number of spike ha^{-1} ('000)

Number of spikes was computed from numbers of spikes per plot and converted to hectare.

3.4.9 Diameter of basal floret

A slide calipers was used to measure the diameter of ten randomly selected basal floret and their mean was calculated and expressed in centimeter.

3.4.10 Diameter of individual corm

A slide calipers was used to measure the diameter of ten randomly selected corm and their mean was calculated and expressed in centimeter.

3.4.11 Weight of individual corm

It was determined by weighing the corms from the ten randomly selected plants and mean weight was calculated and expressed in gram.

3.4.12 Corm yield plot^{-1} and hectare^{-1}

Total corm yield plot^{-1} was recorded by weighing the total harvested corm in a plot and expressed in kilogram and converted to yield hectare^{-1} and expressed in t ha^{-1}.

3.4.13 Number of cormel plot^{-1}

It was calculated from the number of cormels obtained from ten randomly selected plants and mean was recorded.

3.4.14 Weight of individual cormel

Individual weight of cormel was recorded from the mean weight of ten randomly selected sample cormels and expressed in gram.

3.4.15 Cormel yield plot^{-1} and hectare^{-1}

Total cormel yield per plot was recorded by adding the total harvested cormel in a plot and expressed in kilogram and converting the yield of gladiolus cormel per plot to per hectare and expressed in t/ha.

3.5 Statistical Analysis

The experimental data obtained for different parameters were statistically analyzed to find out the influencing of liming and GA_3 on flowering, corm and cormel production of gladiolus. The mean values of all the recorded characters were calculated and analysis of variance was performed by the 'F' (variance ratio) test. The significance of the difference among the individual and treatment combinations means was estimated by the Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

3.6 Economic analysis

The cost of production was analyzed in order to find out the most economic treatment of liming and GA_3. All input cost were considered in computing the cost of production. The market price of spike, corm and cormel were considered for estimating the return. The benefit cost ratio (BCR) was calculated as follows:

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

CHAPTER IV

RESULTS AND DISCUSSION

The present experiment was undertaken to find out the influence of liming and foliar application of GA_3 on growth and flowering of gladiolus. The analysis of variance (ANOVA) of the data on different characters is given in Appendix IV-VII. The results of the study have been presented and discussed and possible interpretations have been given under the following headings:

4.1 Plant height

Plant height of gladiolus showed statistically significant differences due to the application of lime (Appendix IV). The tallest plant (106.9 cm) was found from L_1 (limning 2.5 t ha^{-1}) which was followed (98.4 cm) by L_2 (limning 5.0 t ha^{-1}), whereas the shortest plant (88.8 cm) was recorded from L_0 (control condition) (Table 1). The plant height was higher in liming 2.5 t ha^{-1} because of probably it would be suitable for the availability of different micro and macro nutrients for gladiolus that support to increase the plant height. Azman *et al.* (2014) reported that the low pH had adverse affect on plant growth

Statistically significant variation was recorded for different level of GA_3 in terms of plant height of gladiolus (Appendix IV). The tallest plant (101.5 cm) was recorded from G_2 (200 ppm GA_3) which was closely followed (99.8 cm) by G_3 (250 ppm GA_3), while the shortest plant (93.6 cm) was found from G_0 (control condition), which was followed (97.1 cm) by G_1 (150 ppm GA_3) (Table 2). Plant height varied might be due to genetical and environmental influences but management practices also influenced it. Chopde *et al*. (2011) reported that GA_3 enhance plant height of gladiolus at different concentrations.

Combined effect of the application of lime and GA_3 showed statistically significant variation in terms of plant height of gladiolus (Appendix IV). The tallest plant (111.1 cm) was recorded from L_1G_2 and the shortest plant (82.3 cm) was observed from L_0G_0 (Table 3). Vijai *et al*. (2007) reported that gibberellic acid (GA_3) enhance the plant height of gladiolus at different concentrations with also the application of lime.

Table 1. Effect of lime on gladiolus related to quality attributes[Y]

Treatments[x]	Plant height (cm)	Leaf area per leaf (cm^2)	Chlorophyll content (%)
L_0	88.8 c	143.7 b	42.5 c
L_1	106.9 a	148.8 a	47.0 a
L_2	98.4 b	148.1 a	45.7 b
LSD (0.05)	0.7	4.4	1.2
CV%	0.9	3.6	3.2

[X] L_0-Control, L_1-liming 2.5 ton/ha, L_2- Liming 5 ton/ha

[Y] In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

Table 2. Effect of GA_3 on gladiolus related to quality attributes[Y]

Treatments[x]	Plant height (cm)	Leaf area per leaf (cm^2)	Chlorophyll content (%)
G_0	93.6 d	126.8 c	42.1 c
G_1	97.1 c	138.8 b	44.2 b
G_2	101.5 a	158.3 a	48.6 a
G_3	99.8 b	161.5 a	45.4 b
LSD (0.05)	0.8	5.1	1.4
CV%	0.9	3.6	3.2

[X] G_0-Control, G_1-GA_3 150 ppm, G_2- GA_3 200 ppm, G_3- GA_3 250 ppm

[Y] In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

Table 3. Combined effects of lime and GA_3 on growth related attributes of gladiolus[Y]

Treatment combinations[x]	Plant height (cm)	Days to flower anthesis	Leaf area per leaf (cm^2)	Chlorophyll content (%)
L_0G_0	82.3 j	86.3 a	130.1 fg	39.1 g
L_0G_1	87.4 i	79.7 bc	139.4 e	41.4 fg
L_0G_2	92.7 h	79.3 bc	154.8 cd	45.0 cde
L_0G_3	92.7 h	77.7 cd	150.3 d	44.4 cde
L_1G_0	95.7 g	81.0 b	125.6 g	43.1 ef
L_1G_1	98.7 f	74.3 ef	141.1 e	46.6 bcd
L_1G_2	111.1 a	64.3 h	169.3 a	52.6 a
L_1G_3	98.5 f	71.7 fg	169.4 a	44.9 cde
L_2G_0	102.7 d	79.0 bc	124.7 g	44.0 de
L_2G_1	105.4 c	75.7 de	135.8 ef	44.6 cde
L_2G_2	100.8 e	70.7 g	159.1 bcd	48.1 b
L_2G_3	108.2 b	68.7 g	164.9 ab	46.8 bc
$LSD_{(0.05)}$	**1.5**	**3.0**	**8.8**	**2.5**
CV%	**0.9**	**2.3**	**3.6**	**3.2**

[X] L_0–Control, L_1–liming 2.5 ton/ha, L_2– Liming 5 ton/ha
G_0–Control, G_1–GA_3 150 ppm, G_2– GA_3 200 ppm, G_3– GA_3 250 ppm

[Y] In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

4.2 Days to flower anthesis

Statistically significant variation was recorded due to the application of lime in terms of days to flower anthesis of gladiolus (Appendix IV). The minimum days to flower anthesis was observed from L_1 (71.9 days) which was followed by L_2 (74.4 days), whereas the maximum days to flower anthesis was recorded from L_0 (80.8 days) (Figure 2). The minimum days to flower anthesis was recorded by liming 2.5 t ha^{-1} because of probably it would be suitable for the availability of different nutrients for gladiolus. Findings also reported by Kisinyo *et al.* (2005) from their earlier experiment.

Days to flower anthesis of gladiolus showed statistically significant variation for different level of GA_3 (Appendix IV). The minimum days to flower anthesis was recorded from G_2 (71.4 days) which was statistically similar to G_3 (72.7 days), while the maximum days to flower anthesis was found from G_0 (82.1 days) which was followed by G_1 (76.6 days) (Figure 3). GA_3 is an important factor for maximizing the crop growth and flower production. GA_3 induce early flowering (Taiz and Zeiger, 2002).

Statistically significant variation was recorded in terms of days to flower anthesis due to the combined effect of the application of lime and GA_3 (Appendix IV). The minimum days to flower anthesis was recorded from L_1G_2 (64.3 days) and the maximum days to flower anthesis was observed from L_0G_0 (86.3 days) (Table 3). Gibberellic acid (GA_3) enhance the flowering time of gladiolus at different concentrations with also the application of lime. Findings also reported by Vijai *et al*. (2007) from their earlier experiment.

4.3 Leaf area per leaf

Statistically significant variation was recorded due to the application of lime in leaf area per leaf of gladiolus (Appendix IV). The highest leaf area per leaf was observed from L_1 (148.8 cm^2) which was statistically similar to L_2 (148.1 cm^2), whereas the lowest leaf area per leaf was recorded from L_0 (143.7 cm^2) (Table 1). It was revealed that different leaf area produced for different level of lime. The vegetative and floral traits of gladiolus was promoted with application of lime. Findings also reported by Reddy *et al*. (2014) from their earlier experiment.

Leaf area per leaf of gladiolus showed statistically significant variation for different level of GA_3 (Appendix IV). The highest leaf area per leaf was recorded from G_3 (161.5 cm^2) which was statistically similar to G_2 (158.3 cm^2), while the lowest leaf area per leaf was found from G_0 (126.8 cm^2) which was followed by G_1 (138.8 cm^2) (Table 2). The vegetative and floral traits of Gladiolus are promoted with foliar application of $GA_{3.}$ Singh *et al.* (2013) reported highest leaf area in 200 ppm GA_3.

Combined effect of the application of lime and GA_3 showed statistically significant variation in terms of leaf area per leaf (Appendix IV). The highest leaf area per leaf was recorded from L_1G_3 (169.4 cm^2) and the lowest leaf area per leaf was observed from L_2G_0 (124.7 cm^2) (Table 3). Gibberellic acid (GA_3) and lime enhance the growth of gladiolus at different concentrations. Findings also reported by Vijai *et al*. (2007) from their earlier experiment.

4.4 Chlorophyll content

Chlorophyll content of gladiolus showed statistically significant variation due to the application of lime (Appendix IV). The highest chlorophyll content was observed from L_1 (47.0%) which was followed by L_2 (45.7%), whereas the lowest chlorophyll content was recorded from L_0 (42.5%) (Table 1). The vegetative and floral traits of gladiolus was promoted with application of lime. These results are also in conformity with the result of Reddy *et al*. (2014).

Statistically significant variation was recorded in terms of chlorophyll content of gladiolus for different level of GA_3 (Appendix IV). The highest chlorophyll content was recorded from G_2 (48.6%) which was followed by G_3 (45.4%) and G_1 (44.2%) and they were statistically similar, while the lowest chlorophyll content was found from G_0 (42.1%) (Table 2). GA_3 increase cell division of leaf thus photosynthetic area was increased. Neetu *et al.* (2013) also reported similar results.

Chlorophyll content showed statistically significant variation due to the combined effect of the application of lime and GA_3 (Appendix IV). The highest chlorophyll content was recorded from L_1G_2 (52.6%) and the lowest chlorophyll content was observed from L_0G_0 (39.1%) (Table 3). Gibberellic acid (GA_3) and lime enhance the growth of gladiolus at different concentrations. Findings also reported by Vijai *et al*. (2007) from their earlier experiment.

4.5 Length of flower stalk

Statistically significant variation was recorded due to the application of lime in length of flower stalk of gladiolus (Appendix V). The highest length of flower stalk was observed from L_1 (63.8 cm) which was closely followed by L_2 (56.8 cm), whereas the lowest length of flower stalk was recorded from L_0 (53.9 cm) (Table 4). The highest length of flower stalk was recorded by liming 2.5 t ha^{-1} because of probably it would be suitable for the availability of different nutrients for gladiolus. It was revealed that different length of flower stalk produced for different level of lime. Similar findings also reported by Kisinyo *et al.* (2005) from their earlier experiment.

Length of flower stalk of gladiolus showed statistically significant variation for different level of GA_3 (Appendix V). The highest length of flower stalk was recorded from G_2 (62.6 cm) which was closely followed by G_3 (61.0 cm), while the lowest length of flower stalk was found from G_0 (52.0 cm) which was followed by G_1 (57.0 cm) (Table 5). GA_3 is an important factor for maximizing the crop growth and flower production. Plant growth regulators increased stalk length as compared to the control. These results are also in conformity with the result of Sajid *et al.* (2015).

Combined effect of the application of lime and GA_3 showed statistically significant variation in terms of length of flower stalk (Appendix V). The highest length of flower stalk was recorded from L_1G_2 (70.5 cm) and the lowest length of flower stalk was observed from L_0G_0 (46.8 cm) (Table 6). Gibberellic acid (GA_3) and lime enhance the growth of flower stalk of gladiolus at different concentrations. These results are also in conformity with the result of Vijai *et al.* (2007).

Table 4. Effect of lime on gladiolus related to quality attributes[Y]

Treatments[x]	Length of flower stalk (cm)	Number of floret $spike^{-1}$	Number of spike ha^{-1} ('000')	Diameter of basal floret (cm)
L_0	53.9 c	10.4 b	319 c	9.0 c
L_1	63.8 a	12.8 a	327 a	10.3 a
L_2	56.8 b	9.8 b	323 b	9.9 b
$LSD_{(0.05)}$	**1.1**	**0.7**	**2.0**	**0.4**
CV%	**2.3**	**7.2**	**1.7**	**4.3**

[X] L_0-Control, L_1-liming 2.5 ton/ha, L_2- Liming 5 ton/ha

[Y] In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

Table 5. Effect of GA_3 on gladiolus related to quality attributes[Y]

Treatments[x]	Length of flower stalk (cm)	Number of floret $spike^{-1}$	Number of spike ha^{-1} ('000')	Diameter of basal floret (cm)
G_0	52.0 d	9.3 c	308 d	7.9 d
G_1	57.0 c	10.3 b	319 c	9.8 c
G_2	62.6 a	12.2 a	340 a	10.9 a
G_3	61.0 b	12.1 a	328 b	10.4 b
$LSD_{(0.05)}$	**1.3**	**0.8**	**2.3**	**0.4**
CV%	**2.3**	**7.2**	**1.7**	**4.3**

[X] G_0-Control, G_1-GA_3 150 ppm, G_2- GA_3 200 ppm, G_3- GA_3 250 ppm

[Y] In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

Table 6. Combined effect of lime and GA_3 on growth related attributes of gladiolus[Y]

Treatment combinations[x]	Length of flower stalk (cm)	Length of rachis (cm)	Number of floret $spike^{-1}$	Number of spike ha^{-1} ('000')	Diameter of basal floret (cm)
L_0G_0	46.8 h	18.9 g	8.7 gh	307 d	8.0 h
L_0G_1	52.8 f	26.2 e	10.0 efg	308 d	8.9 g
L_0G_2	54.9 f	28.2 d	11.3 cde	335 b	9.4 fg
L_0G_3	60.8 cd	27.0 de	11.7 cd	325 c	9.7 ef
L_1G_0	50.6 g	23.3 f	8.3 h	308 d	7.9 h
L_1G_1	57.6 e	26.1 e	9.0 fgh	325 c	9.9 def
L_1G_2	70.5 a	36.9 a	15.1 a	350 a	12.6 a
L_1G_3	61.3 c	31.5 c	11.3 cde	325 c	11.1 b
L_2G_0	58.5 de	23.8 f	11.0 cde	308 d	7.9 h
L_2G_1	60.7 cd	33.5 b	12.0 bc	325 c	10.5 bcd
L_2G_2	57.5 e	32.6 bc	10.3 def	335 b	10.7 bc
L_2G_3	65.7 b	32.5 bc	13.2 b	335 b	10.3 cde
$LSD_{(0.05)}$	**2.3**	**1.7**	**1.3**	**3.9**	**0.7**
CV%	**2.3**	**3.5**	**7.2**	**1.7**	**4.3**

[X] L_0–Control, L_1–liming 2.5 ton/ha, L_2– Liming 5 ton/ha

G_0–Control, G_1–GA_3 150 ppm, G_2– GA_3 200 ppm, G_3– GA_3 250 ppm

[Y] In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

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	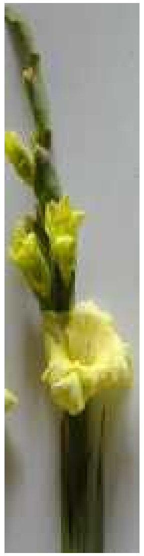	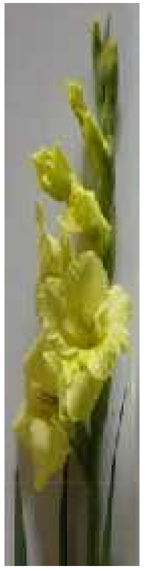			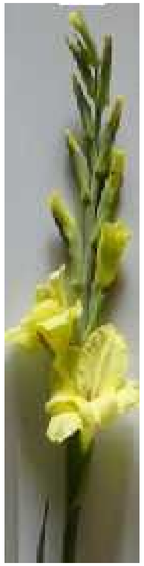				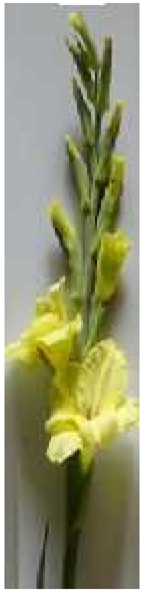		
L_0G_0	L_0G_1	L_0G_2	L_0G_3	L_1G_0	L_1G_1	L_1G_2	L_1G_3	L_2G_0	L_2G_1	L_2G_2	L_2G_3

Plate No 2. Effect of lime and GA_3 on length of flower stalk (cm)

4.6 Length of rachis

Statistically significant variation was recorded due to the application of lime in length of rachis of gladiolus (Appendix V). The highest length of rachis was observed from L_1 (31.7 cm) which was closely followed by L_2 (28.4 cm), whereas the lowest length of rachis was recorded from L_0 (25.1 cm) (Figure 4). It was revealed that different length of rachis produced for different level of lime. The vegetative and floral traits of Gladiolus was promoted with application of lime. Findings also reported by Reddy *et al*. (2014) from their earlier experiment.

Length of rachis of gladiolus showed statistically significant variation for different level of GA_3 (Appendix V). The highest length of rachis was recorded from G_2 (32.6 cm) which was closely followed by G_3 (30.3 cm), while the lowest length of rachis was found from G_0 (22.0 cm) which was followed by G_1 (28.6 cm) (Figure 5). GA_3 is an important factor for maximizing the crop growth and flower production. Plant growth regulators increased rachis length as compared to the control. These results are also in conformity with the result of Sajid *et al.* (2015).

Combined effect of the application of lime and GA_3 showed statistically significant variation in terms of length of rachis (Appendix V). The highest length of rachis was recorded from L_1G_2 (36.9 cm) and the lowest length of rachis was observed from L_0G_0 (18.9 cm) (Table 7).). Gibberellic acid (GA_3) and lime enhance the growth of rachis of gladiolus at different concentrations. These results are also in conformity with the result of Vijai *et al*. (2007).

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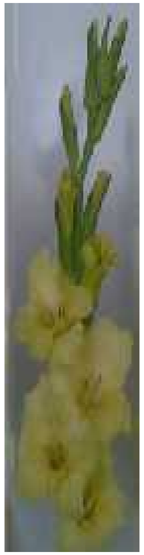	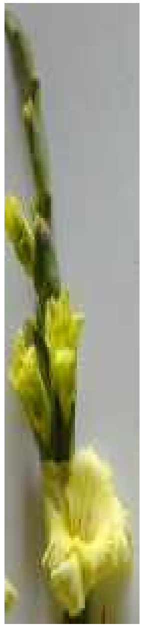		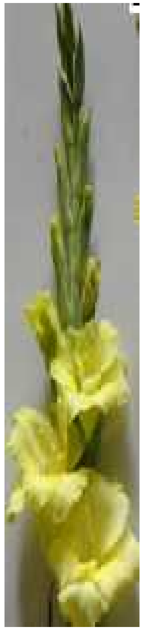	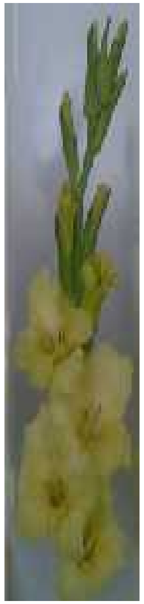	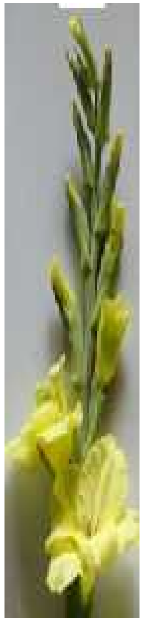	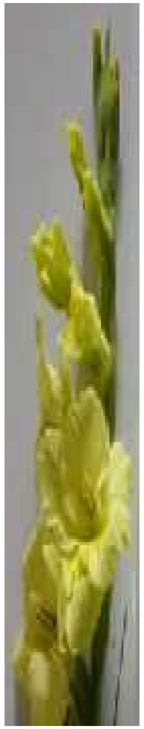	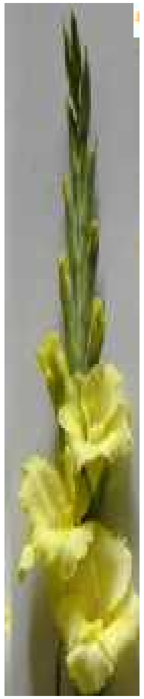	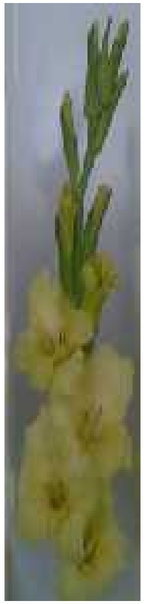	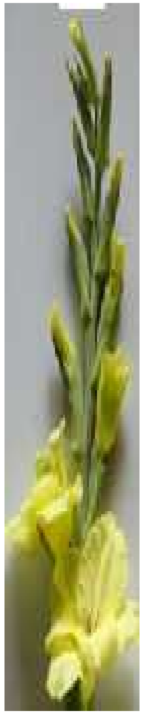	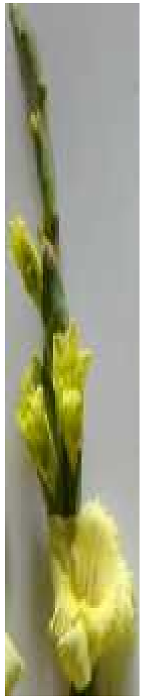	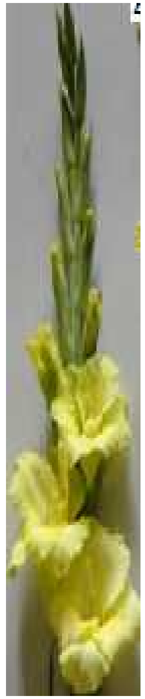
L_0G_0	L_0G_1	L_0G_2	L_0G_3	L_1G_0	L_1G_1	L_1G_2	L_1G_3	L_2G_0	L_2G_1	L_2G_2	L_2G_3

Plate No 3. Effect of lime and GA_3 on length of rachis (cm)

4.7 Number of florets spike^{-1}

Statistically significant variation was recorded due to the application of lime in number of florets spike^{-1} of gladiolus (Appendix V). The highest number of florets spike^{-1} was observed from L_1 (12.8) which was closely followed by L_0 (10.4), whereas the lowest number of florets spike^{-1} was recorded from L_3 (9.8) (Table 4). Application of 2.5 t ha^{-1} lime enhanced the activities of beneficial microbes and hence improved the vegetative and floral trait of gladiolus. Farzana and Dadlani (2014) reported that soil pH should be 6.5 to 7.5 for proper growth and flowering of gladiolus.

Number of florets spike^{-1} of gladiolus showed statistically significant variation for different level of GA_3 (Appendix V). The highest number of florets spike^{-1} was recorded from G_2 (12.2) which was statistically similar to G_3 (12.1), while the lowest number of florets spike^{-1} was found from G_0 (9.3) which was followed by G_1 (10.3) (Table 5). GA_3 is an important factor for maximizing the crop growth and flower production. Plant growth regulators increased number of florets spike^{-1} as compared to the control. Findings also reported by Sajid *et al.* (2015) from their earlier experiment.

Combined effect of the application of lime and GA_3 showed statistically significant variation in terms of number of florets spike^{-1} (Appendix V). The highest number of florets spike^{-1} was recorded from L_1G_2 (15.1) and the lowest number of florets spike^{-1} was observed from L_1G_0 (8.3) (Table 6). Gibberellic acid (GA_3) and lime enhance florets spike^{-1} of gladiolus at different concentrations. These results are also in conformity with the result of Vijai *et al.* (2007).

4.8 Number of spike ha^{-1} ('000)

Statistically significant variation was recorded due to the application of lime in number of spike ha^{-1} of gladiolus (Appendix V). The highest number of spike ha^{-1} was observed from L_1 (327,000) which was closely followed by L_2 (323,000), whereas the lowest number of spike ha^{-1} was recorded from L_0 (319,000) (Table 4). The application of ($CaCO_3$) was used as the liming material and showed statistically identical yield compared to chemical fertilizer. These results are also in conformity with the result of Kamruzzaman *et al.* (2013).

Number of spike ha^{-1} of gladiolus showed statistically significant variation for different level of GA_3 (Appendix V). The highest number of spike ha^{-1} was recorded from G_2 (340,000) which were closely followed by G_3 (328,000), while the lowest number of spike ha^{-1} was found from G_0 (308,000) which was followed by G_1 (319,000) (Table 5). GA_3 is an important factor for maximizing the crop growth and flower production. Arshad (2013) reported that plant growth regulators, GA_3 at 200 ppm produced the highest yield per hectare (300,000 spikes) while control produced lowest yield (250,000 spikes).

Combined effect of the application of lime and GA_3 showed statistically significant variation in terms of number of spike ha^{-1} (Appendix V). The highest number of spike ha^{-1} was recorded from L_1G_2 (350,000) and the lowest number of spike ha^{-1} was observed from L_0G_0 (307,000) (Table 6). Gibberellic acid (GA_3) and lime enhance the yield of gladiolus at different concentrations. Findings also reported by Vijai *et al*. (2007) from their earlier experiment.

4.9 Diameter of basal floret

Statistically significant variation was recorded due to the application of lime in diameter of basal floret of gladiolus (Appendix V). The highest diameter of basal floret was observed from L_1 (10.3 cm) which was closely followed by L_2 (9.9 cm), whereas the lowest diameter of basal floret was recorded from L_0 (9.0 cm) (Table 4). It was revealed that different diameter of basal floret produced for different level of lime. Farzana and Dadlani (2014) reported that soi pH should be 6.5 to 7.5 for proper growth and flowering of gladiolus.

Diameter of basal floret of gladiolus showed statistically significant variation for different level of GA_3 (Appendix V). The highest diameter of basal floret was recorded from G_2 (10.9 cm) which was closely followed by G_3 (10.4 cm), while the lowest diameter of basal floret was found from G_0 (7.9 cm) which was followed by G_1 (9.8 cm) (Table 5). The application of plant growth regulators is one of the most important factors in improving the flower quality. GA_3 at 200 ppm exhibited maximum yield in terms of diameter of floret. These results are also in conformity with the result of Aier *et al.* (2015).

Combined effect of the application of lime and GA_3 showed statistically significant variation in terms of diameter of basal floret (Appendix V). The highest diameter of basal floret was recorded from L_1G_2 (12.6 cm) and the lowest diameter of basal floret was observed from L_1G_0 (7.9 cm) (Table 6). Similar results also reported by Singh *et al.* (2013). Gibbrellic acid GA_3 and lime enhance diameter of basal floret of gladiolus of different concentrations. Findings also reported by Vijai *et al*. (2007) from their earlier experiment.

4.10 Diameter of individual corm

Statistically significant variation was recorded due to the application of lime in diameter of individual corm of gladiolus (Appendix VI). The highest diameter of individual corm was observed from L_1 (5.8 cm) which was closely followed by L_2 (5.4 cm), whereas the lowest diameter of individual corm was recorded from L_0 (5.3 cm) (Table 7). Application of 2.5 t ha^{-1} lime brought several chemical and biological changes in the soils and improved soil structure thus increased corm dia meter. These results are also in conformity with the result of (Fageria and Baligar, 2008).

Diameter of individual corm of gladiolus showed statistically significant variation for different level of GA_3 (Appendix VI). The highest diameter of individual corm was recorded from G_2 (6.4 cm) which was closely followed by G_3 (5.8 cm), while the lowest diameter of individual corm was found from G_0 (4.8 cm) which was followed by G_1 (5.6 cm) (Table 8). Plant growth regulators increased diameter of corms as compared to the control. Findings also reported by Sajid *et al.* (2015) from their earlier experiment.

Combined effect of the application of lime and GA_3 showed statistically significant variation in terms of diameter of individual corm (Appendix VI). The highest diameter of individual corm was recorded from L_1G_2 (6.7 cm) and the lowest diameter of individual corm was observed from L_0G_0 (4.3 cm) (Table 9). Gibbrellic acid and lime enhance diameter of individual corm of gladiolus at different concentrations. These results are also in conformity with the result of Sajid *et al.* (2015).

Table 7. Effect of Lime on gladiolus related to quality attributes[Y]

Treatments[x]	Diameter of individual corm (cm)	Corm yield (g $plot^{-1}$)	Corm yield (t ha^{-1})
L_0	5.3 b	788.2 c	13.1 c
L_1	5.8 a	818.1 a	13.6 a
L_2	5.4 b	803.3 b	13.4 b
LSD (0.05)	**0.1**	**7.3**	**0.1**
CV%	**3.1**	**1.1**	**1.0**

[X] L_0-Control, L_1-liming 2.5 ton/ha, L_2- Liming 5 ton/ha

[Y] In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

Table 8. Effect of GA_3 on gladiolus related to quality attributes[Y]

Treatments[x]	Diameter of individual corm (cm)	Corm yield (g $plot^{-1}$)	Corm yield (t ha^{-1})
G_0	4.8 d	738.7 d	12.3 d
G_1	5.6 c	778.1 c	13.0 c
G_2	6.4 a	851.7 a	14.2 a
G_3	5.8 b	843.3 b	14.1 b
$LSD_{(0.05)}$	0.2	8.4	0.1
CV%	3.1	1.1	1.0

[X] G_0-Control, G_1-GA_3 150 ppm, G_2- GA_3 200 ppm, G_3- GA_3 250 ppm

[Y] In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

Table 9. Combined effect of lime and GA_3 on growth related attributes of gladiolus[Y]

Treatment combinations[x]	Diameter of individual corm (cm)	Weight of individual corm (g)	Corm yield (g $plot^{-1}$)	Corm yield (t ha^{-1})
L_0G_0	4.3 e	35.3 g	706.8 g	11.8 g
L_0G_1	5.1 d	38.3 e	766.3 e	12.8 e
L_0G_2	6.1 b	41.9 b	838.4 b	14.0 b
L_0G_3	5.9 bc	42.1 b	841.2 b	14.0 b
L_1G_0	5.0 d	37.0 f	739.4 f	12.3 f
L_1G_1	5.7 c	39.5 d	789.6 d	13.2 d
L_1G_2	6.7 a	44.9 a	898.6 a	15.0 a
L_1G_3	5.9 bc	42.2 b	844.8 b	14.1 b
L_2G_0	4.9 d	38.5 e	769.8 e	12.8 e
L_2G_1	5.8 bc	38.9 de	778.4 de	13.0 de
L_2G_2	6.1 b	40.9 c	818.0 c	13.6 c
L_2G_3	5.8 c	42.4 b	847.0 b	14.1 b
$LSD_{(0.05)}$	**0.3**	**0.7**	**14.6**	**0.2**
CV%	**3.1**	**1.0**	**1.1**	**1.0**

[X] L_0–Control, L_1–liming 2.5 ton/ha, L_2– Liming 5 ton/ha
G_0–Control, G_1–GA_3 150 ppm, G_2– GA_3 200 ppm, G_3– GA_3 250 ppm

[Y] In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

4.11 Weight of individual corm

Statistically significant variation was recorded due to the application of lime in weight of individual corm of gladiolus (Appendix VI). The highest weight of individual corm was observed from L_1 (40.9 g) which was closely followed by L_2 (40.2 g), whereas the lowest weight of individual corm was recorded from L_0 (39.4 g) (Figure 6).Weight of individual corm was highest due to the application of 2.5 t ha^{-1} lime for improving soil health. Application of lime at an appropriate rate brings several chemical and biological changes in the soils, which are beneficial or helpful in improving crop yields and quality on acid soils (Fageria and Baligar, 2008).

Weight of individual corm of gladiolus showed statistically significant variation for different level of GA_3 (Appendix VI). The highest weight of individual corm was recorded from G_2 (42.6 g) which was closely followed by G_3 (39.0 g), while the lowest weight of individual corm was found from G_0 (36.9 g) which was followed by G_1 (38.9 g) (Figure 7). Plant growth regulators increased weight of corms as compared to the control. These results are also in conformity with the result of Sajid *et al.* (2015).

Combined effect of the application of lime and GA_3 showed statistically significant variation in terms of weight of individual corm (Appendix VI). The highest weight of individual corm was recorded from L_1G_2 (44.9 g) and the lowest weight of individual corm was observed from L_0G_0 (35.3 g) (Table 9). Gibberellic acid (GA_3) and lime enhance the yield of gladiolus at different concentrations. Findings also reported by Vijai *et al*. (2007) from their earlier experiment.

4.12 Corm yield plot^{-1}

Statistically significant variation was recorded due to the application of lime in corm yield plot^{-1} of gladiolus (Appendix VI). The highest corm yield plot^{-1} was observed from L_1 (818.1 g) which was closely followed by L_2 (803.3 g), whereas the lowest corm yield plot^{-1} was recorded from L_0 (788.2 g) (Table 7). It was revealed that different corm yield plot^{-1} was highest due to the application of 2.5 t ha^{-1} lime . Application of lime at an appropriate rate brings several chemical and biological changes in the soils, which are beneficial or helpful in improving crop yields and quality on acid soils (Fageria and Baligar, 2008).

Corm yield plot^{-1} of gladiolus showed statistically significant variation for different level of GA_3 (Appendix VI). The highest corm yield plot^{-1} was recorded from G_2 (851.7 g) which was closely followed by G_3 (843.3 g), while the lowest corm yield plot^{-1} was found from G_0 (738.7 g) which was followed by G_1 (778.1 g) (Table 8). The application of plant growth regulators is one of the most important factors in improving the yield. The highest corm yield plot^{-1} was observed by the foliar application of 200 ppm GA_3. These results are also in conformity with the result of Vijai *et al*. (2007).

Combined effect of the application of lime and GA_3 showed statistically significant variation in terms of corm yield plot^{-1} (Appendix VI). The highest corm yield plot^{-1} was recorded from L_1G_2 (898.6 g) and the lowest corm yield plot^{-1} was observed from L_0G_0 (706.8 g) (Table 9). Gibberellic acid (GA_3) and lime enhance the yield of gladiolus at different concentrations. Findings also reported by Vijai *et al*. (2007) from their earlier experiment.

4.13 Corm yield ha^{-1}

Corm yield ha^{-1} of gladiolus showed statistically significant variation due to the application of lime in (Appendix VI). The highest corm yield ha^{-1} was observed from L_1 (13.6 ton) which was closely followed by L_2 (13.4 ton), whereas the lowest corm yield ha^{-1} was recorded from L_0 (13.1 ton) (Table 7). It was revealed that highest corm yield ha^{-1} produced for 2.5 t ha^{-1} of lime. Kamruzzaman *et al.* (2013) reported that the application of dolochun ($CaCO_3$) was used as the liming material and showed statistically identical yield compared to chemical fertilizer.

Statistically significant variation was recorded in terms of corm yield ha^{-1} of gladiolus for different level of GA_3 (Appendix VI). The highest corm yield ha^{-1} was recorded from G_2 (14.2 ton) which was closely followed by G_3 (14.1 ton), while the lowest corm yield ha^{-1} was found from G_0 (12.3 ton) which was followed by G_1 (13.0 ton) (Table 8). The application of plant growth regulators is one of the most important factors in improving the yield. These results are also in conformity with the result of Sajid *et al.* (2015).

Application of lime and GA_3 showed statistically significant variation in terms of corm yield ha^{-1} due to the combined effect (Appendix VI). The highest corm yield ha^{-1} was recorded from L_1G_2 (15.0 ton) and the lowest corm yield ha^{-1} was observed from L_0G_0 (11.8 ton) (Table 9). Gibberellic acid (GA_3) and lime enhance the yield of gladiolus at different concentrations. Findings also reported by Vijai *et al*. (2007) from their earlier experiment.

4.14 Number of cormel plot^{-1}

Statistically significant variation was recorded due to the application of lime in number of cormel plot^{-1} of gladiolus (Appendix VII). The highest number of cormel plot^{-1} was observed from L_1 (39.8) which was closely followed by L_2 (36.1), whereas the lowest number of cormel plot^{-1} was recorded from L_0 (35.1) (Table 10). It was revealed that different number of cormel plot^{-1} produced for different level of lime. Similar findings also reported by Kisinyo *et al.* (2005) from their earlier experiment.

Number of cormel plot^{-1} of gladiolus showed statistically significant variation for different level of GA_3 (Appendix VII). The highest number of cormel plot^{-1} was recorded from G_2 (47.1) which was closely followed by G_3 (45.2), while the lowest number of cormel plot^{-1} was found from G_0 (21.4) which was followed by G_1 (33.3) (Table 11). The highest number of cormel plot^{-1} was produced by the foliar application of 200 ppm GA_3. Plant growth regulator Gibbrellic acid GA_3 promoted to increase number of cormel plot^{-1} of gladiolus. Singh *et al.* (2013) reported highest leaf area in 200 ppm GA_3.

Combined effect of the application of lime and GA_3 showed statistically significant variation in terms of number of cormel plot^{-1} (Appendix VI). The highest number of cormel plot^{-1} was recorded from L_1G_2 (51.3) and the lowest number of cormel plot^{-1} was observed from L_0G_0 (20.0) (Table 12). Gibbrellic acid GA_3 and lime enhance the number of cormel plot^{-1} at different concentration. These results are also in conformity with the result of Vijai *et al.* (2007).

Table 10. Effect of lime on growth related attributes of gladiolus[Y]

Treatments[x]	No of cormel plot^{-1}	Weight of individual cormel (g)	Cormel yield (g plot^{-1})	Cormel yield (t ha^{-1})
L_0	35.8 b	14.6 b	574.7 c	9.6 c
L_1	39.8 a	15.4 a	637.8 a	10.6 a
L_2	36.1 b	13.9 b	597.1 b	10.0 b
$LSD_{(0.05)}$	1.3	0.7	14.7	0.2
CV%	4.3	4.6	2.9	2.9

[X] L_0-Control, L_1-liming 2.5 ton/ha, L_2- Liming 5 ton/ha

[Y] In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

Table 11. Effect of GA_3 on growth related attributes of gladiolus[Y]

Treatments[x]	No of cormel plot^{-1}	Weight of individual cormel (g)	Cormel yield (g plot^{-1})	Cormel yield (t ha^{-1})
G_0	21.4 d	10.6 c	377.5 d	6.3 d
G_1	33.3 c	13.9 b	537.7 c	9.0 c
G_2	47.1 a	17.1 a	758.1 a	12.6 a
G_3	45.2 b	14.5 b	739.4 b	12.3 b
$LSD_{(0.05)}$	1.5	0.8	17.0	0.3
CV%	4.3	4.6	2.9	2.9

[X] G_0-Control, G_1-GA_3 150 ppm, G_2- GA_3 200 ppm, G_3- GA_3 250 ppm

[Y] In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

Table 12. Combined effect of lime and GA_3 on growth related attributes of gladiolus[Y]

Treatment combinations[x]	No of cormel $plot^{-1}$	Weight of individual cormel (g)	Cormel yield (g $plot^{-1}$)	Cormel yield (t ha^{-1})
L_0G_0	20.0 i	9.3 g	358.8 h	6.0 h
L_0G_1	27.7 g	12.3 de	468.4 f	7.8 f
L_0G_2	48.0 bc	16.5 b	736.4 b	12.3 b
L_0G_3	47.7 bc	16.4 b	734.2 b	12.2 b
L_1G_0	21.0 hi	10.8 f	359.0 h	6.1 h
L_1G_1	38.7 e	16.0 b	598.0 d	10.0 d
L_1G_2	51.3 a	19.2 a	848.0 a	14.1 a
L_1G_3	48.3 b	15.7 b	746.0 b	12.4 b
L_2G_0	23.3 h	11.7 ef	413.8 g	6.9 g
L_2G_1	33.7 f	13.5 cd	546.6 e	9.1 e
L_2G_2	42.0 d	14.0 c	690.0 c	11.5 c
L_2G_3	45.3 c	16.5 b	738.0 b	12.3 b
$LSD_{(0.05)}$	**2.7**	**1.4**	**29.5**	**0.5**
CV%	**4.3**	**4.6**	**2.9**	**2.9**

[X] L_0–Control, L_1–liming 2.5 ton/ha, L_2– Liming 5 ton/ha
G_0–Control, G_1–GA_3 150 ppm, G_2– GA_3 200 ppm, G_3– GA_3 250 ppm

[Y] In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

4.15 Weight of individual cormel

Statistically significant variation was recorded due to the application of lime in weight of individual cormel of gladiolus (Appendix VII). The highest weight of individual cormel was observed from L_1 (15.4 g) which was closely followed by L_0 (14.6 g), whereas the lowest weight of individual cormel was recorded from L_2 (13.9 g) (Table 10). Application of lime at an appropriate rate brings several chemical and biological changes in the soils, which are beneficial or helpful in improving crop yields and quality on acid soils (Fageria and Baligar, 2008).

Weight of individual cormel of gladiolus showed statistically significant variation for different level of GA_3 (Appendix VII). The highest weight of individual cormel was recorded from G_2 (17.1 g) which was closely followed by G_3 (14.5 g), while the lowest weight of individual cormel was found from G_0 (10.6 g) which was followed by G_1 (13.9 g) (Table 11). The application of plant growth regulators GA_3 is one of the most important factors in improving the yield of gladiolus. These results are also in conformity with the result of Arshad *et al*. (2013).

Combined effect of the application of lime and GA_3 showed statistically significant variation in terms of weight of individual cormel (Appendix VII). The highest weight of individual cormel was recorded from L_1G_2 (19.2 g) and the lowest weight of individual cormel was observed from L_0G_0 (9.3 g) (Table 12). Gibberellic acid (GA_3) and lime enhance the yield of gladiolus at different concentrations. These results are also in conformity with the result of Vijai *et al*. (2007).

4.16 Cormel yield plot^{-1}

Statistically significant variation was recorded due to the application of lime in cormel yield plot^{-1} of gladiolus (Appendix VII). The highest cormel yield plot^{-1} was observed from L_1 (637.8 g) which was closely followed by L_2 (597.1 g), whereas the lowest cormel yield plot^{-1} was recorded from L_0 (574.7 g) (Table 10). It was revealed that 2.5 t ha^{-1} of lime produced highest yield plot^{-1}. Application of lime at an appropriate rate brings several chemical and biological changes in the soils, which are beneficial or helpful in improving crop yields and quality on acid soils (Fageria and Baligar, 2008).

Cormel yield plot^{-1} of gladiolus showed statistically significant variation for different level of GA_3 (Appendix VII). The highest cormel yield plot^{-1} was recorded from G_2 (758.1 g) which was closely followed by G_3 (739.4 g), while the lowest cormel yield plot^{-1} was found from G_0 (377.5 g) which was followed by G_1 (537.7 g) (Table 11). The application of plant growth regulators is one of the most important factors in improving the yield. These results are also in conformity with the result of Sajid *et al.* (2015).

Combined effect of the application of lime and GA_3 showed statistically significant variation in terms of cormel yield plot^{-1} (Appendix VII). The highest cormel yield plot^{-1} was recorded from L_1G_2 (848.0 g) and the lowest cormel yield plot^{-1} was observed from L_0G_0 (358.8 g) (Table 12). Gibberellic acid (GA_3) and lime enhance the yield of gladiolus at different concentrations. Findings also reported by Vijai *et al*. (2007) from their earlier experiment.

4.17 Cormel yield ha^{-1}

Statistically significant variation was recorded due to the application of lime in cormel yield ha^{-1} of gladiolus (Appendix VII). The highest cormel yield ha^{-1} was observed from L_1 (10.6 ton) which was closely followed by L_2 (10.0 ton), whereas the lowest cormel yield ha^{-1} was recorded from L_0 (9.6 ton) (Table 10). It was revealed that different corm yield ha^{-1} produced for different level of lime. Kamruzzaman *et al.* (2013) reported that the application of dolochun ($CaCO_3$) was used as the liming material and showed statistically identical yield compared to chemical fertilizer.

Cormel yield ha^{-1} of gladiolus showed statistically significant variation for different level of GA_3 (Appendix VII). The highest cormel yield ha^{-1} was recorded from G_2 (12.6 ton) which was closely followed by G_3 (12.3 ton), while the lowest cormel yield ha^{-1} was found from G_0 (6.3 ton) which was followed by G_1 (9.0 ton) (Table 11). The application of plant growth regulators GA_3 is one of the most important factors in improving the yield. These results are also in conformity with the result of Sajid *et al.* (2015).

Combined effect of the application of lime and GA_3 showed statistically significant variation in terms of cormel yield ha^{-1} (Appendix VII). The highest cormel yield ha^{-1} was recorded from L_1G_2 (14.1 ton) and the lowest cormel yield ha^{-1} was observed from L_0G_0 (6.0 ton) (Table 12). Gibberellic acid (GA_3) and lime enhance the yield of gladiolus at different concentrations. These results are also in conformity with the result of Vijai *et al*. (2007).

4.18 Economic analysis

Input costs for manpower, land preparation, seed cost, nutrient sources, irrigation, lime and GA_3 required for all the operations from planting to harvesting of gladiolus flower, bulb and bulblet were recorded for unit plot and converted into cost per hectare. Price of gladiolus flower, corms and cormels was considered as per market rate. The economic analysis presented under the following headings-

4.18.1 Gross return

The combination of lime and GA_3 showed different gross return. The highest gross return was obtained from L_1G_2 (1,634,600 Tk./ha) and the second highest gross return was found in L_2G_3 (1,554,800 Tk./ha). The lowest gross return was obtained from L_0G_0 (1,338,200 Tk./ha) (Table 13).

4.18.2 Net return

In case of net return different treatments combination showed different net return. The highest net return was found from L_1G_2 (1,184,919 Tk./ha) and the second highest net return was obtained from L_0G_2 (1,110,503 Tk./ha). The lowest net return was obtained L_0G_0 (942,534 Tk./ha) (Table 13).

4.18.3 Benefit cost ratio

In the combination of lime and GA_3 the highest benefit cost ratio was noted from L_1G_2 (2.64) and the second highest benefit cost ratio was estimated from L_0G_2 (2.51). The lowest benefit cost ratio was obtained from L_2G_0 (2.10) (Table 13). From economic point of view, it was apparent from the above results that the combination of L_1G_2 was more profitable than rest of the combination.

Table 13. Cost and return of gladiolus cultivation as influenced of lime and GA_3

Treatment Combination[x]	Cost of Production (Tk. ha^{-1})	Yield of corm (t ha^{-1})	Price of corm (Tk.)	Yield of cormel (t ha^{-1})	Price of cormel	Yield of spike (1000 ha^{-1})	Price of cut flower	Gross return (Tk. ha^{-1})	Net return (Tk. ha^{-1})	Benefit cost ratio
L_0G_0	439,466	11.80	118,000	6.0	36,000	307	1228,000	1338,200	942,534	2.14
L_0G_1	442,020	12.80	128,000	7.8	46,800	308	1232,000	1406,800	964,780	2.18
L_0G_2	443,297	14.00	140,000	12.3	73,800	335	1340,000	1553,800	1110,503	2.51
L_0G_3	444,574	14.00	140,000	12.2	73,200	325	1300,000	1513,200	1068,626	2.40
L_1G_0	445,851	12.30	123,000	6.1	36,600	308	1232,000	1391,000	945,149	2.12
L_1G_1	448,404	13.20	132,000	10.0	60,000	325	1300,000	1492,000	1043,596	2.33
L_1G_2	449,681	15.00	150,000	14.1	84,600	350	1400,000	1634,600	1184,919	2.64
L_1G_3	450,958	14.10	141,000	12.4	74,400	325	1300,000	1515,400	1064,442	2.36
L_2G_0	452,235	12.80	128,000	6.9	41,400	308	1232,000	1401,400	949,165	2.10
L_2G_1	454,789	13.00	130,000	9.1	54,600	325	1300,000	1484,600	1029,811	2.26
L_2G_2	456,066	13.60	136,000	11.5	69,000	335	1340,000	1545,000	1088,934	2.39
L_2G_3	457,343	14.10	141,000	12.3	73,800	335	1340,000	1554,800	1097,457	2.40

[X] L_0–Control, L_1–liming 2.5 ton/ha, L_2– Liming 5 ton/ha
G_0–Control, G_1–GA_3 150 ppm, G_2– GA_3 200 ppm, G_3– GA_3 250 ppm

Price of gladiolus: Tk. 4000.00/thousand
Price of corm and cormels: Tk. 10,000 and 6,000/ton

CHAPTER V

SUMMARY AND CONCLUSION

The present experiment was undertaken at the Horticulture research farm of Sher-e-Bangla Agricultural University (SAU), Dhaka during the period from November 2014 to March 2015 to find out the influence of liming and foliar application of GA_3 on growth and flowering of gladiolus. The experiment was considered as two factors. Factor A: Lime (3 levels) - L_0: 0 t ha^{-1} (control), L_1: 2.5 t ha^{-1}, L_2: 5.0 t ha^{-1} and Factor B: Gibberellic acid GA_3 (4 levels)- G_0: 0 ppm (control), G_1: 150 ppm, G_2: 200 ppm and G_3: 250 ppm. The experiment was laid out following Randomized Complete Block Design (RCBD) with three replications. Data on yield attributes, flower, corm and cormel production were recorded and significant variation was observed for lime and GA_3 application.

The tallest plant (106.9 cm) was found from L_1, whereas the shortest plant (88.8 cm) from L_0. The minimum days to flower anthesis was observed from L_1 (71.9 days), whereas the maximum from L_0 (80.8 days). The highest leaf area per leaf was observed from L_1 (148.8 cm^2), whereas the lowest from L_0 (143.7 cm^2). The highest chlorophyll content was observed from L_1 (47.0%), whereas the lowest chlorophyll content was recorded from L_0 (42.5%). The highest length of flower stalk was observed from L_1 (63.8 cm), whereas the lowest from L_0 (53.9 cm). The highest length of rachis was observed from L_1 (31.7 cm), whereas the lowest from L_0 (25.1 cm). The highest number of florets $spike^{-1}$ was observed from L_1 (12.8), whereas the lowest from L_3 (9.8). The highest number of spike ha^{-1} was observed from L_1 (327,000), whereas the lowest from L_0 (319,000). The highest diameter of basal floret was observed from L_1 (10.3 cm), whereas the lowest from L_0 (9.0 cm). The highest diameter of individual corm was observed from L_1 (5.8 cm), whereas the lowest from L_0 (5.3 cm). The highest weight of individual corm was observed from L_1 (40.9 g), whereas the lowest from L_0 (39.4 g). The highest corm yield $plot^{-1}$ was observed from L_1 (818.1 g), whereas the lowest corm yield $plot^{-1}$ was recorded from L_0 (788.2 g). The highest corm yield ha^{-1} was observed from L_1 (13.6 ton), whereas the lowest corm yield ha^{-1} was recorded from L_0 (13.1 ton). The highest number of cormel $plot^{-1}$ was observed from L_1 (39.8), whereas the lowest number of cormel $plot^{-1}$ was recorded from L_0 (35.1). The highest weight of individual cormel was observed from L_1 (15.4 g), whereas the lowest weight of individual cormel was recorded from L_2 (13.9 g). The highest cormel yield $plot^{-1}$ was observed from L_1 (637.8 g), whereas the lowest cormel yield $plot^{-1}$ was recorded from L_0 (574.7 g). The highest cormel yield ha^{-1} was observed from L_1 (10.6 ton), whereas the lowest cormel yield ha^{-1} was recorded from L_0 (9.6 ton).

The tallest plant (101.5 cm) was recorded from G_2, while the shortest plant (93.6 cm) was found from G_0. The minimum days to flower anthesis was recorded from G_2 (71.4 days), while the maximum days to flower anthesis was found from G_0 (82.1 days). The highest leaf area per leaf was recorded from G_3 (161.5 cm^2), while the lowest leaf area per leaf was found from G_0 (126.8 cm^2). The highest chlorophyll content was recorded from G_2 (48.6%), while the lowest chlorophyll content was found from G_0 (42.1%). The highest length of flower stalk was recorded from G_2 (62.6 cm), while the lowest length of flower stalk was found from G_0 (52.0 cm). The highest length of rachis was recorded from G_2 (32.6 cm), while the lowest length of rachis was found from G_0 (22.0 cm). The highest number of florets $spike^{-1}$ was recorded from G_2 (12.2), while the lowest number of florets $spike^{-1}$ was found from G_0 (9.3). The highest number of spike ha^{-1} was recorded from G_2 (340,000), while the lowest number of spike ha^{-1} was found from G_0 (308,000). The highest diameter of basal floret was recorded from G_2 (10.9 cm), while the lowest diameter of basal floret was found from G_0 (7.9 cm). The highest diameter of individual corm was recorded from G_2 (6.4 cm), while the lowest diameter of individual corm was found from G_0 (4.8 cm). The highest weight of individual corm was recorded from G_2 (42.6 g), while the lowest weight of individual corm was found from G_0 (36.9 g). The highest corm yield $plot^{-1}$ was recorded from G_2 (851.7 g), while the lowest corm yield $plot^{-1}$ was found from G_0 (738.7 g). The highest corm yield ha^{-1} was recorded from G_2 (14.2 ton), while the lowest corm yield ha^{-1} was found from G_0 (12.3 ton). The highest number of cormel plot^{-1} was recorded from G_2 (47.1), while the lowest number of cormel plot^{-1} was found from G_0 (21.4). The highest weight of individual cormel was recorded from G_2 (17.1 g), while the lowest weight of individual cormel was found from G_0 (10.6 g). The highest cormel yield plot^{-1} was recorded from G_2 (758.1 g), while the lowest cormel yield plot $^{-1}$ was found from G_0 (377.5 g). The highest cormel yield ha^{-1} was recorded from G_2 (12.6 ton), while the lowest cormel yield ha^{-1} was found from G_0 (6.3 ton).

The tallest plant (111.1 cm) was recorded from L_1G_2 and the shortest plant was observed from L_0G_0 (82.3 cm). The minimum days to flower anthesis was recorded from L_1G_2 (64.3 days) and the maximum days to flower anthesis was observed from L_0G_0 (86.3 days). The highest leaf area per leaf was recorded from L_1G_3 (169.4 cm^2) and the lowest leaf area per leaf was observed from L_2G_0 (124.7 cm^2). The highest chlorophyll content was recorded from L_1G_2 (52.6%) and the lowest chlorophyll content was observed from L_0G_0 (39.1%). The highest length of flower stalk was recorded from L_1G_2 (70.5 cm) and the lowest length of flower stalk was observed from L_0G_0 (46.8 cm). The highest length of rachis was recorded from L_1G_2 (36.9 cm) and the lowest length of rachis was observed from L_0G_0 (18.9 cm). The highest number of florets spike^{-1} was recorded from L_1G_2 (15.1) and the lowest number of florets spike^{-1} was observed from L_1G_0 (8.3). The highest number of spike ha^{-1} was recorded from L_1G_2 (350,000) and the lowest number of spike ha^{-1} was observed from L_0G_0 (307,000). The highest diameter of basal floret was recorded from L_1G_2 (12.6 cm) and the lowest diameter of basal floret was observed from L_1G_0 (7.9 cm). The highest diameter of individual corm was recorded from L_1G_2 (6.7 cm) and the lowest diameter of individual corm was observed from L_0G_0 (4.3 cm). The highest weight of individual corm was recorded from L_1G_2 (44.9 g) and the lowest weight of individual corm was observed from L_0G_0 (35.3 g). The highest corm yield plot^{-1} was recorded from L_1G_2 (898.6 g) and the lowest corm yield plot^{-1} was observed from L_0G_0 (706.8 g). The highest corm yield ha^{-1} was recorded from L_1G_2 (15.0 ton) and the lowest corm yield ha^{-1} was observed from L_0G_0 (11.8 ton). The highest number of cormel plot^{-1} was recorded from L_1G_2 (51.3) and the lowest number of cormel plot^{-1} was observed from L_0G_0 (20.0). The highest weight of individual cormel was recorded from L_1G_2 (19.2 g) and the lowest weight of individual cormel was observed from L_0G_0 (9.3 g). The highest cormel yield plot^{-1} was recorded from L_1G_2 (848.0 g) and the lowest cormel yield plot^{-1} was observed from L_0G_0 (358.8 g). The highest cormel yield ha^{-1} was recorded from L_1G_2 (14.1 ton) and the lowest from L_0G_0 (6.0 ton).

The highest gross return was obtained from L_1G_2 (1,634,600 Tk./ha) and the lowest gross return was obtained from L_0G_0 (1,338,200 Tk./ha). The highest net return was found from L_1G_2 (1,184,919 Tk./ha) and the lowest net return was obtained L_0G_0 (942,534 Tk./ha). In the combination of lime and GA_3 the highest benefit cost ratio was noted from L_1G_2 (2.64) and the lowest benefit cost ratio was obtained from L_2G_0 (2.10). From economic point of view, it was apparent from the above results that the combination of L_1G_2 was more profitable than rest of the combination.

Conclusion:

Considering the above discussion it may be concluded that

i. In the experiment 2.5 t/ha lime was more effective than control or 5.0 t/ha lime.

ii. Better performance was observed for soil application of 2.5 t/ha lime and foliar application of 200 ppm GA_3.

iii. The treatment under the study, L_1G_2 is the best for growth, flowering and yield of gladiolus.

iv. Several other experiments can be carried with different rates of lime and different concentration of GA_3 to get other results.

v. Considering the situation of the present experiment, further studies might be conducted in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability and other performances.

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APPENDICES

Appendix I. Monthly record of air temperature, relative humidity, rainfall and sunshine hour of the experimental site during the period from November 2014 to March 2015

Month	*Air temperature (°c)		*Relative humidity (%)	Total Rainfall (mm)	*Sunshine (hr)
	Maximum	Minimum			
November, 2014	25.8	16.0	78	00	6.8
December, 2014	22.4	13.5	74	00	6.3
January, 2015	24.5	12.4	68	00	5.7
February, 2015	27.1	16.7	67	30	6.7
March, 2015	31.4	19.6	64	34	8.2

* Monthly average,

* Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka – 1212

Appendix II. Characteristics of soil of experimental field

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Agronomy 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

B. Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	27
% Silt	43
% clay	30
Textural class	Silty-clay
pH	6.1
Organic matter (%)	1.13
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	23

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

Appendix III. Dose and method of application of fertilizers in gladiolus field

Fertilizers	Dose/ha	Application (%)			
		Basal	15 DAP	30 DAP	45 DAP
Cowdung	10 tons	100	--	--	--
Nitrogen (as urea)	200 kg	--	33.33	33.33	33.33
P_2O_5 (as TSP)	225 kg	100	--	--	--
K_2O (as MoP)	200 kg	100	--	--	--

Appendix IV. Analysis of variance (mean square) for plant height, days to flower anthesis, leaf area and chlorophyll content of gladiolus as influenced by liming and GA_3

Source of variance	Degrees of freedom	Plant height (cm)	Days to flower anthesis	Leaf area (cm^2)	Chlorophyll content (%)
Replication	2	28.09	13.783	7.94	0.406
Factor A (lime)	2	30.079**	46.249**	19.737**	6.943**
Factor B (GA_3)	3	808.429**	97.317**	92.108**	11.577**
A × B	6	5.015**	1.9.00**	0.697**	0.274**
Error	22	1.87	0.391	0.217	0.015

**= Significant at 1% level of probability

Appendix V. Analysis of variance (mean square) for length of flower stalk and rachis, number of florets spike^{-1} and diameter of basal floret of gladiolus as influenced by liming and GA_3

Source of variance	Degrees of freedom	Length of flower stalk (cm)	Length of rachis (cm)	Number of floret spike^{-1}	Diameter of basal floret (cm)
Replication	2	3.109	33.391	35.109	0.034
Factor A (lime)	2	11.222**	70.466**	32.258**	0.123**
Factor B (GA_3)	3	18.235**	456.77**	743.853**	0.359**
A × B	6	0.122**	1.677**	9.982**	0.003**
Error	22	0.026	0.41	1.865	0.001

**= Significant at 1% level of probability

Appendix VI. Analysis of variance (mean square) for growth and yield characteristics of corm of gladiolus as influenced by liming and GA_3

Source of variance	Degrees of freedom	Diameter of corm cm)	Weight of individual corm (g)	Corm yield (g plot^{-1})	Corm yield (t ha^{-1})
Replication	2	0.104	0.444	80.455	0.046
Factor A (lime)	2	0.692**	6.705**	2688.123**	0.745**
Factor B (GA_3)	3	1.806**	66.254**	26508.27**	7.362**
A × B	6	0.053**	4.995**	1997.462**	0.555**
Error	22	0.001	0.162	73.796	0.018

**= Significant at 1% level of probability

Appendix VII. Analysis of variance (mean square) for growth and yield characteristics of cormel of gladiolus as influenced by liming and GA_3

Source of variance	**Degrees of freedom**	**No of cormel plot^{-1}**	**Weight of individual cormel (g)**	**Cormel yield (g plot^{-1})**	**Cormel yield (t ha^{-1})**
Replication	2	1.083	0.016	490.51	0.136
Factor A (lime)	2	60.25**	9.875**	12258.97**	3.405**
Factor B (GA_3)	3	1378.917**	138.436**	293324.5**	81.479**
A × B	6	38.028**	4.026**	7790.716**	2.164**
Error	22	2.508	0.299	302.514	0.084

**= Significant at 1% level of probability

Appendix VIII. Per hectare production cost of gladiolus as influenced by lime and GA_3

A. Input cost

Treatment Combination[x]	Labour cost	Ploughing cost	Corm cost	Irrigation cost	Pesticides cost	Lime cost	GA_3 cost	Manure and fertilizers				Sub Total (A)
								Cowdung	Urea	TSP	MP	
L_0G_0	45,000	25,000	45,000	15,000	12,000	0	0	20,000	1,600	4,500	3,500	171,600
L_0G_1	45,000	25,000	45,000	15,000	12,000	0	2,000	20,000	1,600	4,500	3,500	173,600
L_0G_2	45,000	25,000	45,000	15,000	12,000	0	3,000	20,000	1,600	4,500	3,500	174,600
L_0G_3	45,000	25,000	45,000	15,000	12,000	0	4,000	20,000	1,600	4,500	3,500	175,600
L_1G_0	45,000	25,000	45,000	15,000	12,000	5,000	0	20,000	1,600	4,500	3,500	176,600
L_1G_1	45,000	25,000	45,000	15,000	12,000	5,000	2,000	20,000	1,600	4,500	3,500	178,600
L_1G_2	45,000	25,000	45,000	15,000	12,000	5,000	3,000	20,000	1,600	4,500	3,500	179,600
L_1G_3	45,000	25,000	45,000	15,000	12,000	5,000	4,000	20,000	1,600	4,500	3,500	180,600
L_2G_0	45,000	25,000	45,000	15,000	12,000	10,000	0	20,000	1,600	4,500	3,500	181,600
L_2G_1	45,000	25,000	45,000	15,000	12,000	10,000	2,000	20,000	1,600	4,500	3,500	183,600
L_2G_2	45,000	25,000	45,000	15,000	12,000	10,000	3,000	20,000	1,600	4,500	3,500	184,600
L_2G_3	45,000	25,000	45,000	15,000	12,000	10,000	4,000	20,000	1,600	4,500	3,500	185,600

[x] L_0–Control, L_1–liming 2.5 ton/ha, L_2– Liming 5 ton/ha

G_0–Control, G_1–GA_3 150 ppm, G_2– GA_3 200 ppm, G_3– GA_3 250 ppm

Appendix VIII. Contd.

B. Overhead cost (Tk./ha)

Treatment Combination[x]	Cost of lease of land for 6 months (13% of value of land Tk. 15,00000/year	Miscellaneous cost (Tk. 5% of the input cost	Interest on running capital for 12 months (Tk. 13% of cost/year	Sub total (Tk) (B)	Total cost of production (Tk./ha) [Input cost (A)+ overhead cost (B)]
L_0G_0	195,000	22,308	50,558	267,866	439,466
L_0G_1	195,000	22,568	50,852	268,420	442,020
L_0G_2	195,000	22,698	50,999	268,697	443,297
L_0G_3	195,000	22,828	51,146	268,974	444,574
L_1G_0	195,000	22,958	51,293	269,251	445,851
L_1G_1	195,000	23,218	51,586	269,804	448,404
L_1G_2	195,000	23,348	51,733	270,081	449,681
L_1G_3	195,000	23,478	51,880	270,358	450,958
L_2G_0	195,000	23,608	52,027	270,635	452,235
L_2G_1	195,000	23,868	52,321	271,189	454,789
L_2G_2	195,000	23,998	52,468	271,466	456,066
L_2G_3	195,000	24,128	52,615	271,743	457,343

[X] L_0–Control, L_1–liming 2.5 ton/ha, L_2– Liming 5 ton/ha

G_0–Control, G_1–GA_3 150 ppm, G_2– GA_3 200 ppm, G_3– GA_3 250 ppm

Appendix IX. Map showing the experimental site under study