VARIABILITY ANALYSIS AND EFFECT OF GROWTH REGULATORS ON DORMANCY, GROWTH AND YIELD OF GLADIOLUS

A THESIS

BY

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DECLARATION

This is to certify that the thesis entitled, "Variability Analysis and Effect of Growth Regulators on Dormancy, Growth and Yield of Gladiolus" submitted to the 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 bonafide research work carried out by **Md. Moniruzzaman, Registration No. 25156/00296** under my supervision and my guidance. No part of the thesis has been submitted for any other degree in any institutes.

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

Dated:

Dhaka, Bangladesh

Dr. Kabita Anzu-Man-Ara
Supervisor


DEDICATED
TO MY
BELOVED PARENTS

ABSTRACT

The research was carried out at Floriculture Experimental Farm of Horticulture Research Centre (HRC), Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur during April 2005 to June 2006. The first experiment included twenty seven gladiolus genotypes. These were planted to measure variability, character association among them and evaluation in respect of yield and yield contributing characters to select promising line (s) as well as studies on the genetical parameters for further improvement of the crop. Another experiment was conducted to break the dormancy as well as more number of corm productions by BAP, Ethrel and GA_3. The results indicated the existence of wide variability among the genotypes on their physio-morphological characters along with yield and yield attributes. Genotypes varied from 58 to 110 cm and 20-58 cm in spike length and rachis length respectively. Number of flower was the highest in GL-23 (15) and lowest in GL-07 (6). Number of cormel and cormel weight of the genotypes significantly differed and ranged from 05 to 10 and 4.8 to 15 g respectively. Considering genetic parameters, high genetic coefficient variation values were observed for number of flower, vase life, spike length, rachis length, number of cormel and weight of cormel. Correlation studies revealed that positive association of flower yield (spike length) with all the characters both at genotypic and phenotypic level except number of leaves, length of leaves, breadth of leaves, days to 50% spike initiation, flower size, number of corm and weight of corm. Path coefficient analysis indicated maximum direct contribution towards yield through rachis length followed by flower number, vase life, number of cormel and weight of cormel. Large variations in qualitative characters were also observed. Based on these selection criteria, the genotypes GL-02, GL-023 and GL-024 were identified as good genotypes. All the concentration of BAP, Ethrel and GA_3 showed in dormancy breaking but differed markedly. Induction of dormancy breaking in the control was less. However, BAP 150 ppm showed a promotive effect in extent of dormancy breaking. It was also in envisaged that BAP at 150 ppm was found best for corm production.

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LIST OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

ABBREVIATION	EXPANTION
BAP	6 – Benzylaminopurine
BARI	Bangladesh Agricultural Research Institute
cm	Centimeter
Cm^2	Square Centimeter
CRD	Complete Randomized Design
CV	Coefficient of Variation
E	East
et al	And others (at elli)
Fig.	Figure
g	Gram
GA_3	Gibbrellic Acid
GCV	Genotypic Coefficient of Variation
HRC	Horticulture Research Centre
LSD	Least Significant Difference
Max	Maximum
mg	Milli gram
Min	Minimum
mm	Millimeter
MP	Murate of Potash
N	North
^oC	Degree Celcious
PCV	Phenotypic Coefficient of Variation
P^H	Hydrogen ion concentration
ppm	Parts Per Million
RCBD	Randomized Complete Block Design
RH	Relative Humidity
SAU	Sher-e-Bangla Agriculture University
t/ha	Tonne Per Hectare
TSP	Triple Super Phosphate

Chapter I
Introduction

CHAPTER I

INTRODUCTION

Gladiolus (*Gladiolus grandiflorus* L.), popularly known as the Sword Lily, is an ornamental bulbous plant native of South Africa (Sharma and Sharma, 1984). It belongs to the monocot family Iridaceae .It is a very popular flowering plant in international cutflower trade grown throughout the world in a wide range of climatic conditioins. In Bangladesh, the agro ecological conditions are very conducive for the survival and culture of gladiolus.Regarding area and production of gladiolus flowers, no authentic reports are available in the country. In 2003, it was estimated that more than 3,500 ha of land was under this flower cultivation (Dadlani, 2003). It has great economic value as a cut flower and its cultivation is relatively easy. Studies have established by Momin (2006) that income from gladiolus flower production is six times the returns from rice. Its elegant spikes, richly varied in colour and with a long vase life, are the reason for it's ever-increasing demand. Considering the present status it deserves necessity of future improvement for both quantitative and qualitative characters to exploit internal and exotic demand.

Variability is the essence of any planned crop improvement programme. An assembly of diverse genetic stocks of any crop is the raw material from which a new variety can be moulded to suit the requirement of farmers. It is well established that the greater the genetic diversity the higher the chance of getting better hybrid or recombinant. The Floriculture Division of HRC, BARI, Gazipur, has a collection of more than 25 species of gladiolus possessing wide variabilities in respect of both plant and floral characteristics. A plant breeding program can be divided into three stages, viz. building up a gene pool of variable germplasm, selection of individual from the gene pool and utilization of selected individual to evolve a superior variety (Kempthorne, 1957). The quantitative measurement of individual character provides the basis for an interpretation of analysis of variance. The available variability in a population can be partitioned into heritable and non heritable parts with the aid of genetic parameters such as genetic coefficient of variation, heritability and genetic advance (Miller *et al.*, 1958).

Selection of better plant type from the collected germplasms can be of immense value to the breeder for improvement and development of this crop. Further, knowledge of relationship among yield and yield contributing characters is an effective basis for phenotypic selection in plant populations (Anuradha and Gowdha, 1994). Thus, there is ample scope to investigate the genetics of yield as well as morphological characters of the germplasm.

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 (Saha, 2005). The importance of PGRs, both endogenous ones and synthetic compounds, for crop improvement, had 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 (Murali and Reddy,1994; Mahanty *et al.*, 1994). 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 (Gowda, 1994; Ginzburg, 1973). 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 is meager under Bangladesh literature.

Considering the above facts the present study has, therefore, been undertaken with the following objectives:

i) To study the variability in gladiolus germplasm,

ii) To select yield promising quality flower from different gladiolus germplasm and

iii) To find out the effect of growth regulators on dormancy breaking as well as more number of corm production.

Chapter II
Review of Literature

CHAPTER II

REVIEW OF LITERATURE

Gladiolus (Gladiolus L.), a member of the family Iridaceae, is one of the most popular ornamental bulbous plants grown commercially for its bewitching flowers. It is known as "Queen of the bulbous flowers" (Mukhopadhyay, 1995). The name gladiolus has been derived from the Latin word gladius, meaning a sword as it has sword-shaped leaves (Lewis, *et al.*, 1872). Commonly, gladiolus is known as 'sword lily' and as 'Corn flag'. It was first introduced into France and soon after, it spread to England, Germany, Holland, North America and India. In Bangladesh, gladiolus was introduced during mid 80'S in Jhikargacha Thana of Jessore District. A lot of research works have been done all over the world by different workers on genetic variability and correlation studies in gladiolus but information is meager under climatic conditions of Bangladesh. Therefore, information available in the literature pertaining to those aspects of gladiolus and other flowering crops have been reviewed briefly and presented below:

Variability

The extent of genetic variability existing of genotype of a crop plant is an index of its genetic dynamism. Plant breeding revolves around selection, which can be effectively practiced only in the presence of variability of desired traits. Hence the success of breeding depends entirely upon the variability.

Robinson *et al.*, (1951) stressed the need to estimate genotypic and phenotypic variances of various characters for choosing individuals based on phenotypic expression with an aim to identify superior genotypes.

Swarup and Raghava (1972) observed appreciable variability for plant height, spike length, flower number, corm number, flower colour and shelf life in gladiolus.

According to Misra and Chowdhary (1976) a high value of genotypic and phenotypic coefficient of variation was observed for corm number, cormel number and flower number in gladiolus.

Negi *et al.*, (1981) in their study in gladiolus germ plasm, the estimate of genetic parameters revealed a higher phenotypic coefficient of variation than the corresponding genetic coefficient of variation value for plant height, cormel number and weight of spike.

Negi *et al.*, (1978a) conducted an experiment in gladiolus and concluded that the maximum variability was masked for plant height, corm number and flower yield.

Negi *et al.* ,(1978b) found that the estimate of variance in gladiolus for the characters plant height, flower number, corm number, cormel number and flower yield was significant.

Mahanta *et al.*, (1998) studied on variability in gerbera (*Gerbera jamesonii*). Ten cultivars of gerbera were evaluated for 14 characters in trials conducted at Assam Agricultural University. For all these characters, data are tabulated on range, mean, genotypic and phenotypic coefficient of variability, heritability and genetic advance. Plant height, vase life, flower size exhibited greater genetic variability and high heritability coupled with high genetic advance.

Teijaswini *et al.*, (1994) reported that the phenotypic coefficient of variation in spike length of tuberose was observed comparatively low (23.25%) while the range for this character indicated possibility for improvement. By utilizing the character of more spikes per bulb the cut-flower yield could be increased in the varieties of tuberose to be developed.

Induced mutants are a potential tool in creating variability to further improve various crops. Mutation breeding offers speedy results with great potentialities in vegetative propagated crops, as the mutated somatic part can be conveniently perpetuated by vegetable means, resulting in the development of new variants. Physical mutagenesis was found more suitable for highly heterozygous crops such as gladiolus, which were propagated by corms (Misra and Bajpai, 1983).

The Indian Institute of Horticultural Research, Hessaraghatta, Banglore collected a wide array of gladiolus germplasm from indigenous and exotic sources. After thorough assessment on the basis of various vegetative and floral traits, eleven varieties, namely, 'Beauty Spot', 'Cherry Blossom', 'Friendship', 'Jo Wagenaar', 'Melody', 'Picardy', 'Snow Princess', 'Tintorente', 'Tropic Seas', 'Watermelon Pink', and 'Wild Rose' were recommended for commercial cultivation for cut flower and garden display purposes for Bangalore and other places with identical climatic conditions (Negi *et al.,* 1981).

Choudhury *et al.*, (1998) carried out an experiment to observe performance of some gerbera (*Gerbera jamesonii*) cultivars under the agro-climatic condition of Jorhat, Assam. Ten cultivars of gerbera were evaluated for growth and flowering parameters at Jorhat during 1996-97. Cultivars Popular, Evening Bells, Red Monarch and General Kaiser were promising under Jorhat conditions.

Evaluation of various exotic varieties at the Horticulture Experiment and Training Center, Chaubattia, Almora resulted in the selection of nine varieties, namely, 'Apple Blossom', 'Australian Dust', 'Australian Sunday Best', 'Friendship', 'Geliber Herald', 'House of Orange', 'Mozolia', 'Oscar', and 'Prof. Goudrin' for growing under U.P. hill conditions (Lal and Singh, 1978; Lal *et al.*, 1984).

The varieties 'Emerald Queen', 'Melody', and 'Snow Princess' were recommended by the Punjab Agricultural University, Ludhiana for commercial cultivation in Panjab State (Arora and Khanna, 1985).

A large number of hybrids was raised at the Indian Institute of Horticultural Research, Hessaraghatta, and Bangalore. These hybrids were evaluated thoroughly for various vegetative and floral characteristics for 2-3 seasons. Performance trials of very promising hybrids along with the standard cultivars were conducted for three years. Based on the performance in the replicated trials, six hybrids were finally selected and released as ' Meera', 'Nazrana', 'Poonam' and 'Sapna', in 1979 (Negi *et al.*, 1982) and as 'Aarti' and 'Apsar' in 1980 (Raghava *et al.*, 1981).

Efforts made at the Indian Agricultural Institute, New Delhi for breeding new varieties for subtropical conditions through hybridization have resulted in the development of three new varieties, namely,' Agni Rekha', 'Pusa Suhagin' and 'Suchitra' (Singh and Dohare, 1980; Singh and Dadlani, 1988).

The major limitation in commercial cultivation of gladiolus is with disease caused by *Fusarium oxysporum*. Hence, breeding for resistance to fusarium with in gladiolus is of great importance. Misra (1975 b) observed the varieties 'Debonair', 'Golden Goddess', 'Jo Wagenaar', 'Katrain Local' and 'Ratna's Butterfly' to be resistant to Fusarium wilt disease under field conditions. Crosses involving these varieties were made in thirteen combinations and a large number of Fusarium disease tolerant hybrids were produced.

Jagadish Chandra *et al., (*1985c) studied the reaction of different cultivars and hybrids of gladiolus to fusarium wilt disease under artificial conditions. Two cultivars, namely, 'Australian Fair' and 'Mansoer' registered tolerant reaction.

Negi *et al.*, (1991) made a large of crosses involing five commercial but susceptible cultivars and four fusarium wilt tolerant cultivars. One hybrid was found to be resistant and ten were found to be tolerant to fusarium wilt disease. The resistant hybrid ('82-11-90') and two tolerant hybrids ('82-7-59'and '82-18-16') had good vegetative and floral characteristics. The resistant hybrid is from a cross of 'Beauty Spot' x 'Psittacinus hybrid'. It produced 85 cm long spikes each will 16 florets having reddish purple colour with yellow and purple blotch. The tolerant hybrid '82-7-59' ('Watermelon Pink' x 'Lady Jhon') has 103 cm long spikes having 18 bright red- coloured florets per spike. The other tolerant hybrid '82-18-16' ('Watermelon Pink' x 'Mansoer') produced 98 cm long spikes each with 18 pink-coloured florets having yellow blotch. These hybrids were very good multipliers.

Kaur *et al.*, (1989) screened 50 cultivars against Fusarium wilt disease under field conditions. The cultivars which contracted 0-10 per cent of infection were rated as resistant. They were 'Beauty Crest', 'Camellia', 'Callianthus', 'George Mazure', 'Mayur', 'Melody', 'Snow Princess' and 'Sylvia'.

Motial and Basario (1977) observed appreciable variability for plant height, spike length, floret size, floret number and corm number in gladiolus.

An appreciable range of variability was noticed for the various character of hippeastrum studied (Tejaswini *et al.*, 1994). The phenotypic coefficient of variability observed for number of flowers per spike, spike length and vase life indicates the possibility of developing varieties containing long spike with more flowers as well as longevity of individual floret.

Heritability and genetic advance

Heritability is the degree to which variability of quantitative characters is transmitted from parent to the offspring. So the estimation of heritability is of great interest to the breeders primarily as a measure of the value of selection for particular characters in various types of progenies and as an index of transmissibility. A quantitative character having high heritability is transmitted from parent to offspring conveniently. Lush (1940, 1949) defined heritability in both broad and narrow sense. In broad sense, heritability is the ratio of genetic variance to the total variance expressed in percent. In narrow sense, it is only a portion of genetic variance, which is due to additivity of genes. Robinson *et al.*, (1949) defined heritability as the additive variance in percent of total variance in narrow sense. Latter Robinson (1966) have been categorized the heritability values have been categorized into low (below 10%), moderate (10-30%) and high (above 30%).

According to Katiyar *et al.*, (1974) heritability value alone provides the indication of the amount of genetic progress that would result from selecting the best individual. Johnson *et al.*, (1955) mentioned that heritability along with genetic advance would be more useful in predicting yield under phenotype selection than heritability estimation alone.

Genetic advance measures the differences between the mean genotypic values of the few selected line and mean genotypic values of the original population, upon which expected genetic gain resulting from selection of superior individuals can be drawn by experimenter.

Singh and Dohare (1980) reported maximum heritability estimates for the characters for flowering days, plant height, corm weight, spike length and rachis length.

There is a demand from consumers for fragrant gladioli. The species *G. callianthus* bore scented florete but its spikes were not attractive. To produce beautiful, fragrant gladioli, interspecific hybridization was done involving cultivars of Gladiolus sp. as the female parent and *G. callianthus* as the male parent. Six site-specific hybrids along with their seed parent (Beauty spot, Melody, Wild rose) and a pollen parent (*G. callianthus*) were evaluated by Rao and Jamaican (1994). Improvement was observed in site-specific hybrids in comparison with the species with respect to earliness, plant height, spike length, rachis length, number of flower per spike, cormel produced per corm, corm size and weight.

Negi *et al.*, (1981) observed very high heritability (84.45) and high genetic advance as percent of mean (42.30) for plant height but flower diameter showed low heritability (60.39 and 36.91) and low genetic advances as percent of mean (20 .65 and 25.30). Cormel diameter also showed low heritability (53.93) but high genetic advance as percent of mean (44.45).

Negi *et al.*, (1978a, 1978b) studied heritability, interrelationship among various traits and selection index in 10 varieties of gladiolus. Selection indices and the genetic advance expected by selection based on them an well as relative efficiency over straight selection were determined using 11 vegetative and floral characters for improving number of florets per spike, spike length, floret size and a new economic index was computed by giving weightage of 3,2 and 1, respectiively to the above three characters.

Negi *et al.*, (1982) studied the genotypic and phenotypic variability for 13 characters in thirty nine genotypes. Phenotypic and genotypic coefficients of variation, heritability in broad-sense and genetic advance were all high for these characters, namely, number of flowers,weight of cormels produced per corm, cormels produced per corm and weight of corm produced . Arora and Khanna (1985) and Misra and Saini (1988,1990) also reported high heritability and high genetic advance values of cormels producted per plant were the main contributors for the genetic divergence in gladiolus. Genotype x environment interaction of various quantitative traits was studied by Arora and Sharma (1991) in seven cultivars of gladiolus. Interaction of genotype x environment (linear) and the pooled deviation mean spuares (non-linear) were found to be significant for number of cormels per plant indicating the contribution of both linear and non-linear components towards genotype x environment interaction variance for this character, whereas for the characters days taken for basal floret opening, number of florets per spike, spike length and average weight of corms per corm, nonlinear component was predominant.

Wernett *et al*, (1996) carried out an experiment of post harvest longevity of gerbera as a cut flower and heritability of its vase life. Intensive selection to improve vase life was performed on a sample population of Gerbera × hybrida from a broad source of germplasm. Progeny of a 5 × 5 diallel cross yielded estimates of narrow sense heritability ($h^2 = 0.28$) and broad sense heritability ($H^2 = 0.28$) for vase life based on a mean of 1.96 measurements per plant. Additive gene action is postulated to control this character since the difference between total genotypic variance and additive genetic variance components was small. Repeatability ($r = 0.57$) based on a single measurement per plant was moderately high. Heritability ranged from 22 to 39%.

Negi and Raghava (1986) in their study in gladiolus germplasm, the estimate of genetic parameters revealed a higher phenotypic coefficient of variation than the corresponding genetic coefficient of variation value for plant height, flower number, corm number, spike length, spike diameter and rachis length.

In a study with Gladiolus, Sharma and Sharma (1984) found that the estimate of variances for the characters plant height, spike length, rachis length, flower size and vase life was significant.

Singh and Singh (1990) studied genetic parameters in gladiolus. Plant height, spike length, rachis length, corm diameter and cormel diameter had high broad sense heritability, high genetic advance indicating the success of direct selection. Flower diameter was found to have low heritability and genetic advance.

Arora and Sharma (1991) observed only 25% heritability for flower size in gladiolus.

Singh and Dadlani (1988) reported that the estimated heritability values in gladiolus were 9% for plant height, 20% for flower diameter and nearly 46% for spike length.

Thirty- eight genotypes were evaluated by Rao and Negi (1994). Studies on variability, heritability and genetic advance were conducted on 12 biometric characters in china aster. Highly significant differences were observed among the genotypes. Heritability in the broad sense was medium to high and genetic advance as percentage of mean was high for flower weigh, number of ray florets per head and number of laterals per plant.

Misra and Saini (1990) observed moderate heritability value with low genetic advance for the characters flower area, leaf size, plant height, cormel diameter, cormel number and flower weight.

Prasad *et al.* (1997) studied on the genetic components and genotypic correlation in twenty genotypes of diverse origin of orchid genera *Anoectochilus, Goodyera, Macoodes* and *Zeuxine* for 10 characters. They observed that spike length and plant height had the highest heritability during 1991-93, respectively. Leaves per plant, leaf diameter, and flowers per spike, spike length and length of aerial root showed positive association with plant height during 1991-92 and 1992-93, respectively. Length of flower was positively correlated with flower diameter and length of aerial root in both the years. However, the length of aerial root exhibited a negative correlation with leaf length and shoots per plant during 1991-92 and 1992-93, respectively.

Thirty genotypes of gladiolus were evaluated. Highly significant differences were observed among the genotypes. Negi *et al.*, (1984) reported that heritability in the broad sense was medium to high and genetic advance as percentage of mean was high for spike length, rachis length and number of corms per plant in gladiolus.

Analyzing the information about heritability of the characters, it was observed that yield and different yield contributing characters of gladiolus had shown low, moderate and high heritability values. The difference of the heritability value for some characters among the different authors as observed was due to difference in the genetic makeup of their population as well as the environmental influence where they conducted the study.

Correlations between yield and yield contributing characters

Yield, the ultimate goal for a plant breeder, is the outcome of the interaction of a number of factors inherent both in the plants and in the environment in which the plant grow. Yield is a complex character, which is not only polygenically controlled but also influenced by its component characters (Alam *et al.*, 1988).

Robison *et al.*, (1951) found high positive correlation between rachis length and flower number (0.929) in gladiolus and followed by plant height and flower yield (0.889). Hence, taller the plant the higher is its yield.

There was a significant positive correlation of yield of gladiolus with plant height, flower number and corm number but yield per plant had no correlation with flower size, leave size, spike weight and cormel diameter (Kaicker and Naurial, 1964).

Swarup and Raghava (1972) evaluated twenty gladiolus lines and found that flower yield was positively correlated with number of flower, number of corm and of rachis length.

Association analysis of gladiolus by Misra and Chowdhury (1976) indicated had significant positive correlation with number of flower and shelf life.

Lal and Singh (1978) carried out correlation study of 22 gladiolus genotypes and reported that rachis length was significantly associated with spike length but significantly and negatively correlated with weight of corm and numbers of leaves.

Correlation response was studied by Arora and Khanna (1986) on 28 gladiolus genotypes and positive significant correlation were found for plant height and spike length at both genotypic and phenotypic level.

A study by Anuradha and Gowda (1994) of the various yield- contributing characters in gladiolus revealed that all the genotypic correlation coefficients were higher than the phenotypic. The floret diameter was highly significant and positively correlated with floret length, spike length and plant height.

Selection of parents based on characters such as rachis length, spike length and plant height were useful in a breeding programmed of gladiolus described by Singh and Doher (1980).

Huang and Harding (1998) studied quantitative analysis of correlations among flower traits in Gerbera hybrida for genetic variability and structure of principal component traits. A sample of 36 flower traits consisting of six morphological categories in the Davis population of gerbera was restructured into phenotypic and genetic principal component traits. The first 5 phenotypic principal component traits accounted for 62% of the total phenotypic variance of the 36 traits and have moderate to high heritabilities. The first 5 genetic principal component traits accounts for 97% of total genetic variance and all have high heritability. Morphological structure of these component traits suggest an underlying process identified by the first genetic principal component involving largely trans and disk floret traits. The results of this study indicate that the quantitative genetic structure of the gerbera flower is controlled by a few independent components and that principal component analysis is a useful tool to reveal variation in this structure. These composite traits are heritable and are expected to respond to selection.

Flowering behaviour and final corm yields from corms of 6 different sizes (<2-35 g), at different stages of developmental maturity, were studied in cultivars Happy End and Apricot (Ogale *et al.,* 1995). In both cultivars there was a direct correlation between corm size, flower production and final corm yield. Hong *et al.* (1989) reported that the number of daughter corms and flowering ability increased with increasing corm size upto 4-5 cm diameter, but there were no further increases for corms>5 cm in diameter. Wahi *et al.*, (1991) studied a factor analysis in gerbera. Factor analysis was performed using morphological traits in 31 genotypes of gerbera. Phenotypic correlation matrices indicated that flower number/plant was increased by selection for shoots/plants and leaves/plant. Results from genotypic correlation matrices advocated selection for flower diameter, flower stalk length, leaves/plant and number of days from flower bud appearance to opening. Both correlation matrices showed leaf size to be related to flower longevity.

A positive correlation was found between bigger trans floret diameters in large flowers with vase life in gerbera (Negi, *et al.*, 1983) whereas length of stalk, involucres length, number of flowers had failed to show any correlation with vase life.

Negi *et al.*, (1994) found that plant height, flower size, plant spread, flower number showed highly significant correlation coefficients with flower yield in chrysanthemum.

Path analysis

The term path coefficient was coined by Wreight (1921) to denote the direct influence of variable (cause) upon another variable (effect) as measured by the standard deviation remaining in the effect after the influence of all another possible path are estimated except that of cause. Niles (1923), Turkey, (1954) Kempthorne (1957) and Turner and Stevens

(1959) later elaborated it. Li (1956) presented a detail account of both basic and applied aspect for path analysis.

Path analysis helps to find out the direct and indirect causes of association. Path coefficient analysis is a standardized partial regression coefficient analysis and as such measures the direct influence of one variable upon other and allows the partitioning of correlation coefficient onto direct and indirect effects of component chcracters. So it is used to analyses the real contribution of individual complex character in yield.

Singh and Dohare (1980) studied path coefficient analyses of 6 characters in gladiolus and reported that plant height, corm diameter, rachis length, shelf life, corm number and flower number had positive directed effects on flower yield. The effect of plant height was found to be greatest.

Anuradha and Gowda (1994) analyzed data on yield per plant of 24 gladiolus genotypes and indicated that number of flowers had the largest direct position contribution to yield, followed by rachis length.

Path analysis of yield contributing characters in gladiolus revealed that number of corm per plant had the maximum direct positive effect on flower yield per plant for spike emergence had negative direct effects (Singh and Singh,1990).

Anuradha and Gowda (2000) studied the association of cut flower yield with growth and floral characters in gerbera. In studies on 25 gerbera genotypes at Bangalore, cut flower yield exhibited a high level of positive and significant correlation with number of leaves per plant, weight of ray florets and days taken to flower opening. Path analysis revealed that number of leaves per plant had the greatest positive direct effect on flower yield.

Data on yield contributing characters from 23 gladiolus genotypes were analyzed by Neil and Raghava (1994. They observed that maximum direct effect towards yield through rachis length followed by plant height and flower number.

Mahanta *et al.*, (1998) conducted an experiment for correlation and path coefficient analysis in gerbera (*Gerbera jamesonii*). Character association analysis among 14 different characters in a set of 10 gerbera genotypes revealed highly significant positive correlations with number of flowers/clump and leaf area at both the phenotypic and genotypic level and number of suckers at the genotypic level only. The path analysis revealed that leaf area, girth of stalk and days to flower bud opening had high direct effects. The significant positive correlation of leaf area with flower number/clump could thus be attributed to the high positive direct effect of the characters. The non-significant associations of plant height, number of leaves, days to flower bud visibility, size of flower and shelf life with number of flowers/clump were largely due to their high negative direct effect on the dependent variable. Thus, the characters leaf area, girth of stalk and days to flower bud opening could be considered for selection to improve upon the number of flowers/clump.

Lai *et al.*, (1984) reported that highest direct positive effects on flower yield through number of flowers per plant (0.48) followed by plant height (0.36), shelf life (0.30) and rachis length (0.19). The results indicated that the importance of number of flowers and rachis length as a selection criteria for improving gladiolus flower yield.

Higher estimates of phenotypic and genotypic coefficients of variation were obtained for rachis length, number of cormel, weight of daughter corm and cormel weights. Horitability ranged from 25.38 to 32.50 for number of cormel (Anuradha and Gowda, 1990).

Growth regulators

Growth regulators have been found to influence the growth and flowering of gladiolus. Auge (1982) treated corms at 22^{0}C for four weeks and then soaked in GA_3 (as berelex at 0.5 g/l) solution for 24 hours or sprayed with 2g brelex/l water and held for 24 h before planting in a large plastic tunnel for gladiolus. The GA_3 treated corms sprouted and flowered earlier. In an experiment on cv. Sylvia, Dua *et al.* (1984) found improved flower quality and better corm multiplication when the plants were sprayed thrice with 100 ppm of GA_3.

Treatment with GA_3 increased the weight of cormels and IAA that of corms in gladiolus (Winkler, 1969). In a trial on the effect of soaking of gladiolus corms in solutions of IAA, IBA, NAA, TDZ, BAP, GA_3 each at 100, 500, 1000 and 2000 mg/l, Jonecki (1979) recorded inhibition of early growth with all the chemicals except GA_3. He also reported that soaking in GA_3 and IAA solutions hastened differentiation of floral primordia but kinetin retarded corm sprouting and shoot apex differentiation. Awad and Hamid (1985), working with GA_3 (10-500 ppm), kinetin (1-50 ppm) ethophon (1-100 ppm) and gamma irradiation (23-415), recorded differentiation of individual flowers and longer flower spikes by treatment with low concentrations.

Mohanty and Paswan (1994) observed that increased plant height at a concentration of 250 ppm TDZ and colour break in the basal florets occurred significantly earlier than the control. A single foliar spray of GA_3 (100 and 200 ppm) enhanced vegetative growth, flowering and number of corms and cormels produced but, adversely affected individual corm weight (Misra *et al.*, 1993).

In a field trial in Kanpur, Prakash and Jha (1998) observed that GA_3 treatment at 150 ppm improved all the floral traits (time of flowering, inflorescence length, spike length, floret length and number of florets/spike) in gladiolus, cv. Friendship. The longest inflorescence and spikes with the highest number of florets/spike was produced with 150 ppm GA_3. In another experiment, 20 ppm GA_3 gave the greatest spike length while 40 ppm GA_3 produced spikes having the longest (16.2 days) life in the field (Pal and Chowdhury, 1998).

Soaking of corms at 100 ppm GA_3 and 150 ppm BAP for one hour broken the corm dormancy, shortened the time from planting to harvest and increased flower number per unit area, the length of flower stem and spikes, the number of flowers per spike and the diameter of flower stems (Karaguzel *et al.*, 1999).

In an experiment on cv. Friendship, Bhattacharjee (1984) observed increased vegetative growth, cormel production and improvement in dormancy breaking, by using BAP at 100 and 150 ppm. Application of ethrel at 100, 250,500 and 1000 ppm increased flower size. Treatment with ethephon broken the corm dormancy, increased percentage of sprouting, reduced days to sprouting, and increased fresh weight of corm (Goo *et al.*, 1999). Ethrel at 100 ppm significantly increased leaf area, induced early appearance of flower spike, highest number of florets/spike and largest individual florets (Pal and Choudhury, 1998) in gladiolus cv. Hunting Song.

Growth regulator (BAP, TDZ, ethrel and GA_3) treatments had positive effects on leaf parameters (length, width and number) and dormancy breaking in Happy End and BAP doubled the number of spike compared with the control (Ogale *et al.*, 2000).

It was envisaged that BAP at 100 ppm and Ethrel at 150 ppm were optimum to break the dormancy of cormels of Gladiolus cvs. Denobiar and Friendship (Narayana, 1994).

Chapter III
Materials and Methods

CHAPTER III

MATERIALS AND METHODS

An investigation was carried out to find the variabilities of 27 gladiolus genotypes. Details of the experimental materials and methods followed during the time of the present investigation are described in this chapter.

Experiment 1. Variability studies in gladiolus genotypes

Site

The experiment was carried out at Horticulture Research Centre, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur during the period from October 2005 to June 2006 to investigate the performance of 27 genotypes. The location of the site is at 24.09° N Latitude and 90.26° E Longitudes at an elevation of 8.4 meter from sea level (Anon.,2006).

Soil

The soil of the experimental field was clay loam in texture having P^H around 5.7. The land was well drained with good irrigation facilities that are good for gladiolus production. Soil analytical data have been presented in Appendix I.

Climate

The experimental site is situated under the sub-tropical climatic zone which was characterized by heavy rainfall during the month of April to September and scanty rainfall during the rest of the year. The meteorological data in respect of monthly maximum and minimum air temperature, rainfall, relative humidity as recorded by Metrological Department, BARI, Joydebpur, Gazipur during the experimental period have been presented in Appendix II.

Treatments of the experiment

There was single factor in this experiment. The factor including twenty seven genotypes of gladiolus which are as follows: GL-01, GL -02, GL -03, GL -04, GL -05, GL -06, GL -07, GL -08, GL -09, GL -10, GL -11, GL -12, GL -13, GL -14 , GL- 15, GL- 16, GL- 17, GL-18, GL- 19, GL- 20, GL- 21, GL- 22, GL- 23, GL- 24, GL- 25, GL- 26 and BARI Gladiolus-1.

Experimental design and layout

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications.

Planting materials used for the experiment

In this experiment twenty seven (27) gladiolus genotypes were collected from different sources of Bangladesh and considered as the treatments of the experiment. The sources of the gladiolus genotypes are summarized in Table 1.

Table1. Source name of twenty seven (27) gladiolus genotypes

Genotypes	Source of collection
GL-1	Sharsha, Jessore
GL-2	Sharsha, Jessore
GL-3	Sharsha, Jessore
GL-4	Sharsha, Jessore
GL-5	Sharsha, Jessore
GL-6	Sharsha, Jessore
GL-7	Sharsha, Jessore
GL-8	Jhikargacha, Jessore
GL-9	Jhikargacha, Jessore
GL-10	Jhikargacha, Jessore
GL-11	Jhikargacha, Jessore
GL-12	Jhikargacha, Jessore
GL-13	Sharsha, Jessore
GL-14	Sharsha, Jessore
GL-15	Sharsha, Jessore

Genotypes	Source of collection
GL-16	Jhikargacha, Jessore
GL-17	Savar, Dhaka
GL-18	Savar, Dhaka
GL-19	Sreepur, Dhaka
GL-20	Jhikargacha, Jessore
GL-21	Narayangonj, Dhaka
GL-22	Narayangonj, Dhaka
GL-23	Satkhira
GL-24	Satkhira
GL-25	Satkhira
GL-26	Jhikargacha, Jessore
BARI Gladiolus-1	Jhikargacha, Jessore

Land preparation

The land of the experimental plot was first opened by disc plough. Subsequently, the land was prepared by deep and cross ploughing and harrowing. After ploughing, laddering was done for breaking up the large clods of the soil and for levelling the surface of the land. All the weeds and stubbles were removed from the land just after laddering. Special care was taken to remove the rhizomes of mutha grass. The basal doses of manure (well decomposed cow dung) and fertilizer (MP and TSP) were applied during the final land preparation and incorporated into the soil.

Manures and fertilizers

Manures/fertilizers	Dose/ha
Cow dung	10 t
TSP	225 kg
MP	190 kg
Urea	200 kg

The total amount of well decomposed cow dung, TSP and MP were applied during the final land preparation. Urea was applied in two equal installments at 4 leaf stages and later on 7 leaf stages.

Planting of corms

Medium sized corms were planted at 6 cm depth in furrows on October following the row spacing of 25 cm and plant spacing of 15 cm .

Intercultural Operation

Intercultural operation viz. weeding, irrigation was done as and when necessary.

Disease and pest management

Diseases can be a major factor for gladiolus production. The experimental crop was infected by leaf spot during the early growing stage. Data on disease incidence was based scoring, 0-1= Tolerant, 2= moderately tolerate, 3= Susceptible, 4= highly susceptible. The disease was controlled by spraying Ridomil (2g/l). The fungicide was sprayed two times at 15 days interval. The crop was not attacked by any insect.

Harvesting of flowers

The spikes were harvested when the lower 2-3 floret showed their blushes of colour.

Collection of data

Data were collected from 10 plants selected at random from each unit plot. Data were collected in respect of the following parameters:

Plant height (cm)

Plant height refers to the length of the plant from ground level up to shoot apex. Height of 10 randomly selected plants of each unit plot was measured and the mean was calculated. It was measured in cm.

Number of leaves

Number of leaves per plant was recorded by counting all the leaves from 10 randomly selected plants of each unit plot and the mean was calculated.

Length of leaves

The length of leaves from 10 randomly selected plants were measured by a measuring scale from leaf base to the tip in middle and was expressed in cm.

Breadth of leaves

The breadth of leaves from 10 randomly selected plants were measured by a measuring scale from one side of the middle and was expressed in cm.

Number of flower

Number of flowers producing per plant was counted and recorded.

Flower size

Summation of length and breadth were measured by a measuring scale and divided by two was recorded and expressed in cm.

Weight of single stick

Single stick of flower was weighed and expressed in grams.

Vase life

Vase life of different genotypes were recorded from the time of first floret opening to the maximum freshness of spike and expressed in days.

Days required to 50% spike initiation

It was recorded by counting the days from planting to first visible spike initiation of 50% plants for a genotype from each unit plot in field condition.

Spike length

Length of spike was measured from base to the tip of the spike and expressed in cm.

Rachis length

Rachis length was measured by a measuring scale from spike base to the tip and expressed in cm.

Colour of flower

The colour of flower was noted by visual observation. Varieties of colour were recorded.

Floret type

Type of floret were recorded according to Negi *et al.*, (1994).

Floret texture

Texture of floret were recorded according to Negi *et al.*, (1994).

Floret Structure

Structure of floret were recorded according to Negi *et al.*, (1994).

Number of corm/plant

Corm from all 10 randomly selected plants of each genotype were counted and averaged.

Number of cormel/ corm

The cormel of randomly 10 selected corms per genotype were counted and averaged.

Weight of corm

Weight of corm was measured and expressed in grams (g).

Weight of cormel

Weight of cormel was measured and expressed in grams (g).

Statistical analysis

Collected data on plant, leaf, flower and corm were statistically analyzed to find out the significance of difference among the treatment means. The means for all the treatments were calculated.

i. Analysis of variance

The collected data for various characters were statistically analyzed using MSTAT-C computer package programme. The mean for all the treatments was calculated and the analysis of variance for each of the characters was performed by F (variance ratio) test. The difference between treatment means were evaluated by Least Significant Difference (LSD) for the interpretation of the results (Gomez and Gomez, 1984).

ii. Estimation of simple correlation coefficient

Simple correlation coefficient (r) among germplasms was estimated with the following formula (Singh and Chaudhury, 1985).

$$r = \frac{\sum xy - \frac{\sum x \sum y}{N}}{\sqrt{\left\{\sum x^2 - \frac{(\sum x)^2}{N}\right\}\left\{\sum y^2 - \frac{(\sum y)^2}{N}\right\}}}$$

Where,

$\sum$ = Summation

x and y two variable correlated

N = Number of observations

iii. Path co-efficient:

Path co-efficient analysis was done according to the procedure employed by Dewey and Lu (1959), using simple correlation values. In path analysis, correlation co-efficient is partitioned in to direct and indirect effects of independent variable on the dependent variable.

In order to estimate direct and indirect effects of the correlated characters, i.e. X_1, X_2 and X_3, inflorescence length Y, a set of simultaneous equation (three equations in this example) is required to be formulated as shown below-

$ry\ x_1 = Pyx_1 + Pyx_2\ rx_1x_2 + Pyx_3rx_1x_3$

$ry\ x_2 = Pyx_1rx_1x_2 + Pyx_2 + Pyx_3rx_2x_3$

$ry\ x_3 = Pyx_1rx_1x_3 + Pyx_2rx_2x_3 + Pyx_3$

Where, r's denotes simple correlation co-efficient and p's denotes path coefficient. Arranging them in matrix from may conveniently solve P's in the above equations.

Total correlation, say between x_1 and Y is thus partitioned as follows-

Pyx_1 = the direct effect of x_1 on y

$Pyx_1rx_1x_2$ = indirect effect of x_1 via x_2 only

$Pyx_3rx_1x_3$ = indirect effect of x_1 via x_3 only.

After calculating the direct and indirect effect of the characters, residual effect (R) was calculated by using the formula given below (Singh and Chaudhury, 1985).

$P^2RY = 1-\sum P_iy.x_iy.$

Where, $P^2RY = (R^2)$; and hence residual effect,

$R = (P^2RY)$ ½

P_iy = Direct effect of the character on length of spike

r_iy = Correlation of the character with length of spike

iv. Component of variance

The genotypic and phenotypic variance was calculated according to the following formula (Jhonson *et al.*, 1955).

$$\sigma^2 g = \frac{VMS - EMS}{r}$$

Where, VMS and EMS are the varietal and effective error means squares and r is the number of replications.

The phenotypic variance (σ^2ph) was derived by the following formula.

$\sigma^2\text{ph} = \sigma^2\text{g} + \sigma^2\text{e}$

Where, σ^2g is the genotypic variance and σ^2e is the effective error mean square.

v. Estimation of genotypic and phenotypic coefficients of variation

Estimation of genotypic and phenotypic coefficient of variation were calculated according to Burton (1952) as follows-

Genotypic coefficient variation (GCV) = $\frac{\sigma g \times 100}{\bar{x}}$

Where, σ g = Square root of genotypic variance and

$\bar{x}$ = Population mean.

Similarly, the phenotypic coefficient of variation was calculated by the formula,

Phenotypic coefficient of variation (PCV) = $\frac{\sigma ph \times 100}{\bar{x}}$

Where, σ ph = Square root of phenotypic variance and

$\bar{x}$ = Population mean.

vi. Estimation of heritability

Heritability in broad sense (h^2_b) was estimated by the formula as suggested by Johnson *et al.*, (1955).

$$h^2_b (\%) = \frac{\sigma^2 g}{\sigma^2 p} \times 100$$

Where,

ó$^{2}{}_{g}$ = Genotypic variance

ó$^{2}{}_{p}$ = Phenotypic variance

Estimation of genetic advance

The expected genetic advance (GA) = $h^2{}_{b.}$ k. ó$_p$

Where,

$h^2{}_b$ = Heritability in broad sense

k = Selection intensity which is equal to 2. 06 at 5%

ó$_p$ = Phenotypic standard deviation

vii. Genetic advance in percentage of mean

It was calculated by the formula given by Comstock and Robinson (1952) as follows:

$$GA\ (\%) = \frac{GA}{\overline{X}} \times 100$$

Where,

GA = Genetic advance

$\overline{X}$ = Population mean

Experiment 2. Effect of growth regulators on breaking dormancy and corm production in gladiolus

Location

A pot experiment was conducted at the Landscape, Ornamental and Floriculture Division, HRC, BARI since April 2005 to September 2005. The materials and methods used in the experiment are described below.

Climate

The experimental site is situated under the sub-tropical climatic zone which was characterized by heavy rainfall during the month of April to September and scanty rainfall during the rest of the year. The meteorological data in respect of monthly maximum and minimum air temperature, rainfall, relative humidity as recorded by Metrological

Department, BARI, Joydebpur, Gazipur during the experimental period have been presented in Appendix II.

Material

30 days stored corm after lifting of GL-16 was included in this study.

Treatments

i) Four levels of BAP (50,100,150 and 200 ppm)

ii) Four levels of Ethrel (50,100,150 and 200 ppm)

iii) Four levels of GA_3 (50,100,150 and 200 ppm) and control

Design of the experiment

The experiment was laid out in a Complete Randomized Design with three replications.

Pot preparation

The pot experiment was conducted in pots of 20 cm size. The pots were washed and cleaned thoroughly before filling up of potting media. Ten pots in each treatment for 3 replications were filled with required potting media (soil and cowdung 1:1) according to Prokash and Bhandry (1994).

Methods

Uniform size corms of GL-16, weighing an average of each 20g, were descaled and soaked for one hour in freshly prepared different concentration of BA, Ethrel and GA_3 (50,100,150 and 200 ppm). The treated corms were sown in earthen pot.

Fertilization

Muriate of potash (MP) and Triple super phosphate (TSP) @ 5g per pot was applied at the time of potting media preparation. Urea 2g was applied at 3 leaf stages and 3g was applied on 7 leaf stages accordingly by Lai and Plant (1989).

Irrigation and weeding

Weeding and mulching were done in the pots whenever it was necessary to keep the pots free from weeds. The pots were irrigated as and when necessary.

Staking of plant

Each plant was supported by 80 cm long bamboo sticks to facilitate the plant to keep errect. The plant in each pot was fastened loosely with the bamboo stick by jute string to prevent the plant from lodging. The pot was placed under polyshade to protect the plants from heavy rain and storm.

Pest and disease control

Ridomil 2g per litre of water was sprayed once the plants as protective measures against fungal diseases. The crop was not attacked by any insect.

Harvesting of corm

The corms were harvested one month after flowering.

Data collection

Observations were recorded on the number of corms that sprouted and the days required for fifty percent sprouting. Multiplication of corm was also recorded.

Statistical analysis

The collected data for various characters were statistically analyzed using MSTAT-C computer package programme. The mean for all the treatments was calculated and the analysis of variance for each of the characters was performed by F (variance ratio) test. The difference between treatments means were compared by Duncan's Multiple Range Test (DMRT) for the interpretation of the results (Steel and Torrie, 1960).

Chapter IV
Results and Discussion

CHAPTER IV

RESULTS AND DISCUSSION

The present study was conducted during the period from October 2005 to June 2006 to investigate the variabilities in gladiolus genotypes. The characteristics studied included plants, leaves, flowers, corm and cormels. The variabilities among the germplasms, correlation coefficient among different important flower producing characters and also direct and indirect effect of flower producing traits were estimated. The results of present study have been presented and discussed in this chapter under the following headings.

Variabilities in gladiolus genotypes

Plant characteristics

The plant characteristics like height, number of leaves, leaf length, leaf breadth were recorded and shown in Table 2. The field view of gladiolus genotypes at vegetative stage are shown in plate 1.

Plant height

The genotypes varied enormously in plant height (Table 2). The tallest plant (81cm) was in GL-23 and the shortest in GL-14 (31cm). The variation observed in plant height among the genotype might be due to different in genetically constituents as well as environmental effects.

Number of leaves

Significant variation was observed as to the number of leaves among the genotypes. The maximum number of leaves (13.50) was obtained from the genotype GL-24 closely followed by genotype GL-23 (13.00) and GL-25 (13.00) whereas genotype GL-03 attained minimum number of leaves (8.00). This variation might be mainly due to genotype variation as well as environmental effects. Plants produce food materials through the process of photosynthesis. With the increasing number of leaves, photosynthesis will generally increase, thus plant can produce more photosynthesis (Plant food) that influences the growth and development of the plant. So, genotypes that can produce more leaves have more plant growth leading to higher yield.

Leaf length (cm)

Leaf length was affected by genotypes and varied from 28 cm to 55cm (Table 2). The longest leaf (55cm) was recorded in GL-25 followed by GL-24 (54 cm), GL- 26 (53cm) and GL-23 (52cm), while the shortest one was in GL- 07 (28 cm). Wide variation (30 cm to 85 cm) was observed in leaf length among some genotypes of gladiolus by Singh and Singh (1990).

Leaf breadth (cm)

There had variation (1.5 cm to 4.3 cm) in leaf breadth among the genotypes (Table 2). The genotype GL-25 attained the maximum leaf breadth (4.3 cm), which was closely followed by genotypes GL-22 (4.2cm) and GL-24 (4.1cm). Breadth of leaf was found to be minimum in GL-09 (1.5 cm), followed in increasing order by GL-14 (16 cm) and GL-16 (1.7cm). Bhagur (1989) recorded significant variation in respect of leaf breadth among thirty genotypes of gladiolus. They found leaf breadth varied from 1.3 to 4.5 cm.

Table 2. Plant characteristics of different genotypes of Gladiolus

Acc. No.	Plant height (cm)	No. of leaves	Length of leaf (cm)	Breadth of leaf (cm)
GL-01	53.00	9.75	37.00	3.00
GL-02	70.00	10.00	48.00	3.30
GL-03	60.00	8.00	43.50	3.50
GL-04	49.50	9.83	37.50	2.50
GL-05	53.00	9.00	39.00	2.00
GL-06	56.00	10.00	38.75	2.50
GL-07	46.00	10.75	28.00	2.10
GL-08	54.00	10.30	37.50	2.80
GL-09	58.00	8.90	48.50	1.50
GL-10	60.00	9.50	50.00	2.30
GL-11	59.00	11.00	54.00	2.50
GL-12	58.00	8.75	49.00	2.90
GL-13	59.00	11.00	45.00	3.00
GL-14	31.00	8.20	29.30	1.60
GL-15	52.00	9.80	58.00	2.70
GL-16	47.00	8.60	42.00	1.70

Acc. No.	Plant height (cm)	No. of leaves	Length of leaf (cm)	Breadth of leaf (cm)
GL-17	55.00	12.00	34.50	3.50
GL-18	65.00	13.20	43.00	2.40
GL-19	54.00	10.70	46.00	2.90
GL-20	61.00	12.00	47.00	3.50
GL-21	72.00	12.40	32.00	3.30
GL-22	44.00	12.00	35.00	4.20
GL-23	79.00	13.00	52.00	4.00
GL-24	80.00	13.50	54.00	4.10
GL-25	81.00	13.00	55.00	4.30
GL-26	77.00	12.10	53.00	4.00
BARI Gladiolus-1	52.00	11.50	46.00	3.00
CV(%)	22.06	30.89	15.71	11.22
F-test	**	**	**	**

** Significant at 1% level

Plate 1. Part of experimental view at vegetative stage

Flower characteristics

Colour of flower

As regards to the colour of flower, the observed genotypes showed remarkable variation such as yellow, red, white, light yellow, pink, orange and intermediate colour (Table 3).The flower variability of different genotypes of gladiolus are presented in plate 2.

Table 3. Flower colours of different genotypes of gladiolus

Genotypes	Flower colour
GL -01	White colour with red in center
GL -02	Light yellow colour with red in center
GL -003	Light yellow
GL -004	Deep yellow
GL -005	Light yellow
GL -006	Deep red with creamy centre
GL -007	Light orange with red stripe, two petals are yellow
GL -008	Numerous red stripes with biscuit colour
GL-009	Yellowish pink
GL -010	Reddish yellow stripe
GL -011	Golden off white , distinct red colour present in two petals
GL -012	Deep violet, distinct red cream colour present in two petals
GL -013	Light orange stripe
GL -014	Deep red with yellow colour on two petals
GL -015	Yellowish orange
GL -016	Reddish pink
GL -017	Light pink with reddish orange
GL -018	Majenta
GL -019	Light pink with reddish orange
GL -020	Yellowish orange stripe
GL -021	White
GL -022	Deep red, light blue colour present in two petals
GL -023	Yellowish orange
GL -024	Purple with white streak
GL -025	Whitish orange
GL -026	Whitish orange
BARI Gladiolus 1	Red, distinct yellow colour present in two petals

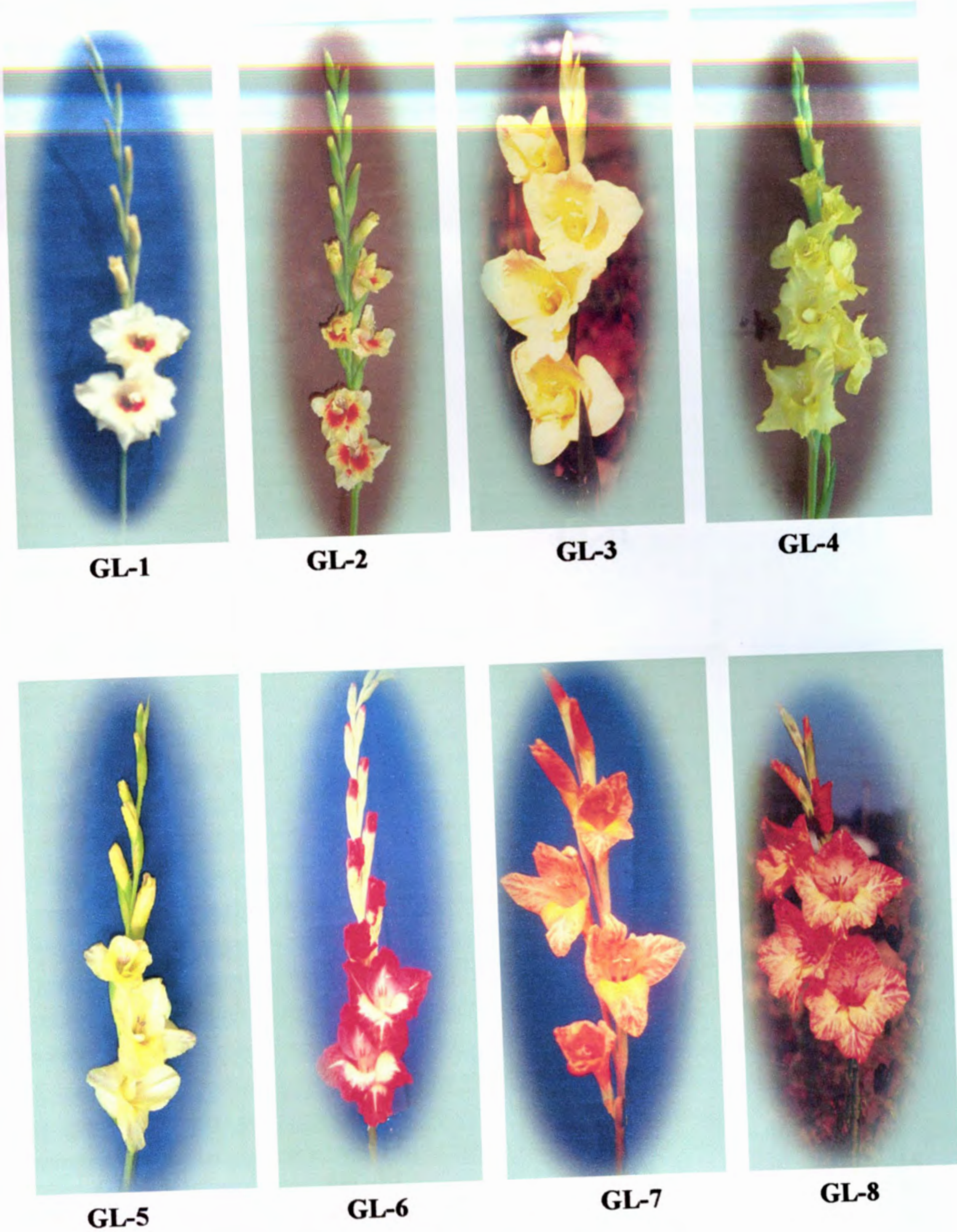


Plate 2. Flower variability in gladiolus genotypes

GL-9

GL-10

GL-11

GL-12

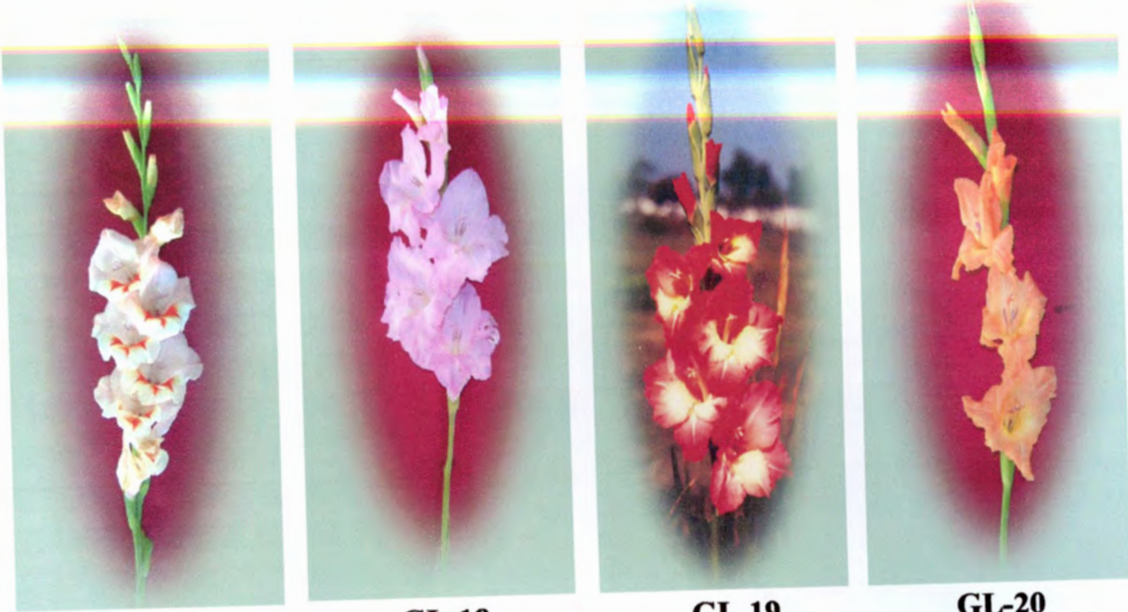
GL-13

GL-14

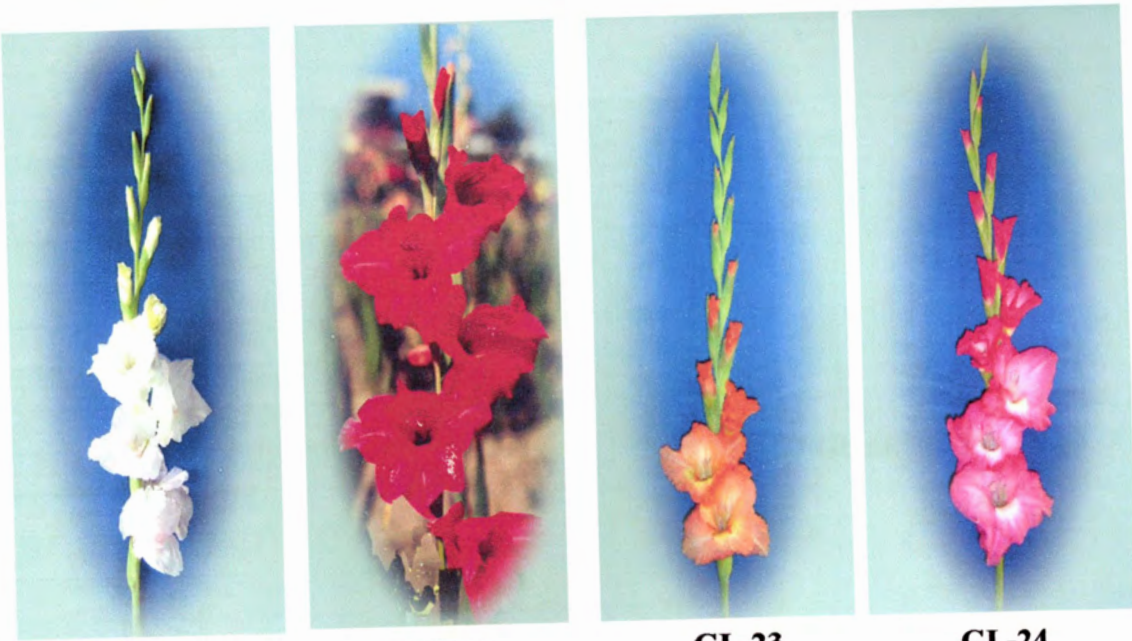
GL-15

GL-16

Plate 2. Flower variability in gladiolus genotypes



GL-17 GL-18 GL-19 GL-20

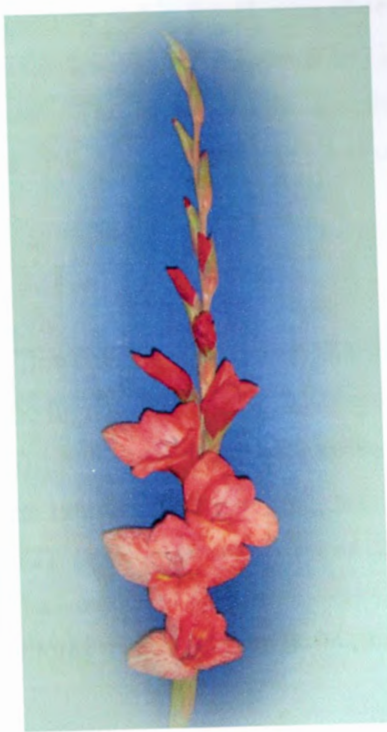


GL-21 GL-22 GL-23 GL-24

Plate 2. Flower variability in gladiolus genotypes

GL-25

GL-26



BARI Gladiolus-1

Plate 2. Flower variability in gladiolus genotypes

Days to 50% spike initiation

Marked genotype differences were for days to 50% spike initiation among the genotypes under investigation (Table 4). The genotypes GL -06 took maximum days (74 days) to 50% spike initiation closely followed by GL-07 (73 days). The four genotypes viz. GL-02 (42 days), GL-23 (43 days), GL-25 (44 days) and GL-24 (45 days) were initiated spike within short duration. In a varietal trial, Ashwath and Parthasarathy (1994) reported that the varieties required 40-70 days to 50% spike imitation which was in consonance with majority of the genotypes under investigation. Singh and Singh (1990) recorded 38.7 days to 50% spike imitation in case of 'Apsara' as an earliest genotype. The differences in days to 50% spike initiation might be due to the genitical factors of the genotype concerned.

Spike length

Significant variation in respect of spike length was found among the germplasm (Table 4). The longest spike (100cm) was produced by genotypes GL-02 followed by GL-23, GL- 24 and GL-25 (99, 98 and 96 cm respectively) while the shortest spike (53cm) was produced by GL-14. Bhagur (1989) recorded spike length ranged from 61.60 to 137.97 cm in varietal evaluation of gladiolus.

Rachis length

A great deal of genotypic variation in rachis length was observed (Table-4) and varied from 24-58 cm. The highest rachis length was observed in GL-23 (58 cm), which was closely followed by GL-02(57cm). The lowest rachis length (24cm) was observed in genotypes GL-14. Anuradha and Gowda (1994) reported that rachis length was highest in genotype GL- 06 (51.77 cm).

Number of flower

Variation regarding number of flower per plant among the genotypes was observed and varied from 6 to 15 (Plate-2). The highest number of flower per plant was produced by GL -23(15). The genotype GL-7 (6) produced the lowest number of flower per plant which was followed by GL-14 (7). The number of flowers per plant varied from 5.33-20.00 as reported by Negi *et al.*, (1982) from their experiment at the Hariana Agricultural University Farm, Hissar, India. Lal and Plant (1989) recorded 8 flowers per plant in GL- 6 to 18 flowers in GL -15 in a gladiolus trail conducted at Maharastra in India.

Table 4. Flower characteristics of different genotypes of gladiolus

Genotypes	Days to 50% spike initiation	Spike length (cm)	Rachis length (cm)	Wt. of single stick (g)	No. of flower
GL-01	58.00	88.00	40.50	43.00	11.75
GL-02	42.00	100.00	57.00	90.00	14.00
GL-03	69.00	76.00	25.00	35.00	9.10
GL-04	51.00	70.50	34.50	44.00	9.50
GL-05	62.00	72.00	35.50	50.00	10.00
GL-06	74.00	79.50	32.00	36.00	11.50
GL-07	73.00	80.00	27.00	25.00	6.00
GL-08	53.00	54.50	36.00	40.00	8.00
GL-09	63.00	71.50	28.00	35.00	9.00
GL-10	46.00	70.00	36.00	39.00	10.00
GL-11	49.00	77.00	25.50	29.00	10.00
GL-12	60.00	80.00	38.00	40.00	12.00
GL-13	62.00	58.00	35.00	50.00	12.00
GL-14	64.00	53.00	24.00	28.00	7.00
GL-15	62.00	70.00	40.00	90.00	11.50
GL-16	60.00	59.00	26.00	26.00	11.80
GL-17	64.00	85.00	28.00	39.00	11.00
GL-18	59.00	84.00	40.00	48.00	12.00
GL-19	51.00	64.00	42.00	52.00	10.50
GL-20	58.00	88.00	39.00	78.00	13.00
GL-21	51.00	77.00	50.00	80.00	8.00
GL-22	49.00	93.00	46.00	90.00	8.33
GL-23	43.00	99.00	58.00	94.00	15.00
GL-24	45.00	98.00	56.00	98.00	14.00
GL-25	44.00	96.00	50.00	100.00	15.00
GL-26	48.00	95.00	53.00	85.00	13.80
BARI Gladiolus-1	60.00	80.00	48.00	82.00	12.50
CV(%)	16.32	28.46	28.35	18.94	29.40
F-test	**	**	**	**	**

** Significant at 1% level

Weight of single stick

Genotypes had displayed a wide range of variability among them in respect of stick weight. It ranged from in 25-100g (Table 4). High stick weight was recorded from genotypes viz. GL-25 (100g) closely followed by GL-24 (98g). The lowest stick weight producer genotype GL-07 (25g) was closely followed by three genotypes namely GL-16 (26g), GL-14 (28g) and GL-11(29g).

Flower size

As regards flower size ranged from 8 to 13.5 with the mean value of 10.45 among the observed genotypes, the largest size of flowers per spike was obtained from genotypes GL-24 (13.5cm) while the smallest flower (8cm) were recorded from the genotypes GL - 07 (Figure1)

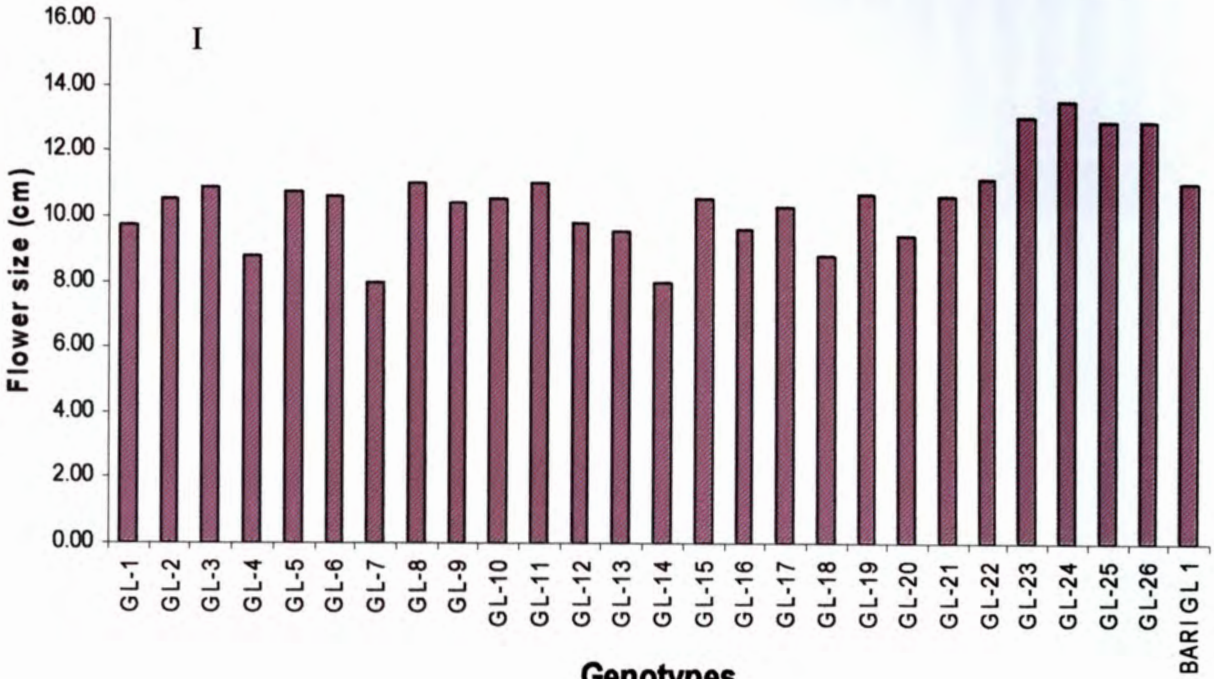


Fig. 1. Flower size of gladiolus genotypes

Vertical bar represent 1% of LSD value

Vase life

A great deal of genotypic variation was observed in case of vase life (Figure-2). Vase life was observed in this experiment varied from 6 to 14 days with the mean value of 10.07. The highest vase life (14 days) was found in genotype GL-24 while the shortest vase life (6 days) was found in genotype GL-07. In a varietal trial, Lal and Danu (1984) reported that the vase life of gladiolus lasted from 8 days to 16 days. Negi *et al.*, (1981) indicated that vase life was essential character for selection of gladiolus varieties. The difference in vase life might be due to different genetic configuration of the genotypes.

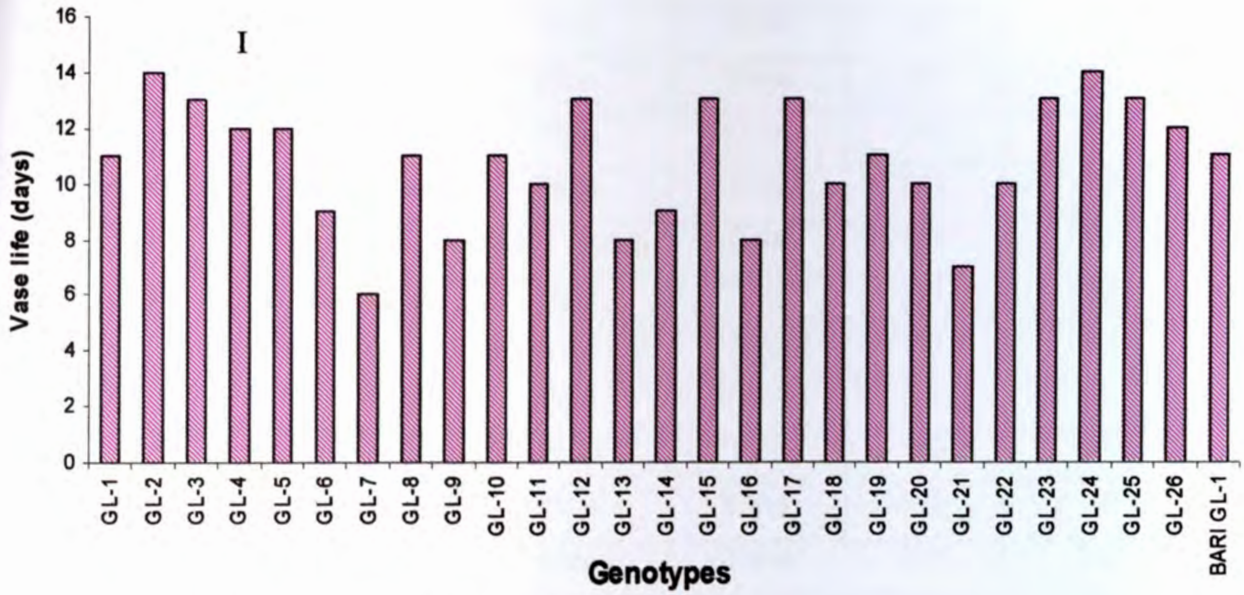


Fig. 2. Vase life of gladiolus genotypes

Vertical bar represent 1% of LSD value

Qualitative traits of Gladiolus genotypes

The qualitative traits of the twenty seven Gladiolus genotypes are presented in (Table 5). In all the genotypes, the floret type was open- faced as in the standard CV. BARI Gladiolus-1, whereasGL-14 and GL-16 had funnel shaped floret. Two genotypes, viz GL-12 and GL-14 had florets with wavy margins while the rest had florets with plain margins. The genotypes GL-14 and GL-16 had thin floret texture while rest of the genotypes possessed thick floret texture. All the genotypes were rated moderately tolerant except h was found susceptible to disease. There was no pest incidence in the field.

Table 5. Qualitative traits of gladiolus genotypes

Acc. No.	Floret type	Floret structure	Floret texture	Disease reaction	Pest incidence
GL-01	Open faced	Plain	Thick	*MT	Nil
GL-02	Open faced	Plain	Thick	MT	Nil
GL-03	Open faced	Wavy margin	Thick	MT	Nil
GL-04	Open faced	Plain	Thick	MT	Nil
GL-05	Open faced	Plain	Thick	MT	Nil
GL-06	Open faced	Plain	Thick	MT	Nil
GL-07	Open faced	Plain	Thick	MT	Nil
GL-08	Open faced	Plain	Thick	MT	Nil
GL-09	Open faced	Plain	Thick	MT	Nil
GL-10	Open faced	Plain	Thick	MT	Nil
GL-11	Open faced	Plain	Thick	MT	Nil
GL-12	Open faced	Wavy margin	Thick	MT	Nil
GL-13	Open faced	Plain	Thick	MT	Nil
GL-14	Funnel shaped	Wavy margin	Thin	MT	Nil
GL-15	Open faced	Plain	Thick	MT	Nil
GL-16	Funnel shaped	Plain	Thin	**S	Nil
GL-17	Open faced	Plain	Thick	MT	Nil
GL-18	Open faced	Plain	Thick	MT	Nil
GL-19	Open faced	Plain	Thick	MT	Nil
GL-20	Open faced	Plain	Thick	MT	Nil
GL-21	Open faced	Plain	Thick	MT	Nil
GL-22	Open faced	Plain	Thick	MT	Nil
GL-23	Open faced	Plain	Thick	MT	Nil
GL-24	Open faced	Plain	Thick	MT	Nil
GL-25	Open faced	Plain	Thick	MT	Nil
GL-26	Open faced	Plain	Thick	MT	Nil
BARI Gladiolus-1	Open faced	Plain	Thick	MT	Nil

*MT- Moderately tolerant, **S- Susceptible

Corm and cormel characteristics in gladiolus

Number of corms

Data recorded in respect of corm production of twenty seven lines of gladiolus are presented in Table 6. The number of corms produced per plant was the highest in GL -14 (3.00) followed by GL-07 (2.00) and GL-16 (2.00) .The lowest number of corms (1.0) was produced by the rest genotypes. The variation observed in corm production among the genotypes might be due to difference in genetically constituents as well as environmental effects. Variation (1.0 to 4.0) in corm production among some genotypes of gladiolus was observed at Bangalore in India by Anuradha and Gowda (1994).

Weight of corms

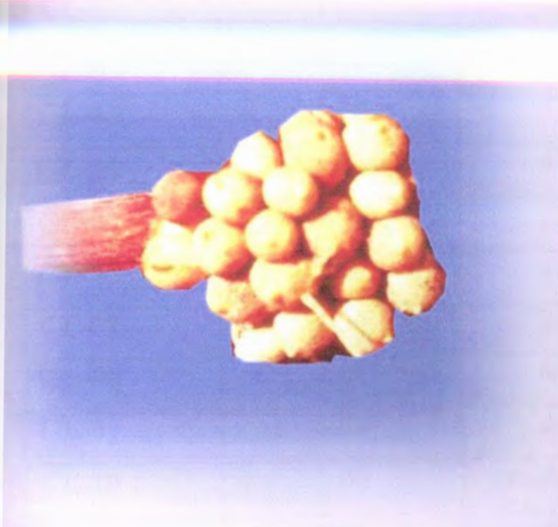
Genotypes had displayed a wide range of variability among them in respect of corm weight. It ranged from 16 to 58 g. The highest corm weight (58g) was recorded from the genotype GL-25 which was closely followed by GL-02 (50g), and GL-24 (50g). The lowest corm weight per plant was obtained from the genotypes GL-14 (16g) closely followed by three genotypes GL -5 (16g) and GL-13 (17g). Sharma and Sharma (1984) reported that corm weight was the highest in genotype GL- 4 (67g) and lowest in genotype GL- 25 (18g) which was more or less in consonance with the present investigation.

Number of cormel/Plant

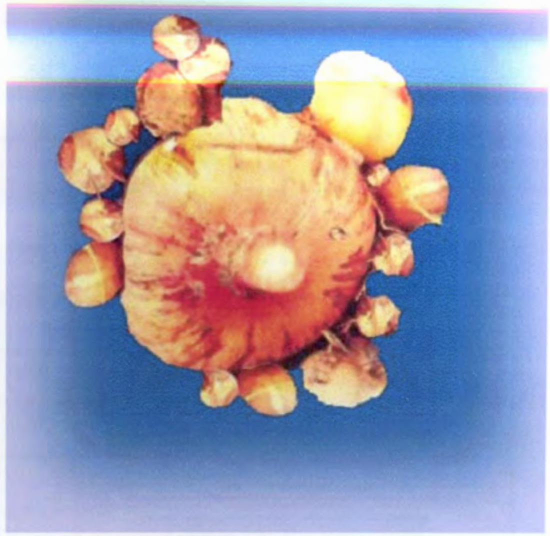
Number of cormel per plant was significantly affected by genotypes (Table 6). The highest number of cormels per plant was obtained from the genotype GL- 02 (15) which was closely followed by GL-23 (14), GL-24(13) and GL-25 (13) (Plate-3). The genotypes GL-05(5) and GL-07(5) produced the lowest number of cormels per plant. Misra and Saini (1990) recorded 5 to 20 cormel per plant in gladiolus genotypes in a trial conducted at Bangalore, India.

Cormel weight

Genotypes had displayed a range of variability among them in respect of cormel weight/corm. It ranged from 4.8-15g. The highest cormel weight was recorded in GL-23 (15g), which was closely followed by GL-24 (13.7g), GL-25(13g) and GL-02(13g). The genotypes GL -04 (4.8g) and GL- 12 (4.4g) produced the lowest weight of cormel per corm. Negi *et al.*, (1982) reported that cormel weight in gladiolus genotypes ranged from 5.2 to 17.0g which is more or less similar result with the findings of the present investigation.



GL-02



GL-23

GL-24

GL-25

Plate 3. Cormel production of some promising gladiolus genotypes

Table 6. Corm and Cormel production from different genotypes of gladiolus

Acc. No.	No. of corm/ Plant	Wt. of corm/ plant (g)	No. of cormel/ plant	Wt. of cormel/plant(g)
GL-01	1.00	44.00	10.00	7.50
GL-02	1.00	56.00	15.00	13.00
GL-03	1.00	42.00	12.00	7.60
GL-04	1.00	47.00	10.00	6.50
GL-05	1.00	16.00	5.00	4.80
GL-06	1.00	46.00	8.00	7.80
GL-07	2.00	35.00	5.00	12.60
GL-08	1.00	40.00	10.00	12.50
GL-09	1.00	28.00	12.00	7.00
GL-10	1.00	46.00	5.00	5.50
GL-11	1.00	45.00	11.00	8.00
GL-12	1.00	42.00	11.00	4.40
GL-13	1.00	17.00	10.00	8.00
GL-14	3.00	16.00	12.00	6.90
GL-15	1.00	30.00	12.00	7.00
GL-16	2.00	40.00	9.00	6.60
GL-17	1.00	44.00	10.00	7.00
GL-18	2.00	39.00	9.00	5.80
GL-19	1.00	48.00	8.00	7.50
GL-20	1.00	29.00	10.00	7.00
GL-21	1.00	45.00	9.00	5.90
GL-22	1.00	46.00	10.00	11.00
GL-23	1.00	39.00	14.00	15.00
GL-24	1.00	50.00	13.00	13.70
GL-25	1.00	58.00	13.00	13.00
GL-26	1.00	40.00	7.00	10.00
BARI Gladiolus-1	1.00	29.00	10.00	12.00
CV (%)	27.24	21.65	20.70	28.48
F- test	**	**	**	**

Estimate of genetic parameters in gladiolus genotypes

The analysis of variance (Appendix II) indicated the existence of significant variability for all the characters studied. The range, coefficient of phenotypic and genotype variations, heritability estimates and expected genetic advance in percent of mean (1%) are shown in Table 7. A wide range of variation was observed for all the 15 characters studied. The range of variation was high for spike length (53-100), rachis length (24-58), vase life (6-14), flower number (6-15), plant height (31-81), leaf length (28-55), flower size (8-13.50), days to 50% spike initiation (42-74), weight of single stick (25-100), cormel number (10-35), cormel weight (2.50-30) and weight of corm (16-70) but low for leaf breadth (1.50-4.30) and number of corm (1.00-3.33).

Gladiolus being a cross pollinated crop has much variation and therefore the present observation is in agreement with that as reported earlier by Bhagur (1989) in gladiolus. Estimates of genetic parameters for each character are important for getting idea about their mode of inheritance. Such idea usually helps the breeder to make efficient selection. In the present study, a narrow difference between phenotypic and genotype coefficients of variation was noticed for spike length, rachis length, plant height, floret number and vase life, indicating less environmental interference on the expression of these characters. Similar observations were made by Anuradha and Gowda (1994) in gladiolus.

A character can be improved only if it is highly heritable. The magnitude of h^2 indicates the effectiveness with which the selection of genotypes can be made based on phenotypic performance (Johnson *et al.*, 1995). Out of 15 quantitative characters studied, spike length, rachis length, plant height, floret number, vase life, cormel number and cormel weight exhibited high heritability. The results were in consonance with the findings of Singh and Singh (1990) and Bhagur (1989) in gladiolus.

Even though the h^2 values give indication of effectiveness of selection based on the phenotypic performance, it does not necessarily mean a high genetic advance for a particular character. Heritability along with estimates of expected genetic advance should be considered while making selection. In crop improvement only the genetic component of variation is important since only this component of h^2 serve as a useful guide to the breeder.

Table 7. Phenotypic and genotypic variability, heritability and genotypic advance in gladiolus

Character	Range	Mean	Coefficient variability (%)		Heritability	Genotypic advance in percent of mean (1%)
			Phenotypic	Genotypic		
Plant height	31.00-81.00	58.82	18.60	16.24	69.35	46.54
No of leaves/ Plant	08.00-13.50	11.39	13.56	11.30	68.43	30.30
Length of leave(cm)	28.00-55.00	44.13	23.44	19.16	58.66	18.84
Breadth of leave(cm)	01.50-04.30	02.93	20.08	17.91	50.46	16.57
Days to 50% spike initiation	42.00-74.00	55.22	21.67	18.66	64.09	34.85
Spike length	53.00-100.00	77.30	35.20	32.77	81.69	90.29
Rachis length	24.00-58.00	18.32	36.42	34.69	82.98	91.34
Wt. of single stick	25.00-100.00	57.19	25.71	20.68	34.50	19.88
No. of flower	06.00-15.00	10.67	29.88	28.56	81.50	85.47
Flower size	08.00-13.50	09.45	14.33	11.85	68.42	40.58
Vase life	06.00-14.00	10.50	34.49	32.18	82.05	83.30
No. of corm/plant	01.00-3.00	01.80	54.50	40.26	69.06	40.42
No. of cormel/ plant	5.00-15.00	24.50	50.79	48.27	87.34	91.29
Wt. of corm	16.00-58.00	40.71	27.25	20.25	22.56	19.90
Wt. of cormel	4.80-15.00	12.27	48.12	42.95	85.70	86.58

If the h^2 of a character is high (0.8 or more), selection for this is very effective. This is because there would be close correspondence between genotype and phenotypic variances due to relatively smaller contribution of environment to the phenotype. But for character with low h^2 (less than 0.4), selection may be ineffective or virtually impractical due to masking effect of environment on the genotypic effects. The characters exhibiting high h^2 with high genetic advance in this study were spike length (81.69% and 90.29), rachis length (82.98% and 90.29), number of flower (81.50% and 85.47), number of cormel per corm (87.34% and 91.29), cormel weight (85.70% and 86.58) and vase life of flower (82.05% and 83.30). This indicated additive gene action, suggesting the possibility of improvement of these traits through selection (Burton, 1952). Similar observations were made by Prasad *et al.* (1994) and Wilbret (1992) in gladiolus. The characters exhibited moderate heritability along with moderate genetic advance was observed in plant height (69.35% and 46.54), number of leaves (68.43% and 30.30), days to 50% spike initiation (64.09% and 34.85), flower size (68.42% and 40.58) and number of corm (69.06% and 40.42) thus indicated moderate scope for improvement by selection for those character. The moderate heritability with lowest genetic advance was observed in length of leave (58.66% and 18.84) and breadth of leave (50.46% and 16.57) thus indicated less scope for improvement by selection for those characters. The lowest heritability along with lower estimates of genetic advance was found in weight of single stick (34.50% and 19.88) and weight of corm (20.25% and 22.56) that might be due to non-additive gene effects for the particular character and would offer less scope for selection; because that was under the influence of environment.

Correlation Coefficient

Yield is a complex product being influence by several interdependable quantitative characters. Thus selection for yield may not be effective unless the other yield components influence it directly or indirectly are taken in to consideration. When selection pressure is exercised for improvement of any character highly associated with yield, it simultaneously affects a number of other correlated characters. Hence knowledge regarding association of character with yield and among themselves provide guideline to the plant breeder for making improvement through selection vis-a-vis provide a clear understanding about the contribution in respect of establishing the association by genetic and non-genetic factors (Dewey and Lu 1959).

The genotypic and phenotypic correlation coefficients between different pairs of characters in gladiolus are presented in Table 8. Character association analysis among flower and flower producing characters revealed that all the genotypic correlation co-efficients were higher than the corresponding phenotypic correlation coefficients. This indicates that suppressing effect of the environment, which modified the phenotypic expression of these characters by reducing phenotypic coefficient values. Accordingly, Anuradha and Gowda (1994) reported that the genotypic correlations were greater than the phenotypic values in gerbera. From this study, it was observed that both at genotypic and phenotypic level, plant height showed significantly positive correlation with rachis length, flower number, weight of single stick, vase life and spike length. On the other hand, this trait showed significantly negative correlation with number of corm and number of cormel. It was also found that plant height had poor correlation with weight of corm and cormel. Highly significant positive correlation was found between rachis length and spike length. Similar result was also reported by Singh and Singh (1990) in gladiolus. Further negative significant correlation was observed between rachis length and weight of single flower stick (Lal *et al.,* 1985). This character again showed significantly positive correlation with vase life of flower indicating vase life could be improve by increasing rachis length. The significantly negative correlation was observed in rachis length with number of corm, cormel and weight of corm, which indicated that increased rachis length decreased the value of this character. Number of flower had significant but negative correlation with single flower stick weight which indicates that decreased with the increase of flower number. On the other hand, this trait had positive significant effect on vase life, which indicated vase life was highly dependent on number of flowers per plant. The correlation of number of flowers per plant with other characters was insignificant. Anuradha and Gowda (1994) also reported similar types of observations. Correlation coefficient revealed that single flower stick weight had negative correlation with vase life as well as spike length. The association of this trait with other characters was insignificant in positive direction. So, selection based on this character would not be effective for increasing yield. Vase life of gladiolus had significant positive correlation with spike length. Bhagur (1989) also reported the similar findings relating to character association and variability studies in gladiolus. The number of cormel and weight of corm and cormel had also shown significant but negative correlation with vase life of flower at both genotypic and phenotypic levels (Table-8). The results agreed with Aswath and Parthasarathy (1994) in gladiolus. The trend of relationship of corm number and spike length per plant was negatively significant both at genotypic and phenotypic level. However, number of corm per plant showed highly significant positive correlation with weight of corm. This feature indicated that increased of corm number would lead to increase the weight of corm. Number of cormel had highly significant positive correlation with spike length. Similar observation was also reported by Lal *et al.*, (1985) in gladiolus. On the other hand this trait had simply positive association with weight of cormel. Negative correlation was observed between weight of corm and spike length at both genotypic and phenotypic level. So, selection based on this character would not be effective for increasing yield. Singh and Singh (1990) reported similar trend of relationship. Highly significant positive correlation was found between spike length and weight of cormel. Anuradha and Gowda (1994) reported that genotypic and phenotypic association between spike length and cormel weight in gladiolus was observed to be positive and highly significant.

However, the correlation study revealed that selection of parents based on characters such as plant height, flower number, rachis length, vase life, cormel number and cormel weight which are useful in a breeding program.

Table 8. Genotypic (g) and phenotypic (p) corrections among ten characters in 27 gladiolus genotypes

Traits	Correlation coefficient	Rachis length	No. of flower	Wt. of single stick	Vase life of flower	No. of corm/ Plant	No. of cormel/ plant	Wt. of corm	Wt. of 10 cormel	Spike length
Plant height	r_g	0.705**	0.690**	-0.872**	0.704**	-0.706**	-0.659**	0.176	0.135	0.792**
	r_p	0.651**	0.574**	-0.706**	0.648**	-0.639**	-0.610**	0.164	0.117	0.756**
Rachis length	r_g		0.614**	-0.699**	0.870**	-0.656**	-0.596**	-0.534**	0.094	0.754**
	r_p		0.505**	-0.647**	0.845**	-0.604**	-0.553**	-0.414**	0.070	0.748**
No. of flower	r_g			-0.734**	0.703**	-0.230	-0.216	0.077	-0.250	0.751**
	r_p			-0.647**	0.635**	-0.214	-0.204	0.074	-0.246	0.733**
Wt. of single stick	r_g				-0.108**	0.136	0.140	0.094	0.096	0.184
	r_p				-0.169**	0.115	0.118	0.092	0.084	0.179
Vase life of flower	r_g					0.132	-0.420**	-0.540**	-0.568**	0.554**
	r_p					0.110	-0.356**	-0.481**	-0.490**	0.573**
No. of corm/ plant	r_g						-0.421**	0.709**	-0.438**	-0.445**
	r_p						-0.349**	0.705**	-0.360**	-0.369**
No. of cormel/plant	r_g							-0.269*	0.258*	0.646**
	r_p							-0.254*	0.249*	0.615**
Wt. of corm	r_g								0.049	0.146
	r_p								0.038	0.116
Wt. of 10 cormel/corm	r_g									0.576**
	r_p									0.520**

Path coefficient

In the present investigation spike length is considered as a resultant variable and plant height, rachis length, number of flower, weight of single stick, vase life of flower, number of corm, number of cormel, weight of corm and weight of cormel were causal (independent) variables. The cause and effect relationship between spike length and yield related characters have been presented in Table-9. Residual effects of other independent variables, which have influence yield to a small extent, have been denoted as 'R'.

Association of characters determined by correlation coefficients may not provide an exact picture of the relative importance of direct and indirect influence of each of the yield components on yield. As a matter of fact, in order to find out a clear picture of the interrelationship between flower yield and other yield attributes, direct and indirect effects were worked out using path analysis at genotypic level which also measured the relative importance of each component.

Path coefficient analysis (Table 9) revealed that rachis length (0.769) had the highest positive direct effect on spike length followed by number of flower (0.754), number of cormel (0.650), weight of cormel weight (0.578), vase life of flower (0.509), plant height (0.335) and number of corm and negligible effect by weight of single stick and weight of corm. The contribution of yield components like, number of flower, rachis length, vase life, number of cormel, weight of cormel were higher in the present study which is in accordance with the findings of Negi *et al.,* (1982) in gladiolus.

Plant height showed positive direct effect (0.335) on flower yield (Table 9). The positive indirect effect via number of flower (0.117), vase life of flower (0.161) and number of cormel (0.050) was however, very low.

The indirect effect of this character on flower yield via number of corm (-0.039), weight of corm (-0.020), weight of single stick (-0.019), weight of cormel weight (-0.058) were negative and almost negligible in magnitude. Where as via rachis length (0.560) showed considerable positive direct effect on flower yield and the total correlation was highly significant and positive (0.792). So, direct selection based on this character or indirect selection via rachis length could be effective for increasing flower yield. Anuradha and Gowda (1994) also reported positive direct effect of plant height on rachis length on flower yield of gladiolus. High positive direct effect (0.769) and correlation coefficients (0.792) with flower yield was exhibited by rachis length. Indirect effect via plant height (0.238), number of flower (0.168), vase life of flower (0.136) and number of cormel (0.143) were positive but other characters showed negative indirect effect on flower yield that can not be influenced to the total effect. Considering high positive direct effect and significant correlation with flower yield the rachis length is the main important character which can help to select better plant type. Sharma and Sharma (1984) reported high direct effects of rachis length on flower yield in gladiolus.

Direct positive effect of number of flower seemed to be second important contributor to flower yield. Positive indirect effect via plant height (0.106), rachis length (0.229), weight of single stick (0.015), number of cormel (0.014), vase life of flower (0.015), weight of cormel (0.025) might be due to significant positive effect of flower number with those character (Table 9). Strong direct effect of flower number on flower yield was reported by Arora and Khanna (1985).

Direct effect of weight of single stick on flower yield (0.184) was positive. The character showed considerable indirect positive effect on flower yield through rachis length. Where as plant height, number of flower, vase life of flower, number of corm, number of cormel, weight of corm and weight of cormel showed small negative indirect effect on yield via this trait. Lai *et al.,* (1984) reported high positive direct effect of single flower stick weight on yield but Arora and Sharma (1991) found low direct positive effects of this trait on yield. This finding confirmed this result.

Vase life of flower had a positive direct effect (0.509) on yield. The character showed considerable indirect positive effect on flower yield were rachis length (0.240) and number of flower (0.441), plant height (-0.295), weight of single stick (-0.159), number of corm (-0.001), number of cormel (-0.165), weight of corm (-0.256) and weight of cormel (-0.179) had negligible negative indirect effect via vase life on yield. The total correlation was highly significant and positive (0.554). High positive direct effect on vase life on yield were also reported by Arora and Khanna (1986) in gladiolus.

Though number of corm (0.281) showed positive direct effect on flower yield, but its indirect effect via plant height (-0.017), rachis length (-0.047), number of flower (-0.083), weight of single stick (-0.142) and vase life of flower (-0.123) were negative which consequently reduced the correlation of this character with flower yield.

Number of cormel had higher direct significant positive effect (0.650) on flower yield. The negative indirect effect via number of flower (-0.140), weight of single stick (-0.121), weight of corm (-0.021) and number of corm (-0.155). The positive indirect effect via plant height (0.238), rachis length (0.083), vase life of flower (0.151) and number of cormel (0.145) were higher that led to have the high positive significant total genotypic correlation (0.646) with flower yield. Singh and Dohre (1980) found greatest direct effect for number of cormel on flower yield which is in agreement with the present findings.

Negative direct effect was exhibited in weight of corm with flower yield was also negative and it was mainly due to negative indirect effects via plant height (-0.221), rachis length (-0.048), number of flower (-0.050) and number of corm (-0.006). Weight of cormel had higher positive direct effect than its significant positive correlation with yield indicating that selection based on this character would be effective. The indirect effect via number of flower (-0.064), weight of single stick (-0.173), number of corm (-0.002) and weight of corm (-0.085) were negative which consequently resulted negative correlation with yield. The results are in agreed with Negi *et al.*, (1982) in gladiolus.

Table 9. Path coefficient (genotypic) showing direct and indirect effects on different characters contributing towards flower yield in gladiolus

Traits	Plant height	Rachis length	No. of flower	Wt. of single stick	Vase life of flower	No. of corm	No. of cormel	Wt. of corm	Wt. of cormel	Spike length
Plant height	**<u>0.335</u>**	0.560	0.117	-0.019	0.161	-0.039	0.050	-0.020	-0.058	0.792**
Rachis length	0.238	**<u>0.769</u>**	0.168	-0.109	0.136	-0.125	0.143	-0.202	-0.024	0.754**
No. of flower	0.106	0.229	**<u>0.754</u>**	0.015	0.015	-0.011	0.014	-0.095	0.025	0.751**
Wt. of single stick	-0.233	0.241	-0.017	**<u>-0.121</u>**	-0.173	-0.356	-0.179	-0.001	-0.217	0.184**
Vase life of flower	-0.295	0.240	0.441	-0.159	**<u>0.509</u>**	-0.001	-0.165	-0.256	-0.179	0.554**
No. of corm	-0.017	-0.047	-0.083	-0.142	-0.123	**<u>0.281</u>**	0.015	6.107	0.006	-0.445**
No. of cormel	0.238	0.083	-0.140	-0.121	0.151	-0.155	**<u>0.650</u>**	-0.021	0.145	0.646**
Wt. of corm	-0.221	-0.048	-0.050	0.167	0.018	-0.006	0.334	**<u>-0.022</u>**	0.048	-0.146
Wt. of 10-cormel	0.250	0.039	-0.064	-0.173	0.335	-0.002	0.306	-0.085	**<u>0.578</u>**	0.576**

Residual effect = 0.35
** Significant at 1% level
The bold and underline values indicate direct effects

The residual effect of the present study was 0.35 indicating that 65 percent of the variability in spike length was contributed by the ten characters studied in the path analysis. This residual effect towards yield in the present study might be due to other characters which were not studied, environmental factors and sampling errors (Sharifuzzaman, 1998). The path analysis indicated that rachis length, flower number, vase life, number of cormel and cormel weights had contributed maximum direct effects on flower yield indicating the importance of three characters as selection indices for gladiolus.

Experiment 2. Effect of growth regulators on breaking dormancy and corm production in gladiolus

In the present investigation corms of GL-16 were treated with different concentration (50, 100, 150, 200 and 250) of BAP, Ethrel and GA_3 to observe their effect on breaking dormancy as well as more number of corm production. It has been evident that growth regulator was essential for sprouting of gladiolus. The lowest percentage (30%) of corm sprouting was observed at control (without growth regulator) and took more days (70 days) for sprouting (Table 10). In all concentration of BAP, Ethrel and GA_3, BARI gladiolus 1 sprouted corm at variable rate. The lowest concentration (50 ppm) at which BAP, Ethrel and GA_3 sprouted corm but this response increased with an increase in the concentration of growth regulator.

Table 10. Effect of BAP, Ethrel and GA_3 on breaking dormancy in gladiolus corms

Treatments (ppm)		Percentage of corm sprouting	Days taken for fifty percent sprouting
BA	50	50 e	45 ef
	100	55 de	48 def
	150	88 a	40 f
	200	70 bc	45 ef
	250	45 e	48 def
Ethrel	50	50 e	48 def
	100	80 ab	45 ef
	150	75 bc	48 def
	200	65 cd	50 de
	250	50 e	55 cd
GA_3	50	50 e	50 de
	100	75 bc	48 def
	150	65 cd	52 cde
	200	50 e	60 bc
	250	45 e	65 ab
Control	-	30 f	70 a
CV%		20.15	20.30
F test	**	**	**

Plate 4. Corm production of gladiolus at 150ppm BAP

However, the overall response of maximum corm sprouting (80%) was observed at 150 ppm BAP. The same treatment also showed minimum days (40 days) taken for sprouting. The experiment with various growth regulators showed that BAP was more active than Ethrel and GA_3. Gowda (1994) and Ogale *et al.*, (2000) showed that corm sprouting to that with either Ethrel or GA_3 which is in consonance with the present findings. Growth regulator of gladiolus with BAP was superior BAP, GA_3 and Ethrel at different concentrations had positive effects on corm production in GL-16. However, the highest number of corm production (5 corms) was observed at 150 ppm BAP (Plate 4) followed by Ethrel 100 ppm (4 corms) and GA_3 150ppm (3 corms). The control treatment (which received no growth regulator) produced the lowest number (2 corm) of corm production.

The present findings regarding best corm production at BAP 150 ppm might be due to the differences in activity of different growth regulator such as BAP was much more active than others (Ogale *et al.*, 2000).

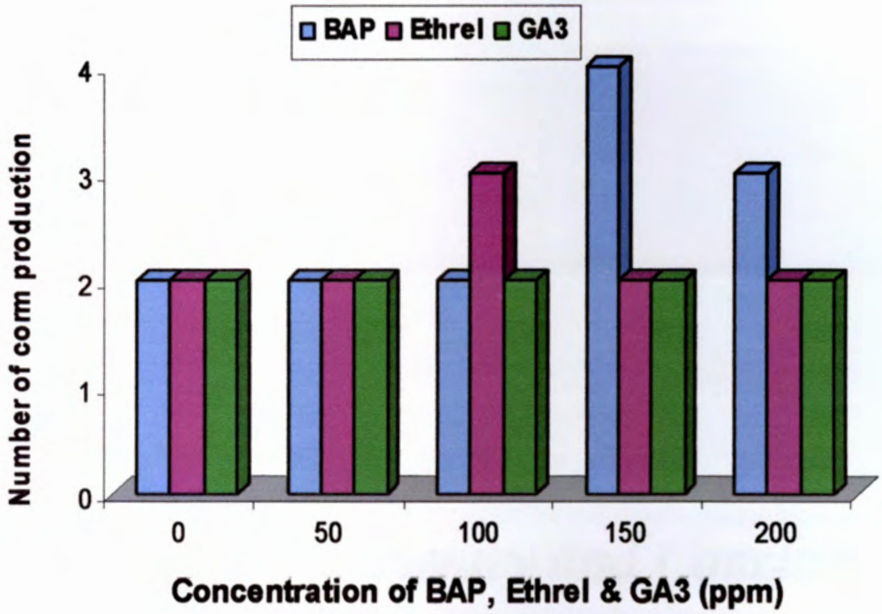


Fig. 3. Effect of BAP, Ethrel & GA_3 on corm production of gladiolus

Chapter V
Summary and Conclusion

CHAPTER V

SUMMARY AND CONCLUSION

Summary

An investigation was carried out at Floriculture Experimental Farm of Horticulture Research Centre (HRC), Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur during April 2005 to June 2006 to study the variability, estimate genetic parameters and the nature of relationship between flower yield and yield contributing characters with 27 genotypes in gladiolus and to develop an effective technique for more number of corm production through dormancy breaking. The salient findings of the present study had been summarized below.

All the genotypes varied significantly with each other for all the characters studied. The genotypes GL-23 (81cm) and GL-14 (31cm) exhibited maximum and minimum plant height, respectively. The highest leave number was obtained by GL-24 (13.50) and lowest in GL-03 (8.00). Leaf length ranged from 28cm (GL-07) to 55cm (GL-25) respectively. The maximum number of flower was found in GL-23 (15) and the minimum in GL-27 (6), the GL-02 took minimum days (42) to 50% spike initiation. The maximum day was required for the genotype GL-06 (74 days). The highest spike length (100cm) was found in GL-02 and the lowest in GL-14 (53cm). Regarding rachis length, the genotypes GL-23 produced the longest rachis (58cm) closely followed by genotypes GL-02 (57cm) and GL-24 (56cm). The shortest rachis (24cm) was observed in GL-14. Considering flower size, GL-24 (13.5cm) was the best. The highest weight of single stick was obtained from GL-25 (100g) and lowest in GL-07 (25g).

A large variation in qualitative traits of gladiolus genotypes were recorded. As regards to colour of flower, the observed genotypes showed remarkable variation such as white, yellow, orange, red, pink, purple, violet and intermediate colours. Genotypes GL-14 and GL-16 had funnel shaped floret as well as thin floret texture. Open faced floret and thick floret texture were recorded in rest of the genotypes. Two genotypes GL-02 and GL-14 had florets with wavy margin while the rest had florets plain with margins. All the genotypes rated moderately tolerant except GL-16 which was found susceptible disease. There was no pest incidence in the field.

The variation of corm and cormel production was remarkable. The highest and lowest number of corm was ranged from 1.0 3.0. The genotype GL-02 had produced maximum (58g) and GL-14 produced minimum (16g) corm weight respectively. Number of cormel ranged from 5 to 15. The highest number of cormel (15) was observed in GL-02 and lowest (10) in GL-7. As regards to cormel weight, GL-23 produced the highest weight (5 g) which was closely followed by genotypes GL-24 (13.7g) and GL-25 (13g) and GL-02 (13g) respectively.

Estimation of genetic parameters of different characters to flower yield has been done for all the characters studied. The genotypic coefficient of variation (GCV) was lower than the phenotypic one for all the characters indicating considerable influence of environment. Heritability as well as genetic advance was high for spike length, rachis length, number of flower, number of cormel per corm, cormel weight and vase life in gladiolus genotypes indicated the presence of additive gene effects. The characters exhibited moderate heritability along with moderate genetic advance was observed in plant height (69.35% and 46.54), number of leaves (68.43% and 30.30), days to 50% spike initiation (64.09% and 34.85), flower size (68.42% and 40.58) and number of corm (69.06% and 40.42) thus indicated moderate scope for improvement by selection for those character. The moderate heritability with lowest genetic advance was observed in length of leave (58.66% and 18.84) and breadth of leave (50.46% and 16.57) thus indicated less scope for improvement by selection for those characters. The lowest heritability along with lower estimates of genetic advance was found in weight of single stick (34.50% and 19.88) and weight of corm (20.25% and 22.56) that might be due to non-additive gene effects for the particular character and would offer less scope for selection; because that was under the influence of environment.

With regard to association of plant characters, number of flower, vase life, rachis length, number of cormel and weight of cormel had high degree of positive significant correlation with flower yield both at genotypic and phenotypic levels demonstrating the importance of these characters in flower yield of gladiolus.

The path coefficient analysis revealed that number of flower per plant (0.754), rachis length (0.769), vase life (0.509), number of cormel (0.650) and weight of cormel (0.578) had positive direct effect on flower yield had these traits deserve high priority in the selection program. Based on this selection criteria, the genotypes GL-02, GL-23 and GL-24 were identified as good genotypes.

Corm and cormels of gladiolus undergo a period of dormancy, when they will not sprout even if all the favorable condition are available. Uniform size (20g) of GL-16 corm descaled and soaked for one hour in freshly prepared different concentration of BAP, Ethrel and GA_3 (50, 100, 150 and 200ppm). The treated corms were sown in earthen pot. It was observed that all the concentration of BAP, Ethel and GA_3 showed in sprouting but differed markedly. Induction of sprouting in the control was less. The maximum number of days taken for sprouting in control was 70 days. On the other hand BAP 150 ppm showed a promotive effect in extent of sprouting and fewer number of days (40 days) taken for sprouting. In case of corm production, it was in envisaged that BAP at 150 ppm was optimum (4 corm/plant) followed by Elthrel 100 ppm (3 corm/plant).

Conclusion

- Evaluation of morphological characters indicated a great variation among the gladiolus genotypes in respect of both qualitative and quantitative characters. The genotypes GL-02, GL-23 and GL-24 were found promising out of 27 genotypes.

- The highest heritability coupled with the highest genetic advance in percent of mean was observed in spike length, rachis length, number of flower, number of cormel, vase life and cormel weight.

- With regard to association of plant characters, rachis length, number of flower, vase life, number of cormel and cormel weight had high degree of positive significant correlation with flower yield.

- The path coefficient analysis at genotypic level revealed that rachis length (0.769), number of flower (0.754), number of cormel (0.650), weight of cormel (0.578) and vase life (0.509) had positive direct effect on flower yield.

- BAP at 150ppm was found best for breaking dormancy as well as more number of corm productions.

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Appendix 1. Physical and chemical properties of soil in the experiment field

Soil properties	Content
Physical	
Texture	Clay loam
Sand (%)	28.00
Silt (%)	44.00
Clay (%)	28.00
Chemical	
PH	5.7
Organic matter (%)	1.23
Total N (%)	0.077
Available P (mg P205/100g soil)	18.00
Exchangeable K (meq/ 100 g soil)	0.19

Appendix 2. Weather data during the period of experimental site (April, 2005 to June, 2006)

Year	Month	** Air temperature (°C)		*Humidity (%)	* Rainfall (mm)
		Max.	Min.		
2005	April	33.90	23.23	78.3	68
2005	May	32.91	23.56	80.55	137
2005	June	33.61	26.76	83.25	90
2005	July	31.81	26.15	85.86	417
2005	August	31.51	25.80	86.34	431
2005	September	31.33	25.11	88.52	444
2005	October	29.13	22.16	85.45	58
2005	November	28.10	17.92	82.76	44
2005	December	27.14	13.95	81.52	96
2006	January	25.27	12.00	81.75	0
2006	February	30.80	17.75	73.42	0
2006	March	32.69	19.49	70.40	0
2006	April	33.74	22.71	79.60	80
2006	May	34.80	25.49	83.90	406
2006	June	35.69	26.35	79.55	465

Appendix 4. Analysis of variance of the data on percentage of corm sprouting from the effect of different concentration of BAP, Ethrel and GA_3

Sources of variation	Degrees of freedom	Mean square
		% of corm sprouting
Replication	2	19.69
Treatment	15	728.19**
Error	30	36.80

** Significant at 0.01 level of probability

Appendix 5. Analysis of variance of the data days taken for 50% corm sprouting from the effect of different concentration of BAP, Ethrel and GA_3

Sources of variation	Degrees of freedom	Mean square
		Days taken 50% of corm sprouting
Replication	2	19.69
Treatment	15	716.10**
Error	30	26.86

** Significant at 0.01 level of probability