REGULATION OF GROWTH AND FLOWERING OF GLADIOLUS CULTIVATED IN SUMMER WITH GIBBERELIC ACID

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CERTIFICATE

This is to certify that the thesis entitled **"Regulation of growth and flowering of gladiolus cultivated in summer with gibberelic acid"** submitted to the Department of Horticulture, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE** in **HORTICULTURE,** embodies the result of a piece of *bona fide* research work carried out by **by Most. Naznin Sultana, Registration No. 09-3744**, under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.

I further certify that such help or sources of information, as has been availed of during the course of this investigation has been duly acknowledged.

Dated: June, 2011
Place: Dhaka, Bangladesh

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ABSTRACT

An experiment was conducted at Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka during the period from June to August 2010 to study the effect of GA_3 on growth and flowering of gladiolus. The experiment comprised with two factors viz. Factor A: two varieties, white gladiolus and yellow gladiolus and Factor B: five concentration of GA_3 application viz. 0, 50, 100, 150 and 200 ppm respectively. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Two different varieties did not influence any of the characters under study. But GA_3 application at different concentration had significant effect on the parameters. GA_3 @ 150 ppm treated white gladiolus showed the highest plant height (132.30 cm), number of florets/spike (14.51), length of flower stalk (74.34 cm), weight of single spike at harvest (62.63 g) and yield (327700 spike/ha). GA_3 treated plant also took the minimum days to spike initiation (64.54 days). So, it is concluded that white variety with 150 ppm GA_3 application is the most effective for improving the growth and flowering of gladiolus cultivated in summer .

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BARI	=	Bangladesh Agricultural Research Institute
cm	=	Centimeter
^{0}C	=	Degree Celsius
DAS	=	Days after sowing
et al.	=	and others *(at elli)*
kg	=	Kilogram
kg/ha	=	Kilogram/hectare
LSD	=	Least Significant Difference
MP	=	Muriate of Potash
P^H	=	Hydrogen ion conc.
RCBD	=	Randomized Complete Block Design
TSP	=	Triple Super Phosphate
t/ha	=	ton/hectare

CHAPTER I

INTRODUCTION

Gladiolus (*Gladiolus sp)* is one of the best bulbous ornamental winter flower crops under lridaceae family, deriving from the latin word gladius, meaning a sword, on account of the sword like shape of its foliage. It is a very popular flowering plant in international cutflower trade grown throughout the world in a wide range of climatic conditions. In India its cultivation dates back to nineteenth century and in Bangladesh gladiolus was introduced in the year 1992 from India (Mollah *et al*., 2002). In Bangladesh, the agro ecological conditions are very conducive for the survival and culture of gladiolus. It has great economic value as a cut flower and its cultivation is relatively easy. Gladiolus is cultivated in most of the tropical and subtropical countries of the world.

There is an increasing demand for its attractive elegant spikes having florets of huge forms, dazzling colours, varying sizes and long vase life. It has recently become popular in Bangladesh and its demand is increasing day by day. But its commercial production is not up to the mark in this country due to lack of information regarding its cultivation technology, such as standard corm size and cormel, adequate planting depth, planting time, fertilizer management, use of plant growth regulator like GA_3, IAA etc. (Khanna and Gill, 1983).

The soil should have sufficient moisture at the time of planting of corms so that no watering is required till sprouting. It is generally a winter season crop and susceptible for water logging condition. The flower spike and corm yield in gladiolus vary according to the cultivar, corm size, planting density and management practices etc. Gladiolus spikes take 60 to 100 days after planting to be harvested depending upon the cultivars and time of year (Jenkins *et al.* 1970). Yield of flower spike approximatly 200000 per hectare (Bosh and Yadav, 2007).

The growth and development of plant is governed by internal factors namely hormonal and nutritional balance. The balanced development of plant is

governed by the growth regulators, which are being increasingly used to manipulate the growth and flowering of ornamental plants. Plant growth regulators (PGR) are organic compounds, other than nutrients, which in small amounts promote, inhibit or otherwise modify any plant physiological processes. Use of PGRs, has tremendous potentialities in flower production in Bangladesh. The importance of PGRs, both endogenous ones and synthetic compounds, for crop improvement, has been realized long ago in many countries. Now a days plant growth regulator are being used to increase flower production in the world. The effect of PGR at corms and cormels prior to planting play important roles. Growth regulators used to promote the growth and flower quality as well as corm production in gladiolus. Dormancy is pronounced in corms and cormels of gladiolus. The growth regulators, BAP, GA_3 and ethylene play a role in breaking dormancy of gladiolus. Although there exists a vast scope for exploitation of breaking dormancy and corm multiplication using growth regulator to fulfill the cultivation of gladiolus year round, information of such research works with gladiolus in meager under Bangladesh literature.

The role of gibberelins is complicated both biologically and biochemically and even today is not fully understood (Arora *et al.,* 1992). Moreover, when applied externally, gibberelins influences the internal chemistry of the plant cell and the interaction among cells, but the degree of interaction still depends mostly upon the plant species, the stage of plant development and the external environment (Arora *et al.,* 1992). The gibberellins are involved in a number of processes including stem extension, flowering and fruit growth (Nomura *et a1*., 1997).

It is high time, therefore, to stream line technology and standardize conventional propagation methods and application of different growth regulators like gibberellins in order to produce quality flower spikes and maximize corm and cormel production.

In Bangladesh the commercial gladiolus production is not conducted in off season (summer season) while other countries like as in India it is cultivated throughout the year. Heavy rain and the Germination failure due to heavy rain one of the major problems for the commercial cultivation of gladiolus in off season. But the demand of gladiolus in Bangladesh is high in all the seasons.

Considering the above facts the present study was under taken with the following Objectives.

Objectives:

1. To maximize the germination of corm.
2. To study the effect of GA_3 on growth and flowering of corm.
3. To test the varietal response to $GA_{3.}$

CHAPTER-II

REVIEW OF LITERATURE

Gladiolus is the fourth most popular cut flower in the world trade. Many research works have been conducted on various aspects of this important cut flower in different parts of the world. But limited research works have been carried out on gladiolus in Bangladesh. A review of literatures related to regulation of germination, growth and flowering of gladiolus cultivated in summer with Gibberelic acid (GA_3) is given below under the following headings.

2.1 Varietal performance:

Studies conducted at Akola by Dod *et al*. (1989) revealed that cv. Dibonar was best among different varieties of gladiolus with respect to plant height and number of leaves.

The major producing countries are the United States (Florida and California) Holland, Australia, Japan, Italy, France, Poland, Iran, India, Brazil, Poland, China, Malaysia and Singapore. However mass production and quality cut flower spikes of gladiolus is still problem in many countries as its commercial cultivation is mainly restricted by rare production of corms and cormels (Singh and Doahre, 1994) through corms and cormels (Hartman *et al*., 1990). One mother corm generally produces one daughter corm of standard size and few cormels. These cormels are auxiliary buds on the corm which is a compressed thickened stem and as the resting perpuating organ (Nagaraju *et al*., 2002; Sinha and Roy, 2002).

Sindhu and Verma (1995) studied the performance of 14 gladiolus cultivars under Katrain conditions and found that cultivars Age Wonder, Thumbolina and Sancerre were best with respect to plant height.

Saini *et al*. (1991) studied the performance of six gladiolus cultivars under Hissar conditions and found that maximum plant height was recorded by the cv. George Mazure (99.70 cm) and minimum by cv. Miniature (59.70 cm).

In an evaluation of five gladiolus cultivars under Kerala conditions by Ravidas *et al*. (1993) indicated that in both seasons, American Beauty surpassed the other cultivars with regard to all the vegetative growth characteristics.

Pasannavar (1994) evaluated ten gladiolus cultivars under transitional tract of Karnataka and reported that cultivar Copper King produced maximum plant height (67.79 cm) and maximum number of leaves (6.86) were found in American Beauty. Similar results also obtained by Hegde (1994) under Dharwad conditions and Shiramagond (1997) in Ghataprabha command area. Kalasaraddi (1996) reported that cultivar American Beauty produced more number of leaves (4.61) and plant height (41.94 cm) compare to that of Melody at 30 DAP (days after planting) under Dharwad conditions.

Singh *et al*. (1997) conducted varietal trial with five cultivars of gladiolus under Andaman conditions. Miss America had maximum plant height (66.75 cm). In prevailing agro-climatic conditions of the Andaman islands, Miss America was found to perform best followed by Snow Princess.

Sidhu and Arora (2000) evaluated gladiolus varieties for summer flower production under Ludhiana conditions and reported that variety White Prosperity produced significantly tall plants (130.85 cm) followed by Pole Position (111.60 cm).

Sanjai and Brahma (2000) evaluated 20 gladiolus varieties for cut flower and corm production in Ladakh by considering different characters and found that variety Princess Margaret Rose showed maximum plant height (136.6 cm).

Kamble (2001) studied the performance of gladiolus cultivar in Arabhavi (Karnataka) and reported that cultivar Trust recorded maximum plant height (81.06 cm) and was significantly superior over other cultivars. He also found that cultivar Vedanapoli (21.27) showed maximum number of leaves at 60 DAP.

Rai *et al*. (2000) evaluated 16 varieties of gladiolus under sodic wasteland. Based on different characters such as plant height and number of tillers per plant, the varieties like White Prosperity, White Goddess, Red Beauty, Friendship, Venetei, Aldebran, First Lady were found superior in comparison to others.

Basavaraddy (2004) evaluated elite hybrids of gladiolus for cut flower production under Transition tract of Karnataka and reported that the hybrids AB x MC, M-HVG and MCxAB were found to be good for cut flower production with respect to their number of days taken for spike initiation, number of days taken for first floret to open, length of spike, rachis length, size of the floret and number of marketable spikes.

Kamble (2001) studied the performance of gladiolus cultivars and reported that maximum spike length (93.90 cm), spike weight (127.26 g), diameter of florets (11.91 cm) and number of florets per spike were noticed in cultivar Summer Sunshine and Vadanapali showed maximum spike girth and spike yield per ha.

Gupta *et al*. (2002) studied the performance of gladiolus cultivars in Malwa region of Madhya Pradesh. They found that American Beauty and Spring Green recorded the maximum spike per corm (1.3) followed by Propeticious (1.25) and White Prosperity recorded maximum spike length (83.20 cm) followed by Thumbiliana (72.00 cm).

Studies conducted on performance of various cultivars of gladiolus under valley conditions of Uttaranchal by Jagdish *et al*. (2003) revealed that Oscar cultivar showed best performance as far as spike length and number of florets per spike is concerned.

Evaluation of gladiolus cultivars under Mahabaleshwar conditions by Patil (2003) revealed that the variety Sancerre produced larger spikes, more number of florets per spike. Varieties Yellow Stone and Tropic Sea were also found to be superior in respect of spike length and number of florets per spike compared to rest of varieties.

Seetharamu *et al*. (2003) evaluated six varieties of gladiolus under polyhouse conditions. American Beauty preformed well with respect to plant height (Stalk length), number of florets per spike and uniform distribution of florets on the spike, corm and cormel production, followed by Her Majesty and Cheaper White for hill zone.

Nair and Shiva (2003) evaluated several gladiolus cultivars for cut flower production. The cultivar Darshan produced the maximum number of spikes per plant (3.0) and Dhiraj had the maximum number of florets per spike (12.94) with 5.32 florets opening at a time. Pusa Suhagin had the largest vase life (9.20).

Kamble *et al*. (2004) evaluated nine gladiolus varieties for flowering and yield characters. The varieties Summer Sunshine, Melody, Trust and Yellow Cup were found to be superior for spike length, number of florets per spike and yield and so recommend these cultivars for Ghataprabha Command area of Karnataka.

Kishan *et al.* (2005) studied on the performance of gladiolus under Delhi conditions and found that variety Dhanvantari produced tallest plants (130.83

cm), followed by Anjali (124:00: cm) whereas sylvia was the smallest (74.33 cm) in height. Anjali produced maximum number of leaves per plant (11.33) followed by Dhanavantari (10.66).

2.2 Effect of GA_3

Generally propagating materials for gladiolus are corm and cormels. GA_3 influences corm and cormels to initiate more flowering of gladiolus and corm and cormel production.

The gibberellins are involved in a number of processes including stem elongation, flowering and fruit growth (Li *et al.*, 1996; Szekeres *et al.*, 1996; Yang *et al.,* 1996: Nomura *et a1*., 1997).

Kumar *et al*. (2009) studied the effect of plant growth regulators on dormancy, corm and cormel production in gladiolus cvs. American Beauty and White Prosperity during 2008–09. The plant growth regulators, Gibberellic acid (GA_3) at 75, 100 and 125 ppm; Benzyl Adenine (BA) at 25, 50 and 100 ppm; Naphthalene Acetic Acid (NAA) at 50, 100 and 150 ppm were used in this study. The gladiolus corms were dipped in the plant growth regulator solutions for a period of 10 hours before planting after removal of corm scales. Cultivar American Beauty treated GA_3 @ 125 ppm took less number of days to sprout (17.00) and 50 per cent sprouting (29.00) of gladiolus corms. All the plant growth regulator treatments at higher concentrations recorded minimum number of days to sprouting and 50 per cent sprouting of gladiolus corms. GA_3 at 125 ppm recorded highest percentage of sprouting (100.00) in both the cultivars. BA at 100 ppm recorded maximum number of replacement corms (1.28) and number of cormels produced per corm (5.29) in cv. American Beauty whereas cv. White Prosperity recorded maximum cormel weight per corm (8.02 g) and highest propagation coefficient (193.68) with BA at 100 ppm. NAA at 150 ppm recorded maximum corm size (4.66 cm) and corm weight (23.15 g) in cv. White Prosperity.

Rana *et al*. (2005) carried out a study to find out the effect of different levels of

GA_3, spacing and depth of planting on growth, flowering and corm production parameters in gladiolus cv. Candyman. The treatments consisted of four concentrations qf GA_3 (0, 100, 250 and 500 ppm) as foliar spray, three plant spacings (20 × 20, 30×20 and 40 × 20 cm) and two depths of corm planting (5 and 10 cm). Gibberellic acid @ 100 ppm, plant spacing of 30x 20 cm and planting depth of 10 cm resulted in maximum plant height, number of leaves/plant, length of leaf and corm production.

Ali and Al-Safar (2004) conducted a field experiment to evaluate the effect of nitrogen and gibberellin pretreatment on growth and development of two cultivars (Topaz and Sancerre) of gladiolus corms during 2003 and 2004 in Al-Hassa, Saudi Arabia. The experimental soil was loamy sand and received four levels of nitrogen (0, 25, 50 and 75 kg N $ha^{-'}$) applied as urea. Gladioli corms were presoaked for 24 h in the gibberellic acid (GA,) solutions at a concentration of 0 and 100 mg L^{-1}. Mean stem height, number of leaves per plant, leaf area, shoot dry weight, number of corms per plant, cones dry weight and flower diameter increased significantly with nitrogen and GA, fleatrnent. A significant difference was observed between the performance of two cultivars and the Topaz proved superior to Sancerre in all growth parameters. This study also confirmed the higher potential of Topaz gladiolus established as a benchmark for nitrogen application rate of 75 kg $ha^{-1}$for gladioli in Saudi Arabia and suggested that high corm and flower yield of gladioli may be obtained when corns are soaked in GA, solution of 100 mg L^{-1} before plantation.

Kumar *et al*. (2002) conducted a field experiment during 2000-2001 in New Delhi, India on gladiolus cv. Jester to determine the effect of GA_3 (400 ppm). The number of leaves (7.66) per shoot, leaf area (591.00 cm^2), plant height (76.33 cm), number of florets per spike (15.66), spike length (65 cm), and rachis length (41.66 cm) were maximum in dipping+spraying at 40+65+90 days after planting (DAP) treatment. In addition, the days to 50% sprouting,

size of corm at lifting, average weight of corm per plant, and propagation coefficient increased with dipping + spraying at 40+65+90 DAP treatment.

Sanjaya (1995) conducted this experiment to determine the effect of application of GA3 on the dormancy breaking o1995f various corm size of G. hybridus cv. Queen Occer. The experiment was conducted at the Laboratory of Cipanas Horticultural Research Station from March to June 1992. A Factorial Randomized Block Design comprised of 2 factors i.e. concentration of GA3 (0, 50, 100, and 150 ppm) and corm sizes (diameter more than or same with 3.5 cm, diameter 2.5 - 3.5 cm, and diameter 1.5 - 2.5 cm) was used. The result showed that application of GA3 did not effectively accelerate shoot and root initiation of the corm, as well as increase the number of shoot per corm and percentage of sprouting corm. The bigger corm size, the faster ending time of dormancy. In order to get equally plant growth, it should be planted the same corm size. The growing period can be shortened by applying bigger corm size as planting material.

The effectiveness of chemicals such as gibberellins (Arora *et al*., 1992), benzyladenine (Goo *et al*., 1998)) and methyl disulfide (Hosoki and Kubara, 1989) in breaking the dormancy of gladiolus (*Gladiolus* ×*grandiflora* Hort.) corms and cormels has been studied extensively; treatment efficacy varies with chemical, cultivar, and other factors.

Roychowdhury (1987) conduct experiments for five years (1982 – 1987) under polythene tunnel with gladiolus cv. 'Psittacinus hybrid'. The corms (2.5–2.7 cm in diameter) were soaked (for 6 hours) in GA_3 (50 and 100 ppm), Ethrel (100 and 200 ppm) and Kinetin (25 and 50 ppm) before planting at 25 and 33 corms/m^2 densities. Results show that higher plant density (33 corms/m^2) increases the plant height, length of flower stalk and corm yield/unit area, while it decreases the number of florets/ spike, length and diameter of flower, irrespective of the treatments including control. Treatment with Ethrel inhibited plant growth but markedly increased the corm yield and the maximum corm

yield of 132.5/plot (25 corms/m^2) and 138.6/plot (33 corms/m^2) were noted by soaking of corms with Ethrel at 100 and 200 ppm respectively, compared to 60.0 and 79.2 corms/plot in control. Soaking of corms with Kinetin however, showed an increase in the number of florets/spike and size of flowers.

Singh *et al*. (2002) conduct a field experiment in India, to evaluate the effects of cormel and methods and levels of GA_3 application on gladiolus corm production. Cormels of three different sizes (small, 1.0-1.5 cm; medium, 1,5-2.0 cm; and large, ≥2.0 cm) were treated with four concentrations of GA_3 (0, 25, 50 and 75 ppm) in two different modes of application (pre-planting dip for 12 h or foliar spray at the four-leaf stage). All parameters improved with increasing size of cormels, with the large cormels recording the lowest number of days for sprouting (4.54) and the highest values for percentage of cormels sprouted (80.59%), plant height before spike emergence (33.96 cm), number of leaves (7.45), neck diameter (0.98 cm), number of corms per plant (0.99), corm weight (21.57 g), corm diameter (3.49 cm), number of cormels per plant (4.56), cormel weight (1.34 g), cormel weight per plant (6.22 g) and cormel diameter (1.27 cm). Similarly, all parameters improved with increasing level of GA_3, with GA_3 at 75 ppm recording the lowest number of days for sprouting (4.66) and the highest values for percentage of cormels sprouted (78.14%), plant height before spike emergence (34.13 cm), number of leaves (7.08), neck diameter (0.96 cm), number of corms per plant (0.98), corm weight (20.92 g), corm diameter (3.56 cm), number of cormels per plant (4.50), cormel weight (1.34 g), cormel weight per plant (5.91 g) and cormel diameter (1.28 cm). The method of application had varying effects on the different parameters, i.e. pre-planting dip improved days for sprouting, percentage of cormels sprouted, corm weight, corm diameter, cormel weight and corm diameter, while the foliar spray was better than the other application method for the other parameters studied.

Kumar *et al*. (2008) conducted an experiment to observe the effect of growth regulators on flowering and corm production in gladiolus. The effect of foliar spray of brassinosteroids (BR), N-2-chloro 4-pyridyl N-phenyl urea (CPPU) and jasmonic acid (JA) along with traditional growth regulators like GA_3, benzyl adenine (BA) and NAA on growth, flowering and corm and cornmel production of two gladiolus varieties Jyotsna and Shabnum were investigated. Jyotsna recorded maximum plant height, number of leaves and leaf area over cv. Shabnum. GA_3 treatment recorded maximum plant height, number of leaves and leaf length over other treatments. Jyotsna was superior over Shabnum in respect of spike length, spike field life and number of days taken for flowering. GA_3 and jasmonic acid increased spike length, number of florets per spike and spike field life over other treatments. All the growth regulators except NAA recorded maximum leaf area during vegetative growth resulting early flowering. The two cultivars did not differ in the number of corms produced per plot but the cv. Shabnum was superior in producing more number of big cormels. Corm size, corm weight and corm volume were maximum in Jyotsna than Shabnum. Propagation coefficient was highest in the Shabnum. Foliar sprays of jasmonic acid and brassinosteroids significantly increased the number of corms and cormels produced per plot and propagation coefficient.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at Sher-e-Bangla Agricultural University, Dhaka during June - August 2010. Materials and methods followed for conducting the experiment are presented under the following headings:

3.1 Experimental site

The experiment was conducted at Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh. Location of the site is 23º74´ N latitude and 90º35´ E longitude with an elevation of 8.2 meter from sea level.

3.2 Climatic condition

Climate of the experimental site is subtropical, characterized by heavy rainfall during the months from April to September (Kharif season) and scanty rainfall during the rest of the year (Rabi season). Maximum and minimum temperature, humidity and rainfall during the study period were collected from the Bangladesh Meteorological Department (climate division), Agargaon, Dhaka and have been presented in Appendix I.

3.3 Soil

The land topography was medium high and soil texture was silt clay with pH 8.0. The morphological, physical and chemical characteristics of the site soil have been presented in Appendix-II.

3.4 Land Preparation

The land was first opened by a power tiller. It was then ploughed and cross ploughed several times and the clods were broken. Weeds were collected before final land preparation. Manure and TSP were applied as basal dose. Urea and MP were applied in two installments after germination of corms/cormels.

3.5 Experimental design and layout

The experiment was laid out in a factorial Randomized Complete Block Design (RCBD) with 3 replications. There were 30 (10x 3) unit plots in the experiment. The size of unit plot was 0.75 m x 0.75 m. The distance between the blocks was 0.5 m and between the plots was 0.5 m. The plots were raised upto 15 cm (Appendix III).

3.6 Planting materials

The materials of the experiment were collected from Agritech Nursery, Khamarbari, Farmgate, Dhaka.

Plate 1 : White colored flower

Plate 1: Yellow colored flower

3.7 Treatments of the experiment

These were two factors in the experiment.

Factor A: Variety (2 levels):

i. V_1: White colored

ii. V_2: Yellow colored

Factor B: Foliar application of Gibberellic acid (GA_3**) (5 levels):**

i. C_0: Control

ii. C_1: 50 ppm

iii. C_2: 100 ppm

iv. C_3: 150 ppm

v. C_4: 200 ppm

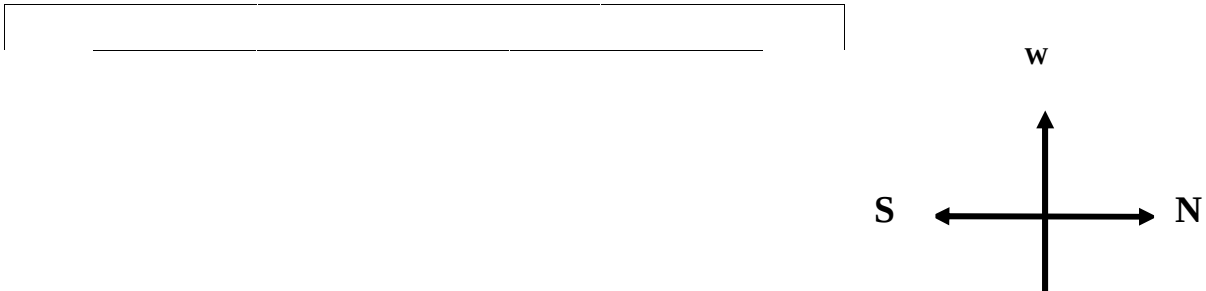
There were 10 (2 × 5) treatment combinations as follows

V_1C_0, V_1C_1, V_1C_2, V_1C_3, V_1C_4, V_2C_0, V_2C_1, V_2C_2, V_2C_3 and V_2C_4.

3.8 Preparation and application of GA_3

Different concentrations of GA_3 were prepared following the procedure mentioned. Plants were sprayed at 15, 30 and 45 days after sowing with a hand sprayer.

A 50 ppm solution of GA_3 was prepared by dissolving 50 mg of it in a small quantity of ethanol prior to dilution with distilled water. Then distilled water was added to make the volume 1 litre . In the similar way, 100, 150 and 200 ppm concentrations of solutions were prepared.



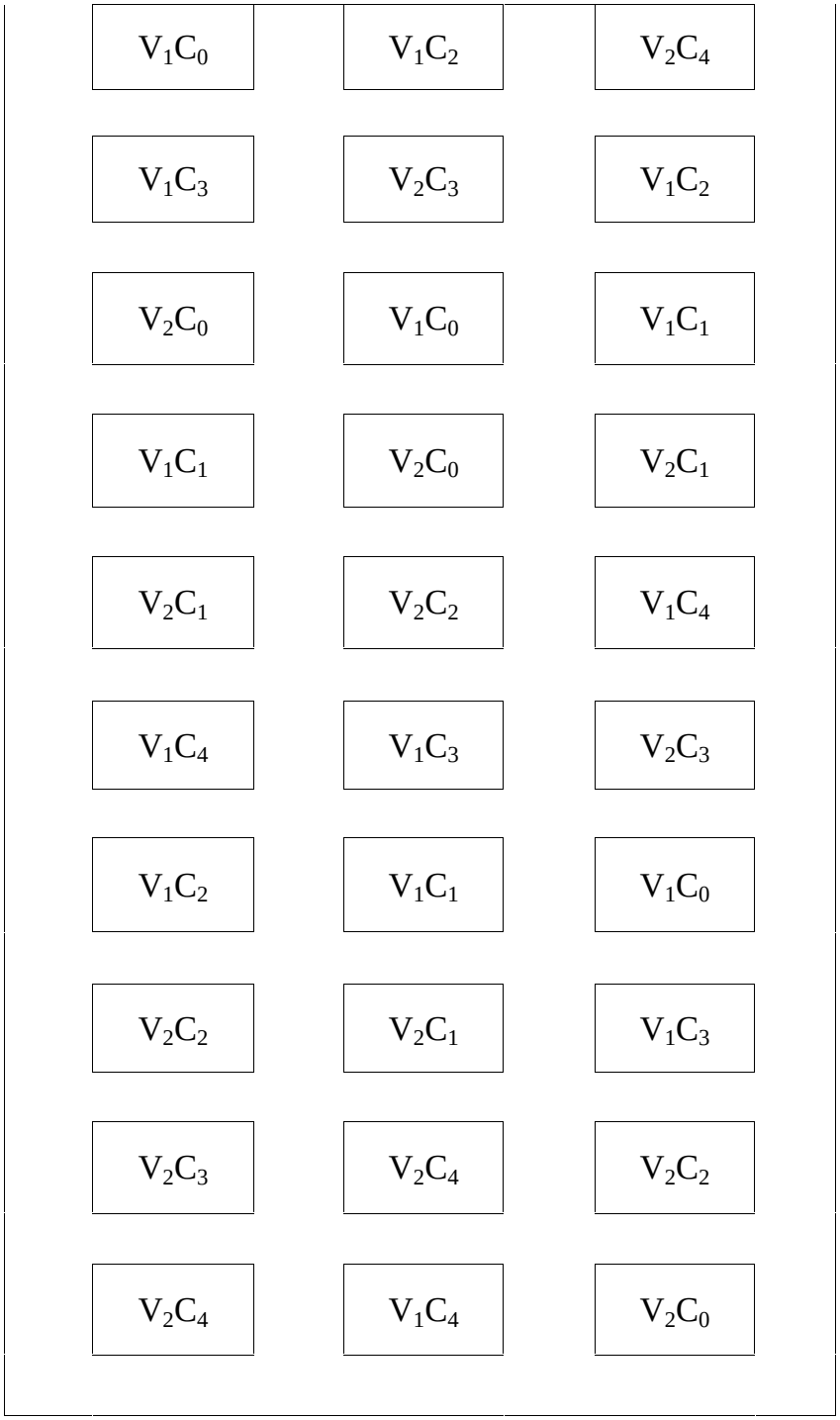


Fig. 1. Field layout of the experiment

3.9 Manure and fertilizer

The crop was fertilized with the following doses of manure and fertilizers as recommended in a report of BARI (BARI- 2002).

Cowdung	10 t/ha
Urea	200 kg/ha
TSP	225 kg/ha
MP	200 kg/ha

Entire amount of cowdung and TSP were applied during final land preparation. Urea and MP were applied in two installments at 25 and 50 days after planting of corms.

3.10 Planting of corms

Corms were planted at 7 cm depth in the plot on 2 June, 2010 with sufficient care for minimum injury of corms. Spacing was maintained 25 cm x 15 cm.

3.11 Intercultural operation

3.11.1 Weeding

Weeding was done in all the plots as and when required to keep the plant free from weeds.

3.11.2 Irrigation

Frequency of watering depended upon the moisture status of the soil. However, water logging was avoided, to maintain optimum soil moisture.

3.11.3 Disease and pest management

No pesticide was needed for disease and pest management during experimental period.

3.12 Data collection

Data were collected in respect of the following parameters from each plot with in the mentioned period.

3.12.2 Days to germination percentage

It was achieved by recording the days taken for emergence of plant from date of planting of corms.

3.12.3 Plant height

Height of plant was measured from ground level up to the tip of the longest leaf. It measured in cm. Data were recorded at every 20 days interval after 20 days of transplanting (DAT) and continued up to harvest. Harvest was done at 3/4 days after spike initiation i.e., when minimum two florets were bloom at the lower portion of the spike.

3.12.4 Days to spike initiation

It was achieved by recording the days taken for emergence of spike from the date of planting of corm/cormels.

3.12.5 Length of flower stalk at harvest

Length of flower stalk was measured from the base to the tip of the spike.

3.12.6 Number of floret/spike

All the florets of the spike were counted from 10 randomly selected plants and their mean was calculated.

3.12.7 Weight of single spike at harvest

Ten spikes were cut from randomly selected plants from each unit plot and the weights of spikes were recorded to calculate their means.

3.12.8 Yield (number of spike/ha)

The total number of spikes per unit plot was converted to yield per hectare.

3.13 Statistical analysis

Collected data for various characters were statistically analyzed using MSTAT program. Means for all the treatments were calculated and the analysis of variance for each of the character was performed by F (variance ratio) test. Difference between treatments was evaluated by Duncan's Multiple Range Test (DMRT) test at 5% level of significance (Gomez and Gomez, 1984).

CHAPTER-IV

RESULTS AND DISCUSSION

The present experiment was conducted to Regulation of germination, growth and flowering of gladiolus cultivated in summer with Gibberelic acid (GA_3). The results have been presented and discussed, and possible interpretations have been given under the following headings:

4.1 Days to 100% germination

Days to 100% germination percentage was significantly influenced by two varieties (white and yellow) (Table 1). The highest days required for 100% germination was observed with yellow variety, V_2 (18.87 days) where the lowest (17.56 days) was observed with white variety, V_1.

In considering days to 100% germination, different levels of GA_3 application showed a statistically significant dissimilarity (Table 2). With the application of GA_3, the highest days required for 100% germination (18.64 days) was recorded in the control plot which was significantly identical with C_1. On the other hand the lowest % germination (17.72 days) was recorded in C_4 (GA_3 @ 200 ppm) which was statistically identical with C_2 and C_3.

Days to 100% germination percentage was not influenced by different treatment combinations presented in Table 3. But the highest days required for germination (19.83 days) was observed in V_2C_0 where the lowest (17.11 days) was observed in V_1C_4 (GA_3 @ 200 ppm). Because GA_3 promotes germination by allowing enzymes to convert starch stored within the seed into sugar, which is used for embryo growth.

Table 1. . Individual effect of variety on germination

Treatment [X]	Days to 100% germination
V_1	17.56 b
V_2	18.87 a
$LSD_{0.05}$	0.894
CV(%)	5.86

[X] V_1; White colored, V_2; Yellow colored

Table 2. Individual effect of GA3 application on germination

Treatment [X]	Days to 100% germination
C_0	18.64 a
C_1	18.56 a
C_2	18.26 a
C_3	17.86 b
C_4	17.72 b
$LSD_{0.05}$	0.568
CV(%)	5.86

[X] C_0; 0 ppm, C_1; 50 ppm, C_2; 100 ppm, C_3; 150 ppm, C_4; 200 ppm

Table 3. Interaction effect of variety and GA3 application on germination

Treatment [X]	Days to 100% germination
V_1C_0	17.52
V_1C_1	18.16
V_1C_2	17.65
V_1C_3	17.34
V_1C_4	17.11
V_2C_0	19.83
V_2C_1	18.36
V_2C_2	18.32
V_2C_3	18.38
V_2C_4	19.46
$LSD_{0.05}$	NS
CV(%)	5.86

[X] V_1; White colored, V_2; Yellow colored, C_0; 0 ppm, C_1; 50 ppm, C_2; 100 ppm, C_3; 150 ppm, C_4; 200 ppm

4.2 Plant height

Plant height was not significantly influenced by varieties (white and yellow) at different growth stages of gladiolus (Table 4 and Appendix III). Plant height was observed with white variety, V_1 (23.27, 56.95, 102.11 and 122.88 cm at 20, 40, 60 DAS and at harvest) where the lowest (22.60, 56.50, 100.79 and 122.64 cm at 20, 40, 60 DAS and at harvest) was observed with yellow variety, V_2. These results indicating that both the varieties are well adopted in the

prevailing climatic condition. However, Kishan *et al.* (2005), Saini *et al*. (1991) and Dod *et al*. (1989) reported that plant height of gladiolus influenced by different variety.

In considering the plant height at 20, 40, 60 DAS and at harvest, different levels of GA_3 application showed a statistically significant dissimilarity (Table 5 and Appendix III). With the increases of GA_3, plant height of gladiolus increases and represents an increasing trend up to 150 ppm. The highest gladiolus plant (25.59, 65.23, 110.90 and 131.20 cm at 20, 40, 60 DAS and at harvest respectively) was recorded in GA_3 @ 150 ppm.So GA_3 can affect growth by its effect on cell growth and cell elongation.

The shortest gladiolus plant height (19.17, 47.88, 91.94 and 115.40 cm at 20, 40, 60 DAS and at harvest respectively) was recorded in the control plot (C_0). The result obtained from the study was similar with the findings of Rana *et al.* (2005) and Ali and Al-Safar (2004).

Table 4. Individual effect of variety on plant height

Treatment [X]	Plant height at different days after sowing (DAS)			
	20 DAS	40 DAS	60 DAS	At harvest
V_1	23.27	56.95	102.11	122.88
V_2	22.60	56.50	100.79	122.64
$LSD_{0.05}$	NS	NS	NS	NS
CV(%)	8.56	7.68	9.12	10.54

[X] V_1; White colored, V_2; Yellow colored

Table 5. Individual effect of GA3 application on plant height

Treatment [X]	Plant height at different days after sowing (DAS)			
	20 DAS	40 DAS	60 DAS	At harvest
C_0	19.17 e	47.88 e	91.94 e	115.40 e
C_1	21.03 d	53.08 d	95.98 d	119.40 d
C_2	23.68 c	56.64 c	101.60 c	122.20 c
C_3	25.59 a	65.23 a	110.90 a	131.20 a

C_4	25.18 b	60.78 b	106.90 b	125.60 b
$LSD_{0.05}$	0.1085	0.7935	1.215	1.349
CV(%)	8.56	7.68	9.12	10.54

[X] C_0; 0 ppm, C_1; 50 ppm, C_2; 100 ppm, C_3; 150 ppm, C_4; 200 ppm

Interaction effect between variety and GA_3 application showed significant differences in all the date recorded for plant height of gladiolus (Table 6 and Appendix III). A gradual increasing trend was observed in height from start to at harvest. The tallest gladiolus plant (26.33, 66.33, 112.4 and 132.30 cm at 20, 40, 60 DAS and at harvest respectively) was recorded in interaction effect of white variety with GA_3-150 ppm (V_1C_3). On the other hand, the shortest gladiolus plant (18.71, 47.23, 91.35 and 114.9 cm at 20, 40, 60 DAS and at harvest respectively) was recorded for yellow variety corm and no GA_3 application (V_2C_0).

Table 6: Interaction effect of variety and GA3 application on plant height

Treatment [X]	Plant height at different days after sowing (DAS)			
	20 DAS	40 DAS	60 DAS	At harvest
V_1C_0	19.63 f	48.54 g	92.53 fg	115.9 de
V_1C_1	21.13 e	54.31 e	97.41 e	118.8 cd
V_1C_2	24.11 c	55.45 e	100.9 d	120.6 c
V_1C_3	26.33 a	66.33 a	112.4 a	132.3 a
V_1C_4	25.14 b	60.11 c	107.4 bc	126.8 b
V_2C_0	18.71 g	47.23 g	91.35 g	114.9 e
V_2C_1	20.93 e	51.84 f	94.55 f	120.0 c
V_2C_2	23.25 d	57.83 d	102.3 d	123.8 b
V_2C_3	24.85 b	64.14 b	109.3 b	130.1 a
V_2C_4	25.23 b	61.45 c	106.4 c	124.3 b

$LSD_{0.05}$	0.5893	1.811	2.427	3.027
CV(%)	8.56	7.68	9.12	10.54

[x] V_1; White colored, V_2; Yellow colored, C_0; 0 ppm, C_1; 50 ppm, C_2; 100 ppm, C_3; 150 ppm, C_4; 200 ppm

4.3 Days to spike initiation

The effect of variety on days required for spike initiation of plant was not significantly influenced (Table 7 and Appendix IV). But the minimum days (71.26) required for spike initiation was recorded in white variety; V_1 whereas the maximum days (71.72) required for spike initiation was recorded for yellow variety; V_2. The result from the present study was not found to similar with Basavaraddy (2004). They observed that days to spike initiation was significantly influence by different variety.

Different levels of GA_3 application showed statistically significant variation for days to initiation of gladiolus spike (Table 8 and Appendix IV). The maximum (78.88) days required for days to gladiolus spike initiation were recorded in the plot with no GA_3 application, C_0 where the minimum (64.88) days to spike initiation was recorded in the plot with 150 ppm GA_3 application; C_3 which was statistically different from all other treatments. These results might be due to cause of available nutrients properly facilitate with GA3 application. Singh *et al*. (2002) were also found the similar findings.

Interaction effect between variety and GA_3 application showed significant differences for days to spike initiation of gladiolus among the treatments (Table 9 and Appendix IV). The results of days to spike initiation ranged from 64.54 to 78.88 days. It was observed that the minimum days (64.54) required for initiation of gladiolus spike was recorded in V_1C_3 which was statistically identical with V_2C_3. On the other hand, the maximum (78.88) days to initiation of gladiolus spike were recorded with V_2C_0 which was statistically identical with V_1C_0. The results obtained from all other treatment combinations were

significantly different compared to highest and lowest days to spike initiation of gladiolus plant.

4.4 Length of flower stalk at harvest

The effect of variety on length of flower stalk at harvest was not significantly influenced (Table 7 and Appendix IV). But the maximum length of flower stalk at harvest (67.15 cm) was recorded in white variety; V_1 whereas the minimum length of flower stalk at harvest (66.46 cm) was recorded for yellow variety; V_2. The results under the present study were not conformity with the findings of Basavaraddy (2004). They observed that length of flower stalk at harvest was significantly influence by different variety.

Length of flower stalk at harvest was significantly influenced by different levels of GA_3 application (Table 8 and Appendix IV). The length of flower stalk at harvest increased with the increase of GA_3 application to a certain level. It was observed that the maximum length of flower stalk at harvest (73.23 cm) was recorded in C_3 where the minimum (58.18 cm) was recorded in the plot with control treatment; C_0. The result found under the present study was similar with the findings of Kumar *et al*. (2002).

Interaction effect between variety and GA_3 application showed significant differences on length of flower stalk at harvest of gladiolus plant among the treatments (Table 9 and Appendix IV). The results of length of flower stalk at harvest ranged from 57.43 cm to 74.34 cm. It was observed that the maximum length of flower stalk at harvest (74.34 cm) was recorded in V_1C_3 which was statistically similar with V_2C_3 and V_2C_4. On the other hand, the minimum length of flower stalk at harvest (57.43 cm) was recorded with V_2C_0 which was statistically identical with V_1C_0. The results obtained from all other treatment combinations were significantly different compared to highest and lowest length of flower stalk at harvest of gladiolus plant.

4.5 Number of floret/spike

The effect of variety on number of floret/spike at maturity stage was not significantly influenced (Table 7 and Appendix IV). But the maximum number of floret/spike (10.98) was recorded in white variety; V_1 whereas the minimum number of floret/spike (10.80) was recorded in yellow variety; V_2. Similar results were not found by Basavaraddy (2004), Patil (2003) and Kamble (2001). They observed that number of floret/spike was significantly influence by different variety.

Different levels of GA_3 application showed statistically significant variation number of floret/spike (Table 8 and Appendix IV). Increased number of floret/spike was obtained with the higher concentration of GA_3 application to a certain level. It was observed that the maximum number of floret/spike (14.13) was recorded in where GA_3 applied @150 ppm while the minimum (7.19) was recorded in control plot . The result found under the present study was similar with the findings of Kumar *et al*. (2002) and Kumar *et al*. (2008).

Interaction effect of variety and concentration of GA_3 application showed significant differences for number of floret/spike of gladiolus plant among the treatments (Table 9 and Appendix IV). The results of number of floret/spike ranged from 7.04 to 14.51. The maximum number of floret/spike (14.51) was recorded in white colour variety treated with 150 ppm GA_3 which was statistically identical with yellow colour variety treated with 150 ppm GA_3. On the other hand, the minimum number of floret/spike (7.04) was recorded in yellow colour variety with no GA_3 application which was statistically identical to that of white colour variety with no GA_3 application. The results obtained from all other treatment combinations were significantly different compared to highest and lowest number of floret/spike of gladiolus plant.

4.6 Weight of single spike at harvest

Weight of single spike at harvest was not significantly influenced by variety of gladiolus plant (Table 7 and Appendix IV). But it was observed that the

maximum weight of single spike at harvest (54.06 g) was recorded in white variety; V_1 where the minimum weight of single spike (53.63 g) was recorded for yellow variety; V_2. The results under the present study were not conformity with the findings of Kamble (2001). They observed that weight of single spike at harvest was significantly influence by different variety.

Weight of single spike at harvest was statistically significant with different levels of GA_3 application (Table 8 and Appendix IV). The higher weight of single spike was achieved with the higher GA_3 application to at a certain level. It was observed that the maximum weight of single spike at harvest (61.24 g) was recorded in C_3 where the minimum weight of single spike (46.08 g) was recorded in the plot with control treatment; C_0. It can be seemed that GA3 may help to increase spike length, number of florets/spike etc. and that the cause of higher weight of single spike.

Interaction effect between variety and GA_3 application showed significant differences for weight of single spike at harvest of gladiolus plant among the treatments (Table 9 and Appendix IV). The results of single spike weight at harvest ranged from 45.85 g to 62.63 g. It was observed that the maximum weight of single spike at harvest (62.63 g) was recorded in V_1C_3 which was statistically different from all other treatments. On the other hand, the minimum weight of single spike at harvest (45.85 g) was recorded with V_2C_0 which was statistically identical with V_1C_0. The results obtained from all other treatment combinations were significantly different compared to highest and lowest peduncle height of gladiolus plant.

Table 7. Individual effect of variety on days to spike initiation, peduncle height, number of floret/spike and weight of single spike

Treatment [X]	Days to spike initiation	Length of flower stalk (cm)	Number of floret/ spike	Weight of single spike at harvest (g)
V_1	71.26	67.15	10.98	54.06
V_2	71.72	66.46	10.80	53.63

$LSD_{0.05}$	NS	NS	NS	NS
CV(%)	9.65	6.38	7.85	8.24

[X] V_1; White colored, V_2; Yellow colored

Table 8. Individual effect of GA3 application on days to spike initiation, peduncle height, number of floret/spike and weight of single spike

Treatment [X]	Days to spike initiation	Length of flower stalk (cm)	Number of floret/ spike	Weight of single spike at harvest (g)
C_0	78.88 a	58.18 e	7.19 e	46.08 e
C_1	73.68 b	64.04 d	9.88 d	50.23 d
C_2	71.14 c	67.53 c	10.88 c	54.00 c
C_3	64.88 e	73.23 a	14.13 a	61.24 a
C_4	68.87 d	71.05 b	12.38 b	57.64 b
$LSD_{0.05}$	1.214	1.287	0.4167	0.4095
CV(%)	9.65	6.38	7.85	8.24

[X] C_0; 0 ppm, C_1; 50 ppm, C_2; 100 ppm, C_3; 150 ppm, C_4; 200 ppm

Table 9. Interaction effect of variety and GA3 application on days to spike initiation, peduncle height, number of floret/spike and weight of single spike

Treatment [X]	Days to spike initiation	Length of flower stalk (cm)	Number of floret/ spike	Weight of single spike at harvest (g)
V_1C_0	78.53 a	58.93 g	7.34 e	46.31 f
V_1C_1	73.25 bc	63.53 f	9.61 d	50.73 e
V_1C_2	71.53 cd	68.73 cd	10.33 cd	53.25 d
V_1C_3	64.54 g	74.34 a	14.51 a	62.63 a
V_1C_4	68.45 f	70.25 bc	12.21 b	57.35 c
V_2C_0	79.24 a	57.43 g	7.04 e	45.85 f
V_2C_1	74.11 b	64.55 ef	10.15 d	49.74 e
V_2C_2	70.75 de	66.34 de	11.43 bc	54.75 d
V_2C_3	65.23 g	72.13 ab	13.74 a	59.85 b
V_2C_4	69.28 ef	71.85 ab	12.55 b	57.93 c
$LSD_{0.05}$	1.975	2.616	1.127	1.811
CV(%)	9.65	6.38	7.85	8.24

[x] V_1; White colored, V_2; Yellow colored, C_0; 0 ppm, C_1; 50 ppm, C_2; 100 ppm, C_3; 150 ppm, C_4; 200 ppm

4.7 Yield (Number of spike/ha)

The effect of variety on yield (number of spike/ha) of gladiolus plant was significantly influenced (Table 10 and Appendix IV). The maximum number of spike/ha (299.10 thousand) was recorded in white variety; V_1 whereas the minimum number of spike/ha (292.10 thousand) was recorded for yellow variety; V_2. The results under the present study was conformity with the findings of Basavaraddy (2004), Gupta *et al*. (2002) and Kamble (2001).

Yield (number of spike/ha) was statistically significant by different levels of GA_3 application (Table 11 and Appendix IV). The higher yield (number of spike/ha) was obtained with the higher rate of GA_3 application to a certain level. It was observed that the maximum number of spike/ha (322.3 thousand) was recorded in C_3 where the minimum number of spike/ha (262.70 thousand) was recorded in the plot with control treatment; C_0. The results obtained from the present findings was similar with the findings of Ali and Al-Safar (2004).

Interaction effect between variety and GA_3 application showed significant differences for yield (number of spike/ha) of gladiolus plant among the treatments (Table 12 and Appendix IV). The results of number of spike/ha ranged from 261.30 to 327.70. It was observed that the maximum number of

spike/ha (327.70 thousand) was recorded in V_1C_3 which was statistically different from all other treatments. On the other hand, the minimum number of spike/ha (261.30 thousand) was recorded with V_2C_0 which was statistically identical with V_1C_0. The results obtained from all other treatment combinations were significantly different compared to highest and lowest peduncle height of gladiolus plant.

Table 10. Effect of variety in terms (number of spike) on yield of gladiolus cultivated in summer

Treatment [X]	Yield (Number of spike /ha) (‘000)
V_1	299.10 a
V_2	292.10 b
$LSD_{0.05}$	3.456
CV(%)	9.26

[X] V_1; White colored, V_2; Yellow colored,

Table 11. Effect of GA3 application in terms (number of spike) on yield of gladiolus cultivated in summer

Treatment [X]	Yield (Number of spike /ha) (‘000)
C_0	262.70 e
C_1	287.30 d
C_2	297.80 c
C_3	322.30 a
C_4	307.70 b
$LSD_{0.05}$	2.145
CV(%)	9.26

[X] C_0; 0 ppm, C_1; 50 ppm, C_2; 100 ppm, C_3; 150 ppm, C_4; 200 ppm

Table 12. Interaction effect of variety and GA3 application in terms (number of spike) on yield of gladiolus cultivated in summer

Treatment [X]	Yield (Number of spike /ha) (‘000)
V_1C_0	264.00 g
V_1C_1	290.70 e
V_1C_2	301.70 d
V_1C_3	327.70 a
V_1C_4	311.30 c
V_2C_0	261.30 g

V_2C_1	284.00 f
V_2C_2	294.00 e
V_2C_3	317.00 b
V_2C_4	304.00 d
$LSD_{0.05}$	3.568
CV(%)	9.26

[X] V_1; White colored, V_2; Yellow colored, C_0; 0 ppm, C_1; 50 ppm, C_2; 100 ppm, C_3; 150 ppm, C_4; 200 ppm

CHAPTER V
SUMMARY AND CONCLUSION

An experiment was conducted at Sher-e-Bangla Agricultural University, Dhaka during the period from June - August 2010 to find out the Regulation of germination, growth and flowering of gladiolus with Gibberelic acid (GA_3). The experiment was comprised with two factors viz. (1) Factor A: Variety – (two) i.e. V_1 = White gladiolus and ii) V_2 = Yellow gladiolus and (2) Factor B: GA_3 application (five levels) i.e. C_0 = No application, C_{50} = 50 ppm, C_{100} = 100 ppm, C_{150}= 150 ppm and C_{200}= 200 ppm. There were on the whole 10 (2×5) treatments combinations. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications.

The results under the present study revealed that there was no significant effect on days to germination percentage with the interaction effect of variety and GA_3 application. But variety and GA_3 had significant effect. It was observed that white variety showed the best response (17.56) regarding days to germination percentage where yellow variety showed the lowest performance (18.87). Again, 200 ppm concentration of GA_3 (C_4) showed the best result (17.72) for days to germination percentage where no GA_3 application (C_0) showed the lowest result (18.68). On the other hand, it was also observed that the lowest days to germination percentage (17.11) was recorded with the treatment combination of White gladiolus and 200 ppm GA_3 (V_1C_4) concentration where the highest Days to germination percentage (19.83) were recorded with yellow colored gladiolus and no GA_3 concentration (V_2C_0).

The varietal performance on plant height, number of floret/spike, length of flower stalk at harvest and weight of single spike at harvest had no significant effect. But the results showed that the highest plant height at harvest (122.88 cm), number of floret/spike (10.98), length of flower stalk at harvest (67.15 cm), and weight of single spike at harvest (54.06 g) were observed with white variety, V_1 where the lowest Plant height at harvest (122.64 cm), number of

floret/spike (10.80), length of flower stalk at harvest (66.46 cm), and weight of single spike at harvest (53.63 g) were obtained with yellow variety, V_2. On the other hand, the highest Days to spike initiation (71.72) with yellow variety, V_2 and the lowest (71.26) were with white variety, V_1. In terms of yield on number of spike/ha, variety had significant effect. The highest number of spike/ha (299100.00) was achieved by white variety, V_1 where the lowest (292100.00) was obtained by yellow variety, V_2.

GA_3 application at different concentration had significant effect on plant height at harvest, days to spike initiation, number of floret/spike, length of flower stalk at harvest, weight of single spike at harvest and yield on number of spike/ha. It was observed that the highest plant height at harvest (131.20 cm), number of floret/spike (14.13), length of flower stalk at harvest (73.23 cm), weight of single spike at harvest (61.24 g) and yield on number of spike/ha (322300.00) were obtained with 150 ppm GA_3 application (C_3). On the other hand, the lowest plant height at harvest (115.40 cm), number of floret/spike (7.19), length of flower stalk at harvest (58.18 cm), weight of single spike at harvest (46.08 g) and yield on Number of spike/ha (262700.00) were obtained with no GA_3 application (C_0). But in case of days to spike initiation the highest days (78.88) was taken with no GA_3 application (C_0) where the lowest (64.88) was with 150 ppm GA_3 application (C_3).

Different growth and yield parameters were also significantly influenced by interaction effect of variety and GA_3 application.

Results showed that the highest plant height at harvest (132.3 cm), number of floret/spike (14.51), length of flower stalk at harvest (74.34 cm), weight of single spike at harvest (62.63 g) and yield on Number of spike/ha (327700.00) were obtained with white variety and 150 ppm GA_3 application (V_1C_3). On the other hand, the lowest plant height at harvest (114.9 cm), number of floret/spike (7.04), length of flower stalk at harvest (57.43 cm), weight of single spike at harvest (45.85 g) and yield on number of spike/ha (261300.00)

were obtained with yellow variety and no GA_3 application (V_2C_0). But in case of days to spike initiation the highest days (79.24) was taken with yellow variety and no GA_3 application (V_2C_0) where the lowest (64.54) was with white variety and 150 ppm GA_3 application (V_1C_3).

CONCLUSION

From the above discussion, it can be concluded that in terms of yield and yield contributing parameters, white gladiolus variety and 150 ppm GA_3 application (V_1C_3) was the best treatment compared to all other treatment combinations under the present study.

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

1. Such study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional compliance and other performance.
2. Another experiment may be carried out with more gladiolus varieties.
3. GA_3 application had significant influence on the growth and yield of gladiolus. So, further study in needed to optimize the level.

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APPENDICES

Appendix I. Monthly records of Air Temperature, relative humidity, rainfall and sunshine hours during June 2010 to August 2010.

Month	*RH (%)*	*Air temperature (^{o}C)*			*Rainfall (mm)*
		Max.	*Min.*	*Mean*	
June	66.24	28.28	25.34	26.81	184
July	81	31.4	25.8	28.6	542
August	82	32.0	26.6	29.3	361

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

Appendix II: Characteristics of experimental soil.

A. Morphological characteristics of the experimental field

Morphological features	***Characteristics***
Location	Agronomy Farm, SAU, Dhaka
AEZ	Modhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	Not Applicable

Source: Soil Resource Development Institute (SRDI)

B. PPhysical and chemical soil properties of experimental plot.

Characteristics	**Value**
Partical size analysis	
% Sand	27
%Silt	43
% Clay	30
Textural class	Silty-clay
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

Source: Soil Resource Development Institute (SRDI)

Appendix III. Analysis of varience (ANOVA) for plant height at different days after sowing

Source of variance	Degrees of Freedom	Plant height at different days after sowing (DAS)			
		20 DAS	40 DAS	60 DAS	At harvest
Replication	2	0.007	0.008	0.006	0.013
Factor A	1	NS	NS	NS	NS
Factor B	4	8.695*	7.532*	7.071*	8.515*
AB	4	1.577*	1.136*	1.949*	0.916*
Error	18	0.328	0.384	0.202	0.289

* Significant at 5% level of significant

** Significant at 1% level of significant

Appendix IV. Analysis of varience (ANOVA) for spike initiation, length of flower stalk, number of floret/ spike, weight of single spike at harvest (g) and number of spike/ha (‘000)

Source of variance	Degrees of Freedom	Days to spike initiation	Length of flower stalk (cm)	Number of floret/ spike	Weight of single spike at harvest (g)	Number of spike/ha (‘000)
Replication	2	0.010	0.010	0.005	0.012	26.233
Factor A	1	NS	NS	NS	NS	NS
Factor B	4	5.152*	8.979*	4.133*	3.601*	7.300*
AB	4	0.723**	5.270*	0.799**	3.950*	2.333*
Error	18	0.248	1.224	0.569	0.114	1.715

* Significant at 5% level of significant

** Significant at 1% level of significant