

**STUDIES ON GENETIC VARIABILITY OF
GLADIOLUS (*Gladiolus grandiflorum* L.)**

S. ANURADHA

**DIVISION OF HORTICULTURE
UNIVERSITY OF AGRICULTURAL SCIENCES
BANGALORE**

1990

ಕೃಷಿ ವಿಶ್ವವಿದ್ಯಾನಿಲಯ
ಕೃಷಿ-ಪ್ರಾಣಿ-ವೈದ್ಯಕೀಯ ಕ್ರಾಂತಿಯ
ಗ್ರಂಥಾಲಯ
ಬೆಂಗಳೂರು-65.
2 Jan. 1991
Th. 2557
ಇವುಗಳಿಗೆ ಸಂಬಂಧಿಸಿದಂತೆ
ವಿವರಣೆ

**STUDIES ON GENETIC VARIABILITY OF
GLADIOLUS (*Gladiolus grandiflorum* L.)**

S. ANURADHA

Thesis submitted to the
University of Agricultural Sciences, Bangalore
in partial fulfilment of the requirements
for the award of the Degree of

Master of Science (Horticulture)

IN

FLORICULTURE

BANGALORE

NOVEMBER 1990

Dedicated to
My Beloved Parents

Division of Horticulture
University of Agricultural Sciences
Bangalore

C E R T I F I C A T E

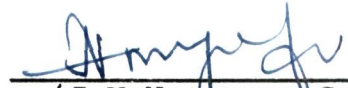
This is to certify that the thesis entitled
"STUDIES ON GENETIC VARIABILITY OF GLADIOLUS (Gladiolus
grandiflorum L.)" submitted in partial fulfilment of the
requirements for the degree of **MASTER OF SCIENCE
(HORTICULTURE)** in **FLORICULTURE** to the University of
Agricultural Sciences, Bangalore, is a record of
bona-fide research work carried out by **Miss.S.Anuradha**
under my guidance and supervision. No part of the thesis
has been submitted for the award of any other degree,
diploma, associateship, fellowship or other similar
titles.

Bangalore
November 29, 1990

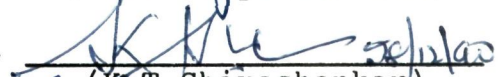

(J.V.Narayana Gowda) 28/12/90
Horticulturist
Floriculture & Landscape Gardening

APPROVED BY:

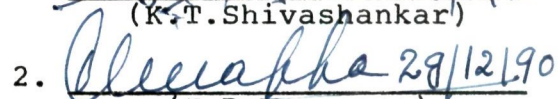
Chairman:


(J.V.Narayana Gowda)

Members : 1.


(K.T.Shivashankar)

2.


(K.B.Veerappa) 28/12/90

3.

(K.Seenappa)

A C K N O W L E D G E M E N T

I wish to express my deep sense of gratitude and heartfelt respects to **Dr.J.V.Narayana Gowda**, Horticulturist, Division of Horticulture, University of Agricultural Sciences, Bangalore and Chairman of my advisory committee for his invaluable guidance, keen interest and constant encouragement throughout the course of this investigation.

I am very grateful to the members of my advisory committee, **Mr.K.T.Shivashankar**, Associate Professor, Department of Horticulture, **Dr.K.B.Veerappa**, Professor, Department of Agricultural Botany and **Mr.K.Seenappa**, Jr.Statistician, Project Coordinating Unit(Sunflower), U.A.S., Bangalore for their valuable guidance and advice during the course of this investigation.

My sincere thanks are due to staff members of the Division of Horticulture, who helped me directly or indirectly during the period of this study.

I greatly acknowledge the award of the I.C.A.R. Junior Fellowship during the course of the study.

I affectionately express my gratitude to my beloved parents, sister and brothers for their constant help, and invaluable encouragement during the course of the study.

I thank all those who have helped me in one way or the other during the course of this investigation.

I express my sincere thanks to **Mr.N.V.Srinivasa**, for neat and quick typing of this manuscript.

Bangalore
November 29, 1990

Anuradha.S.
[S.ANURADHA]

C O N T E N T S

<u>CHAPTER</u>	<u>TITLE</u>	<u>PAGE</u>
I	INTRODUCTION	1
II	REVIEW OF LITERATURE	4
III	MATERIAL AND METHODS	28
IV	EXPERIMENTAL RESULTS	39
V	DISCUSSION	84
VI	SUMMARY	108
VII	REFERENCES	113
Appx.	APPENDIX	121

L I S T O F T A B L E S

<u>TABLE</u>	<u>TITLE</u>	<u>PAGE</u>
1	List of twenty five <u>Gladiolus grandiflorum</u> L. genotypes used in the experiment with source	... 29
2	Mean performance of twenty five genotypes of <u>Gladiolus grandiflorum</u> L. for growth and yield parameters	... 40 & 41
3	Analysis of variance for twenty four characters in twenty five genotypes of <u>Gladiolus grandiflorum</u> L.	... 42
4	Phenotypic and genotypic variability in <u>Gladiolus grandiflorum</u> L.	... 44
5	Heritability and Genetic advance in <u>Gladiolus grandiflorum</u> L.	... 45
6	Phenotypic correlation coefficients for 17 quantitative characters in <u>Gladiolus grandiflorum</u> L.	... 60
7	Genotypic correlation coefficients for 17 quantitative characters in <u>Gladiolus grandiflorum</u> L.	... 67
8	Direct (Diagonal) and indirect (above and below diagonal) effects of eight characters on spike length in <u>Gladiolus grandiflorum</u> L. at phenotypic level	... 75
9	Direct (Diagonal) and indirect (above and below diagonal) effects of eight characters on floret diameter in <u>Gladiolus grandiflorum</u> L. at phenotypic level	... 79
10	Direct (Diagonal) and indirect (above and below diagonal) effects of eight characters on number of florets per spike in <u>Gladiolus grandiflorum</u> L. at phenotypic level	... 82

L I S T O F F I G U R E S

<u>FIGURE</u>	<u>TITLE</u>	<u>BETWEEN</u> <u>PAGES</u>
1	Phenotypic and genotypic coefficients of variability for 24 characters in <u>Gladiolus grandiflorum</u> L.	... 44 to 45 to
2	Heritability (broad sense) and genetic advance (per cent of mean) for 24 characters in <u>Gladiolus grandiflorum</u> L.	... 45 to 46
3	Phenotypic and genotypic correlation coefficients of different characters with spike length in <u>Gladiolus grandiflorum</u> L.	... 67 to 68
4	Phenotypic and genotypic correlation coefficients of different characters with floret diameter in <u>Gladiolus grandiflorum</u> L.	... 67 to 68
5	Phenotypic and genotypic correlation coefficients of different characters with number of florets per spike in <u>Gladiolus grandiflorum</u> L.	... 67 to 68
6	Phenotypic path diagram showing influence of different characters on spike length in <u>Gladiolus grandiflorum</u> L.	... 75 to 76
7	Phenotypic path diagram showing influence of different characters on floret diameter in <u>Gladiolus grandiflorum</u> L.	... 79 to 80
8	Phenotypic path diagram showing influence of different characters on number of florets per spike in <u>Gladiolus grandiflorum</u> L.	... 82 to 83

L I S T O F P L A T E S

<u>PLATE</u>	<u>TITLE</u>	<u>BETWEEN</u> <u>PAGES</u>
1-20	General view of <u>Gladiolus</u> <u>grandiflorum</u> L. genotypes during flowering	... 29 to 30

INTRODUCTION

I. INTRODUCTION

Gladiolus (Gladiolus grandiflorum L.) also called 'sword lily' is one of the most popular bulbous ornamental grown in many parts of the world for cut flower and garden display. It belongs to the family Iridaceae, with 200 known species scattered throughout Tropical and South Africa. It ranks second best cut flower in Holland and other European countries in commercial importance. The magnificent inflorescence with variety of colours and long keeping quality of flowers had made Gladiolus attractive for use in herbaceous borders, bedding, rockeries and as pot plants.

The Modern garden Gladiolus has been developed through a succession of crosses involving definitely twelve Gladiolus species (Buch, 1972). Though there are now more than 10,000 Gladiolus cultivars with different number, placement, texture, structure, colour and size of florets with different spike length, symmetry and vigour available in the world, there is still a great scope for improving these characters through breeding.

The range of variation in Gladiolus is very large. Species and cultivars with different growth habits

producing various types of flowers of different shape, size and colour are available. A knowledge of the gene pool of the cultivated species is a pre-requisite for a programme of purposeful and effective crop improvement. As the phenotypic expression of traits is the product of the heritable and non-heritable components, it becomes necessary to apportion the same into genetic and non-genetic parts.

Biometrical techniques have been developed and employed extensively to determine separately the heritable and non-heritable components of variation.

Yield being a final product of many contributing characters, the efficiency of selection for yield mainly depends on the direction and magnitude of association between yield and its components and among components themselves. The degree of interaction of many components, which are intimately associated among themselves and with yield could be known through precise estimation of genotypic and phenotypic correlations among yield components themselves.

The correlation coefficients denote only the extent of association existing between pairs of characters, which is often misleading due to the

relationship existing among the components themselves. The method of path-coefficients developed by Wright (1921) is helpful in breaking the correlation coefficients into direct and indirect effects so that relative influence of each component character on yield could be assessed.

Hence, with the knowledge of genetic variability existing in the available germplasm, the present study was undertaken with the following objectives.

1. To evaluate Gladiolus cultivars for morphological and yield components.
2. To estimate the magnitude of variability available in the selected genotypes by means of genetic parameters for various characters.
3. To work out genotypic and phenotypic correlation coefficients among yield and yield components.
4. To determine the direct and indirect effects of yield components on yield through path coefficient analysis.

REVIEW OF LITERATURE

II. REVIEW OF LITERATURE

The genetic variability in a crop is of prime importance in its crop improvement. A knowledge of the available variability within the species for the desired characters enables the breeder in determining the most potential parents. Hence, the genetic potentialities of yield and yield contributing characters and their relationship should be properly assessed, for improving the crop.

Breeding in *Gladiolus* has received its attention only in recent past and as such information available on this crop is very meagre. Hence such information in respect of other closely related flower crops have been included in this review. Brief review of relevant literature on *Gladiolus* and other flower crops are presented under the following headings.

2.1. Variability, heritability and genetic advance.

2.2. Correlation and path coefficient analysis.

2.1. VARIABILITY, HERITABILITY AND GENETIC ADVANCE

For effective selection and utilization of genotypes for breeding programme, a thorough study of

genetic variability, heritability and genetic advance is essential. Genotypic coefficient of variation indicates the relative magnitude of genetic diversity present in the material and helps to compare the genetic variability present for different characters.

The effectiveness of selection for any character does not depend on the amount of Phenotypic variability alone. It is of great interest to the breeder to determine how much of the Phenotypic variability present in a character is heritable. The heritability estimate provides such a measure. The other parameter of utility is the genetic advance which is a measure of the expected genetic progress and enables to evaluate the selection procedure.

In the early part of this century, Johannsen (1909) demonstrated that Phenotype (P) is the interaction product of Genotype (G) and the environment (E). He further attributed the variation in a segregating population to both heritable and non-heritable agencies and the variation in a pure line to only environmental factors. Nilson Ehle (1909) established the basis for quantitative genetics by discovering the additive gene effects.

Nilson Ehle (1909) and East (1916) showed that the segregation and recombination of polygenes confirmed the mendelian pattern of inheritance. Fisher (1918) laid the foundation of biometrical genetics and developed the statistical parameters like mean, variance and co-variance. Charles and Smith (1939), Power (1942) and Power et al. (1950) separated genetic variance from total variance using estimate of environmental variance in non-segregating population.

Lush (1949) proposed heritability in narrow sense as the ratio of additive variance to the total variance while Hanson et al. (1956) proposed heritability in broad sense as the ratio of genotypic variance to the total variance.

Expected genetic gain as proposed by Burton and Devane (1953) is the product of heritability, phenotypic standard deviation and selection differential. According to Johnson et al. (1955) the genetic advance is more useful in predicting the actual value of selection than heritability, though the latter value indicates the relative effectiveness of selection based on phenotypic expression of the character.

Ober (1955) studied the extent of variability and degree of heritability in William Sim carnation and four of its mutant clones. He noticed variations in flower characters though no distinct differences in vegetative characters were observed. Tapalov (1961) reported wide variation in the number of petals per flower and oil content of attar in Kazantah cultivar of Rose.

Alpi et al. (1968) reported high hereditary component for number of petals per flower and significant values for vase life in populations of selfed commercial carnation. Katsuyoshi and Harding (1969) estimated genotypic component of variance for traits, petal length, petal width and petal number in a sample from a commercial seed lot of Portulaca grandiflora. Heritability value was high for Petal number (64.3 per cent), intermediate for petal width (31.3 per cent) and low for petal length (12.3 per cent).

Khan and Muthuswamy (1970) observed existence of morphological variants in Jasminum mutant Mullai (Jasminum auriculatum Vahl).

A quantitative evaluation of attributes of economic value was made by Mohamed et al. (1970) in Jasminum sambac Ait. cultivars for characters like shape

of flower bud, length of pedicel, length of corolla tube, diameter of open flower, number of flowers produced per flowering shoot, keeping quality of flowers and time taken for full opening of the buds. They reported that variety 'Madanban' rank first and registered highest score based on score-card.

Relatively high heritability both in narrow sense and broad sense was obtained for flowering date, plant height and leaf number in several genotypes and clones of Phlox paniculata L. (Morgner and Horn, 1970).

Muthuswamy et al. (1972) observed variations in seedlings of Jasminum auriculatum Vahl. for flower characters like the length of the flower bud and corolla tube, diameter of flower bud and flower.

Swarup et al. (1973) observed high genotypic coefficient of variation, heritability (broad sense) and genetic advance for number of flowers on side branches, flower weight and number of flowers on main stem in Althea rosea.

Schiva (1973) estimated the genetic components of variance in selfed progeny and cuttings of Gerbera jamesonii. Heritability was high for inflorescence

diameter and number of ray florets and relatively low for disc diameter and stem length.

Singh and Swarup (1973) found that dominance and dominance interaction play major role in the inheritance of time taken to flower and flower weight in progenies of African marigold. They further reported that the number of flowers per plant was governed mainly by additive gene effects.

A high variability in Rose cultivars 'Forever Yours' and 'Town Crier' for yield has been reported by Jobson and Hanan (1977).

Rabinowitch et al. (1977) in a study with seven F_1 hybrids of Antirrhinum majus, partitioned total variance present in economically important characters into its genetic, environmental and interaction components.

High heritability (broad sense) estimates for seed size and days to flowering in Lotus corniculatus L. cv. Leo has been reported by Sandha et al. (1977). The characters like seed yield, plant height and seeds per pod exhibited moderate to high heritability and pods per inflorescence showed the lowest heritability.

Negi et al. (1978) reported heritability in fourteen important characters in *Gladiolus*. Heritability estimates were high for number of florets per spike (92 per cent), weight of corms planted (86 per cent), breadth of leaves (82 per cent), Rachis length (80 per cent) and spike length (72 per cent). Heritability values were medium for size of corms planted (69 per cent), number of corms produced (67 per cent), weight of cormels produced (64 per cent), days to flowering (63 per cent), weight of corms (49 per cent), length of leaves (47 per cent) and plant height (44 per cent). Low heritability values were observed for floret size and floret length.

Weber and Horn (1978) while studying heritability in progenies of 38 tulip cultivars reported 40 per cent of heritability for bulb weight and 45 per cent for bulb number.

In *Petunia hybrida* Hort., Hussein and Misiha (1979) recorded heritability estimates (broad sense) as 0.84, 0.88 and 0.89 for flowering time, plant height and flower size respectively.

Genetic variability for flower characteristics in the Melange classique, Pink Dunkel, Elegance and

Symphonie cultivars of gerbera have been reported by Cocozza et al. (1980).

Bankar and Mukhopadhyay (1980) reported significant differences in all the four cultivars of Polianthes tuberosa L. for morphological characters which include number of leaves, number of spikes per plant, length of spike, number of florets per spike, number of days required for flowering, duration of flowering and the number of bulbs produced per plant.

Jaswinder Singh and Arora (1980) reported significant varietal differences for all the characters studied in thirteen cultivars of Antirrhinum majus. The range of variation was maximum for the final plant height and minimum for flower size. The heritability estimates were highest for number of days to flower bud initiation and lowest for number of spikes per plant.

Harding et al. (1981a) reported that heritability (broad sense) averaged 42 per cent for cut flower yield in Gerbera. He further noticed that heritability (narrow sense) averaged 68 per cent based on half sib families and 60 per cent based on parent offspring regression.

Harding et al. (1981b) in a study with cut-flower vase life reported heritability (broad sense) which varied from 36 to 46 per cent for a sample of *Gerbera* clones and indicated that heritability (narrow sense) for vase life longevity as 0, 24 and 38 per cent over three generations respectively.

Thangaraj et al. (1982) studied the genetic variability in the flower characters of open-pollinated seedlings of *Jasminum auriculatum* Vahl. A wide range of variability was observed for flower yield with a coefficient of variation ranging from 64.57 to 92.36 per cent. Low variability was reported for flower bud weight, corolla tube length, flower bud length and flower bud diameter with a coefficient of variation ranging from 16.31 to 30.15 per cent. High heritability of 90 to 98 per cent was recorded for corolla tube length and flower bud diameter while genetic advance was high for flower yield and flower bud weight.

Wricke et al. (1982) estimated heritability using genetic variance in genotypes obtained from a random crossing of *Gerbera jamesonii*. The estimates of heritability were 0.77 for stem length, 0.79 for flower diameter, 0.69 for flower disc diameter and 0.33 for number of flowers per plant.

In Rose, Lal et al. (1982) observed a wide range of phenotypic variability, coefficient of variation and genetic advance for most of the characters studied. High heritability with high genetic advance was obtained for number of branches, number of spines, number of flower buds and petals and average flower weight showing the additive gene effects. High heritability with low genetic advance was reported for flower diameter and plant spread showing non-additive gene action, while high heritability with moderate values of genetic advance was obtained for plant height.

Manjunath Rao (1982) reported wide and significant variation in China aster for all the characters studied. High phenotypic and genotypic coefficient of variation, heritability (broad sense) and genetic gain were observed for flower weight and number of ray florets per flower.

Indiresh (1982) investigated extent of variability among the open pollinated seedlings of Jasminum auriculatum Vahl. with respect to several quantitative and qualitative characters. The genetic coefficient of variation was found to be highest for spread of the plant, plant height and weight of

hundred flower buds. Combination of high heritability (narrow sense) and a high estimate of genetic gain was exhibited by plant spread, plant height and weight of 100 flower buds indicating additive gene action.

Negi et al. (1983) conducted variability studies in 19 varieties of China aster. High genotypic coefficient of variation, heritability and genetic advance as percentage of mean were recorded for flower weight and stalk length, which confirmed additive gene action for these two characters.

In 30 cultivars of Gladiolus, Lal et al. (1985a) studied genetic parameters on six quantitative characters. A wide range of variation was observed for days to flower, plant height, spike length, and spike weight. Genetic coefficient of variation varied from 125.53 per cent for leaf number per plant to 457.96 per cent for spike length. High heritability with high genetic advance was obtained for spike length, spike weight and number of florets per spike.

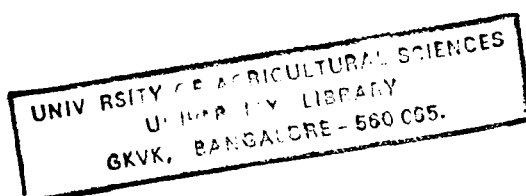
Components of variance and heritability estimates were tabulated for inflorescence and floret traits in Gerbera hybrida (Drennan et al., 1985).

Fonnuswamy et al. (1985) assessed genetic variance in twenty seven cultivars of chrysanthemum. Genotypic variance was generally lower than phenotypic variance for plant height and spread, number of branches, earliness, number of flowers per plant and flower yield.

Arora and Khanna (1986) studied the genetic parameters in 31 varieties of Gladiolus. The phenotypic and genotypic coefficients of variation were maximum for the number of cormels produced (55.4 and 55.2 per cent, respectively). High heritability along with high genetic advance was observed for days to spike emergence. Low heritability was recorded for number of days taken for basal floret to show colour and number of florets open at a time.

Ponnuswami et al. (1986) noticed high variability for plant volume and number of flowers per spike in a study of clones in Nerium oleander. High genotypic coefficient of variation was reported for number of spikes per plant and hundred flower weight. Heritability was comparatively high for hundred flower weight followed by yield per plant and plant volume. High genetic advance was displayed by hundred flower weight.

Th. 2557



Singh and Singh (1987) observed variation in all the eight characters studied in *Gladiolus*. Genotypic and phenotypic coefficient of variation for the characters studied ranged from 10.17 to 24.79 per cent and 10.35 to 25.65 per cent respectively, except for number of cormels (19.64 to 91.93 per cent). The heritability and genetic advance were high for all the characters studied. High heritability accompanied with high genetic advance in terms of percentage of mean was highest in number of cormels (180) while for remaining characters, it ranged from 20.57 to 49.39.

In a study with twenty five *Dahlia* cultivars, Choudhary (1987) reported high heritability for eight quantitative characters studied. High heritability along with high genetic advance was found in plant height, number of flowers per plant and weight of tubers, while days to flowering, number of tubers and size of tubers exhibited high heritability with low genetic advance.

Byrne et al. (1987) investigated components of variance in sample obtained from Davis population of *Gerbera hybrida*. He opined that half the genetic variance obtained for cut flower yield attributed to genotype x environment interaction.

Misra and Saini (1988) conducted an experiment to study variability for twenty characters in sixty varieties of *Gladiolus*. They found that the genetic coefficient of variation was highest for number of side spikes per shoot, followed by 10-cormel weight, number of seeds per capsule and number of cormels produced per plant. Heritability and genetic advance were high for number of shoots per plant and number of cormels produced per plant whereas characters like days to flowering and weight of one daughter corm had moderate to high heritability and genetic advance. High heritability with low genetic advance was recorded for diameter of foremost floret, number of capsules per shoot and the polar diameter of the daughter corms.

In *Gladiolus*, Gowda (1989) observed a wide range of variability in plant height, spike length, spike weight and number of days to flowering. High heritability accompanied with high genetic advance was reported in spike length, spike weight and number of florets per spike.

2.2. CORRELATIONS AND PATH COEFFICIENT ANALYSIS

A knowledge of correlations that exist among different characters is a basic thing which may

facilitate the interpretation of results already obtained and provide a basic for planning more efficient breeding programmes.

The idea of correlation was presented by Galton (1889) and later elaborated by Fisher (1918) and Wright (1921), Lush (1940) and Hazel (1943) applied genotypic correlations in animal breeding. The direct observed phenotypic correlation does not indicate the magnitude or direction of genetic correlation, which presents a true genetic picture of relationship between the genes controlling the characters.

The technique of path coefficient analysis was developed by Wright (1921) as a means of separating direct and indirect contribution of various factors. Path coefficient analysis is a standardised partial regression coefficient analysis and as such measures the direct influence of one variable upon the other and permits the separation of correlation coefficients into components of direct and indirect effects. Use of this technique requires a cause and effect situation among the variables.

Ozawa (1962) reported positive correlation between leaf length and leaf width in perpetual carnation

var. Peter fisher. It was observed that number of early flowers correlated negatively with both number of stems and leaf length.

Uemoto (1964) found a positive correlation coefficient ($r=0.7$) between plant height and number of days to flowering in F_1 hybrids of Antirrhinum majus L. A significant positive correlation between petal length and width has been reported by Katsuyoshi and Harding (1969) in Portulaca grandiflora.

Morgner and Horn (1970) conducted genetic investigations on clones and progenies of Phlox paniculata L. to study the linear phenotypic and genotypic correlations and interactions between genotypes, years and location.

Correlation studies in Rose by Besscetnova (1970) indicated the existance of correlation between petal length in the outer row of the corolla and length of the terminal leaflet of the compound leaf in six groups of garden roses and these correlations were helpful for every primary selection.

In 'white' and 'yellow' cultivars of chrysanthemum, Shanmugam et al. (1972) worked out correlation coefficients between the flower yield and

each of six characters, namely, height at first flowering, total increase in height, number of laterals, duration of flowering, number of days to first flowering and size of flowers. All relationships were significant at 5 per cent level except for size of flowers in the 'white' cv. and height at flowering in the cv. 'yellow'.

In Althea rosea, Swarup et al. (1973) found positive significant correlation of days to flowering, with flower size and flower weight, while its correlation with flowers on main stem and side branches were negatively significant. The flowers on main stem and side branches had positive correlation with plant height whereas the correlation of days to flowering with plant height was negatively significant.

Ligule length, which showed high heritability was well correlated with other flower characters in Gerbera jamesonii (Schiva, 1974). Horn et al. (1974) conducted variability and correlation studies using clones and complete sibbling families in Gerbera jamesonii. Linear correlation coefficients amounted to 40 to 50 per cent between the number of shoots and number of flowers on a single plant.

Chang (1977) studied statistical correlations between nine vegetative characters in four year old plant of 69 tree paeony (Paeonia suffruticosa) cultivars.

In Hybrid Tea Rose, Vries and Dubois (1977) observed significant positive correlation of length of seedlings at first flowering with shoot lengths of the same plant on root stock ($r=0.70$) and the Juvenile periods of the seedlings with their stem lengths when grafted on a rootstock ($r=0.88$). He further noticed negative correlation between the Juvenile period and the flower production of the seedlings.

No significant correlation was observed between duration of flowering and productivity in Rosa rugosa hybrids (Svejda, 1977).

In Edward Rose (Rosa bourboniana), Irulappan and Rao (1980a) reported high genotypic correlation coefficients of flower yield with the number of flowers per plant, individual flower weight and flower diameter; further reported that the phenotypic and environmental correlation coefficients between number of flowers per plant and flower yield were positively significant. Shoot length, however, showed a significant negative

genotypic correlation with flower yield. Genotypic correlations were generally higher than phenotypic correlation coefficients.

Path coefficient analysis of flower yield in Edward Rose showed that characters viz., flower diameter, number of petals per flower and number of leaves were directly related with flower yield, whereas the number of flowers per plant and individual flower weight, influenced the flower yield through effects on either flower diameter or number of leaves or both (Irulappan and Rao, 1980b).

Horn et al. (1979) studied correlations between the seedling and subsequent clonal generations in Pelargonium zonale hybrids. Large phenotypic and genotypic correlation coefficients were observed in eight continuously varying characters like plant height without inflorescence stem, number of days before the first flower, number of nodes between the first and second inflorescence stem, number of flowers in the first inflorescence and diameter of first flower.

In a study of correlation and path analysis on yield and yield components in *Jasminum*, More (1980)

reported significant correlation of flowers with yield and observed a significant regression coefficient with number of flowers on total yield, indicating that number of flowers was the major attribute to determine the yield in Jasmine.

Indiresh (1982) in a study with the open pollinated seedlings of Jasminum auriculatum Vahl. reported high positive and significant correlation between 100 flower bud weight and diameter of opened flower. Further in path coefficient studies, he recorded greatest positive direct effect between flower bud length and diameter of open flower while style length and plant height had low positive direct effect. Corolla tube length and number of petals per flower exhibited greatest negative direct effects.

Manjunath Rao (1982) reported that in China aster, genotypic correlation coefficients were slightly higher than the phenotypic correlation coefficients in most of the characters studied. He reported that each of the characters, stalk length, flower size and number of flowers per plant had a positive significant correlation between themselves and with plant height, plant spread, number of laterals per plant and days to flower.

Singh and Singh (1983) conducted correlation and path coefficient studies for fourteen different characters in fortyone different cultivars of *Gladiolus*. Direct, positive correlation was observed between number of shoots per plant and the number of florets per spike. The direct effect of number of corms was dependent on number of shoots, while number of florets per spike depend on the length of the spike, wherein the latter was indicated by significant correlation and direct contribution in path analysis.

Lal et al. (1983) reported that in Rose, genotypic correlation coefficients exceeded the phenotypic correlation coefficients and noted that flower weight correlated positively with number of petals and negatively correlated with plant height.

Negi et al. (1983) in a study with 19 varieties of China aster indicated that stalk length and flower weight had positive and significant correlation between themselves and with flower size, plant height and days taken to flower. Further found that flower size had significant positive correlation with plant height and days to flower whereas number of flowers per plant and days to flower had positive significant association with number of branches per plant.

Correlation studies carried out by Lal et al. (1985b) in *Gladiolus*, indicated that plant height significantly correlated with spike length and leaf number showed positive correlation with spike weight.

Wahi and Bhattacharjee (1986) investigated the interrelationships among eleven quantitative characters in forty five genotypes of *Hippeastrum hybridum*. The number of bulbs per plant significantly associated with number of shoots, number of leaves, length of leaves and number of flowers per stalk. The number of flowers per stalk exhibited significant correlation with number of shoots and leaves.

In *Jasminum auriculatum* Vahl., path analysis revealed that number of flowers per plant had the maximum direct effect on flower yield in pin type plants, whereas in thrum type 100-bud weight and number of flowers per plant determined the yield (Karmakar and Srivastava, 1986).

Indiresha et al. (1986) in a study of path analysis for floral traits in *Jasminum auriculata* Vahl. reported that 100-flower bud weight was positively and significantly correlated with the number of petals per flower, style length and corolla tube length.

Misra et al. (1987) in a study of correlations in nine characters of twenty three Dahlia varieties observed that number of flowers per plant was positively and significantly correlated with plant spread and days to flower had negative correlation with plant spread.

Srivastava and Devaiah (1988) in a study with six genotypes of Jasminum auriculatum Vahl. reported that 100-flower weight was significantly associated with flower diameter, petal width, petal length, anther length, floral bud length and width and 100-flower bud weight. Path analysis of 100-bud weight and flower diameter had marked direct effect on yield in positive direction while the rest of the characters affected yield indirectly through these two characters.

A positive correlation between plant height and spike length, spike weight and number of leaves per plant in *Gladiolus* has been reported by Gowda (1989).

Negi et al. (1978) reported interrelationship among various characters in ten varieties of *Gladiolus*. Spike length was observed to be positively correlated with Rachis length, number of florets per spike, weight and size of corms produced and breadth of leaves. Number

of florets per spike was positively correlated with Rachis length, floret size, weight of the corm and size of corms planted and weight of corms produced. Floret size showed significant positive correlations with weight and size of corms planted, whereas its association with days to flowering and number of corms produced was significant and negative. Weight of corms produced had a significant positive correlation with the breadth of leaves.

MATERIAL AND METHODS

III. MATERIAL AND METHODS

The material used and methods followed in conducting the experiment are presented below.

3.1. MATERIAL

Twenty five genotypes of Gladiolus grandiflorum L. belonging to different Eco Geographical regions of the world were collected for the present study entitled as "Genetic variability studies in Gladiolus". The names of the genotypes along with their origin are presented in Table 1 and Plates 1-20.

3.2. METHODS

3.2.1. Experimental design and layout

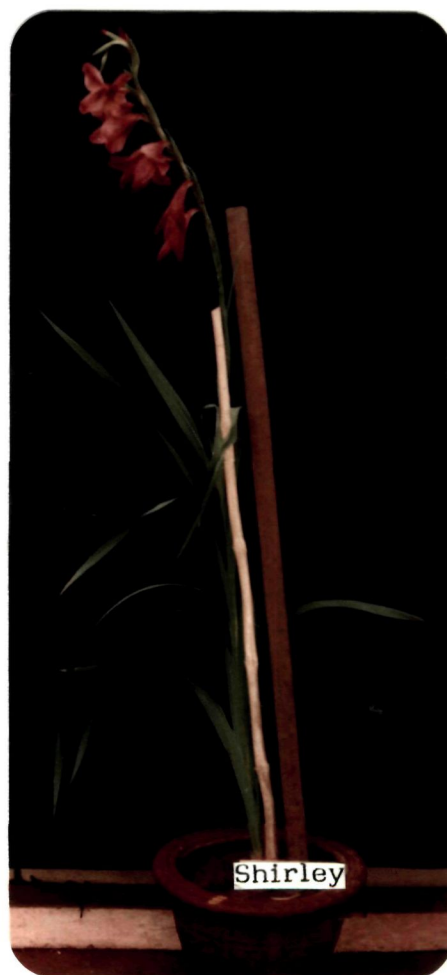
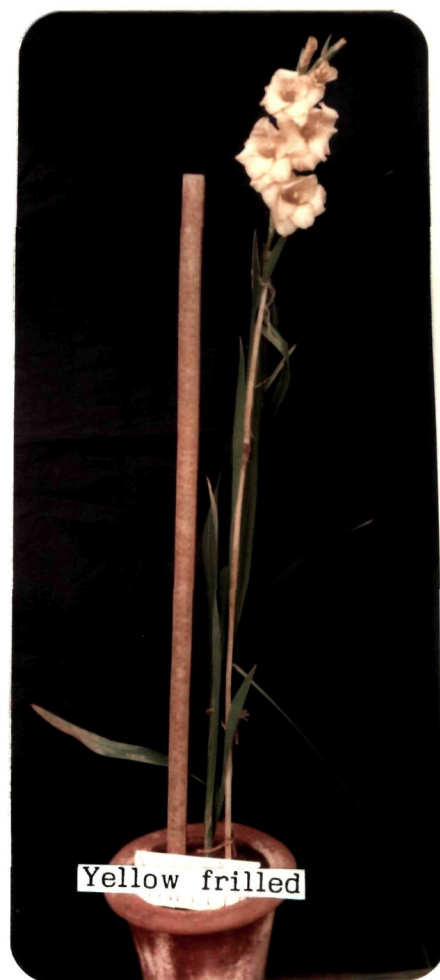
The experiment was carried out at the Division of Horticultural Sciences, University of Agricultural Sciences, GKVK, Bangalore. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Corms of each genotype were planted in pots on 9th February 1990 at the rate of one corm per pot.

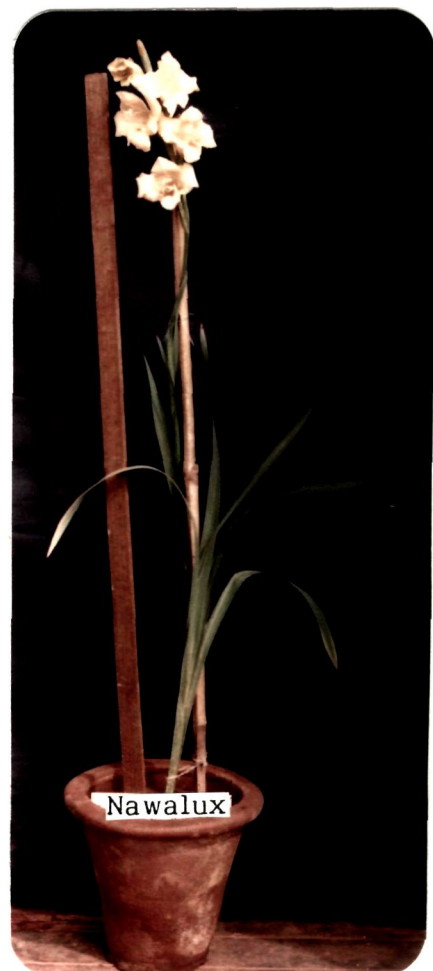
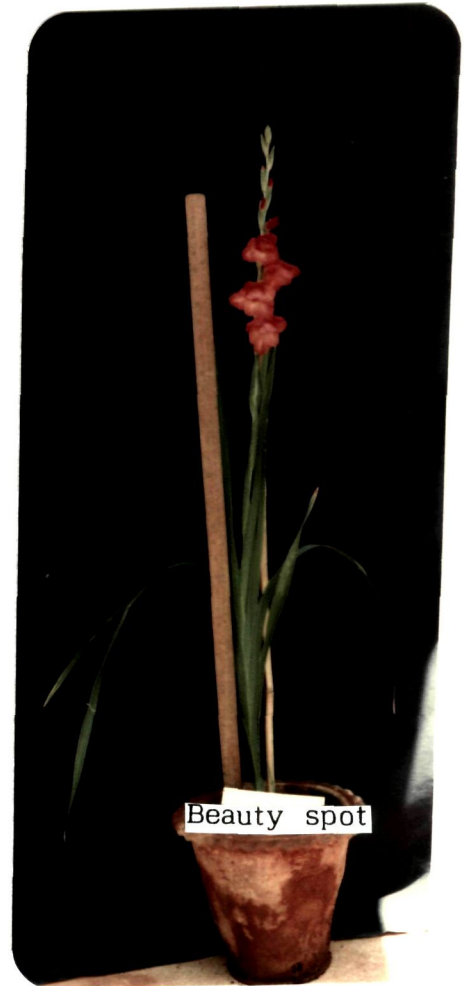
3.3. CULTURAL PRACTICES

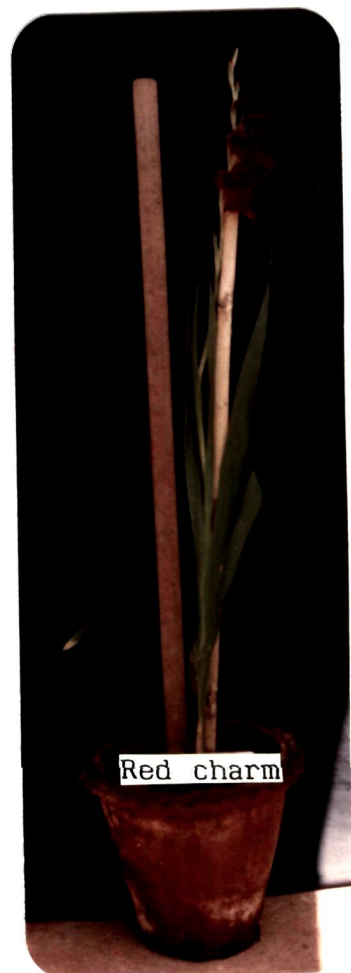
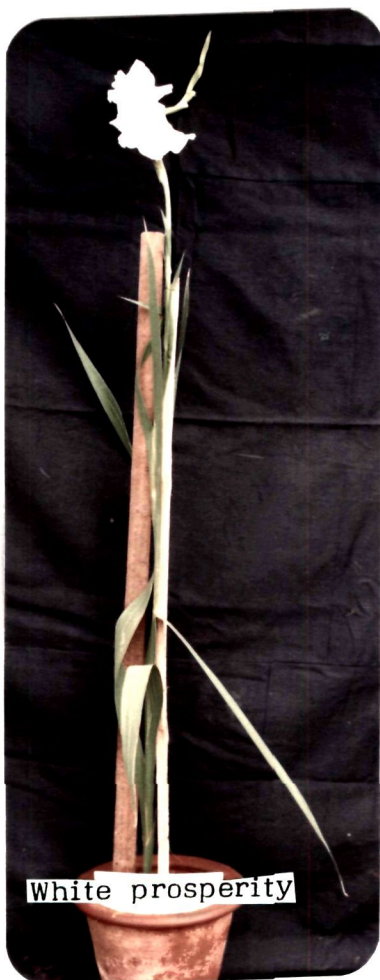
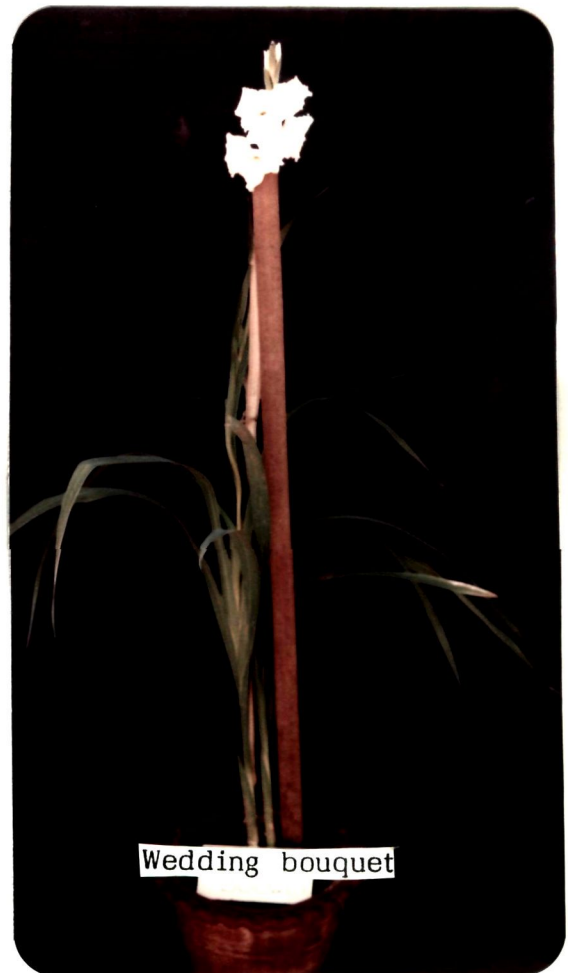
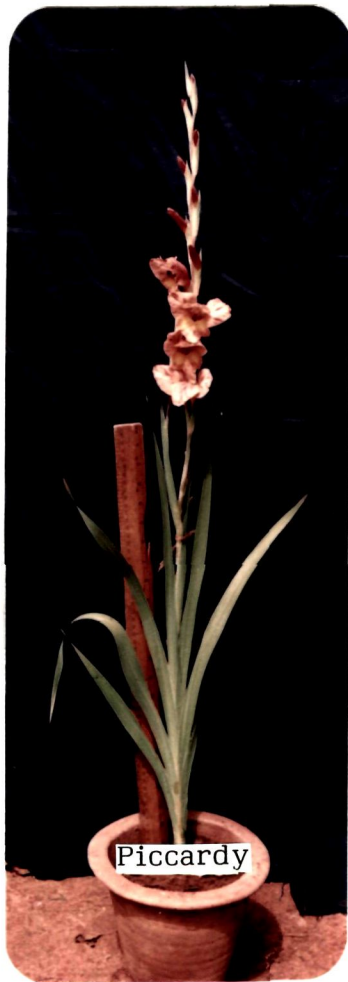
All the cultivation practices for Gladiolus were done as per the recommended package of practices (Anon., 1990).

Table 1. List of twenty five Gladiolus genotypes used in the experiment with source

Sl.No.	Genotypes	Source
1	Friendship	Dutch
2	Wedding bouquet	U.S.A.
3	Agnirekha	I.I.H.R.
4	Moon magic	U.S.A.
5	Oscar red	Dutch
6	Red charm	Dutch
7	Powder puff	U.S.A.
8	Shirley	Dutch
9	Water melon pink	U.S.A.
10	G.S.Porter	Dutch
11	Pink Pixola	Dutch
12	Mansoor red	Dutch
13	Flemingo	Dutch
14	Yellow frilled	U.S.A.
15	Cherry blossom	Dutch
16	Bakes dozen	U.S.A.
17	Han-Van magreen	Dutch
18	Dr.Fleming	U.S.A.
19	Beauty spot	Dutch
20	Wild Rose	U.S.A.
21	Ariate	Dutch
22	Little pencey	U.S.A.
23	White prosperity	U.S.A.
24	Nawalux	Dutch
25	Piccardy	Dutch

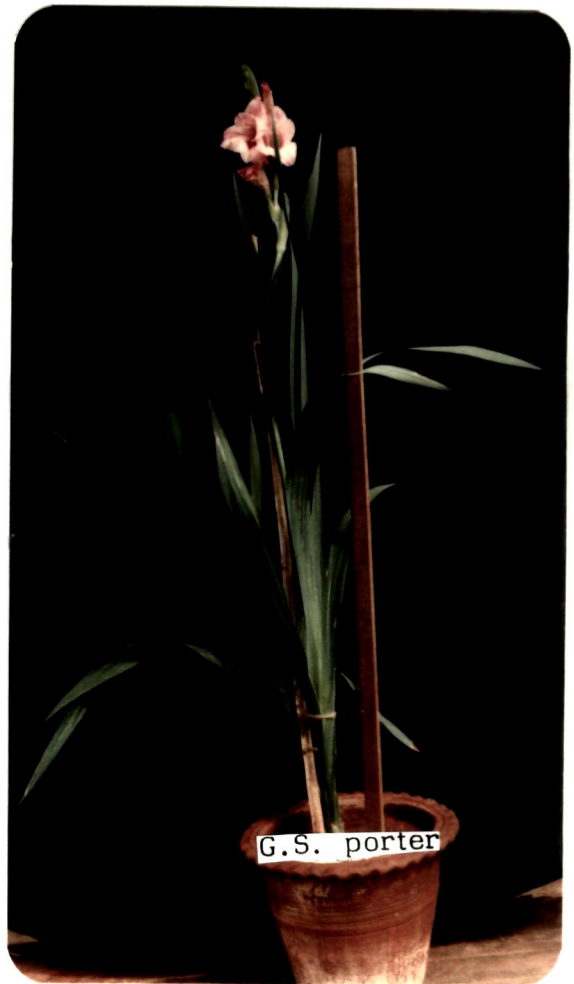




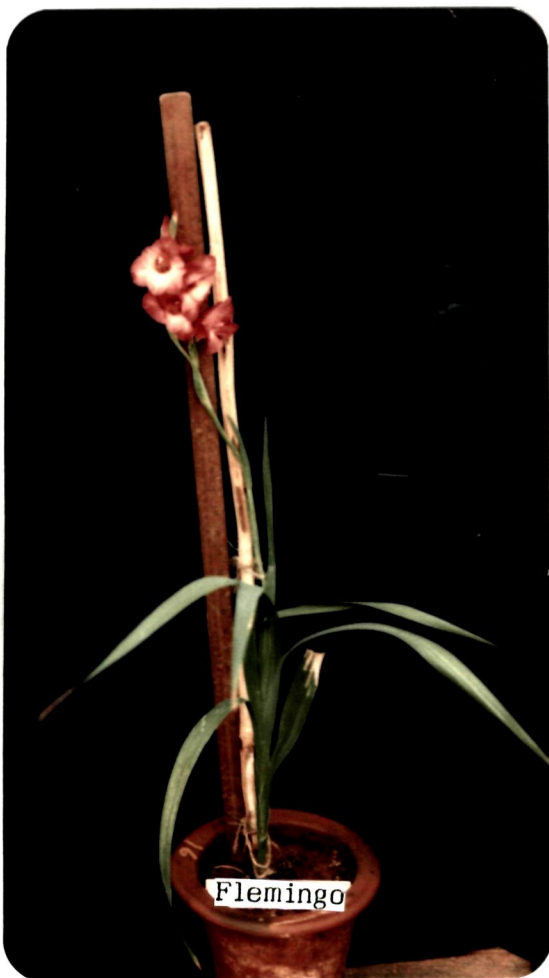




Powder puff



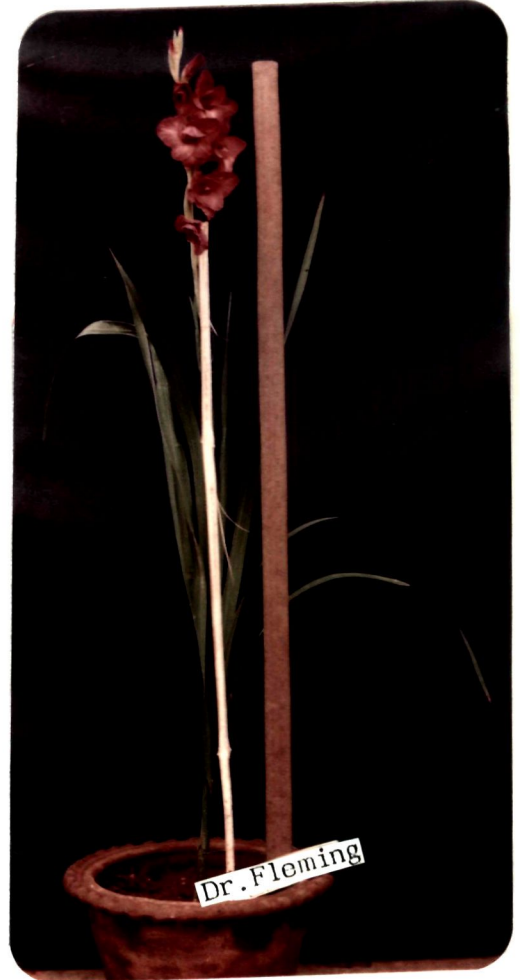
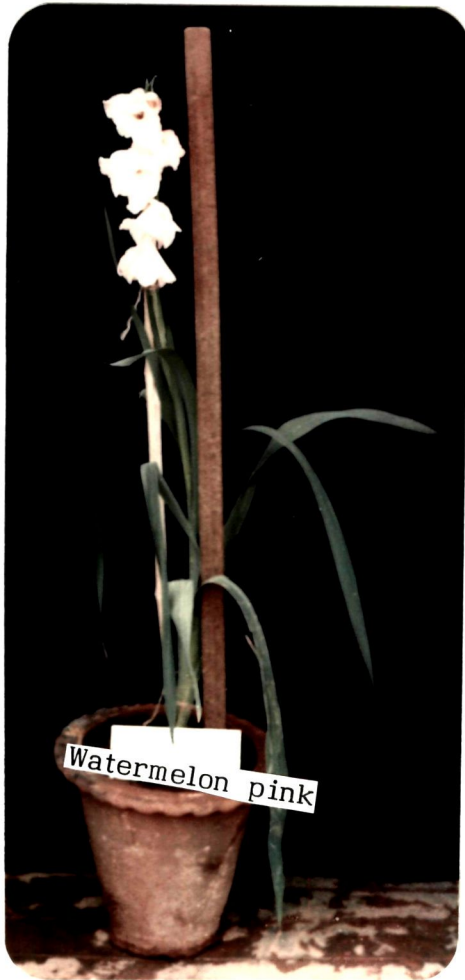
G.S. porter



Flemingo



FRIENDSHIP



3.3.1. Pot culture

Pots of uniform size, 12"x9", were selected and filled with potting mixture containing two parts of Garden soil, one part of leaf mould, one part of well rotten Farm yard manure and a fair quantity of sand.

3.3.2. Fertilizer application

The recommended fertilizer dose of 50 kg N: 60 kg P_2O_5 :24 kg K_2O per hectare in the form of urea, super phosphate and Muriate of potash were given in four split doses at

- i) Pre plant incorporation before planting of corms.
- ii) Side dressed at two-to three leaf stage.
- iii) Side dressed at the slipping stage when the inflorescence emerges from leaves.
- iv) Side dressed about 2 weeks after flowering.

3.3.3. After care

Irrigation was given on alternate days upto 15 days after planting of Gladiolus corms. Subsequent irrigations were given at an interval of 3-4 days. Stakes were provided at the time of flowering to enable the spikes to stand erect. Need based plant protection

measures were adopted to control pests and diseases (Anon., 1990) weeding was done whenever found necessary.

3.4. OBSERVATIONS RECORDED

Observations were recorded from the five random plants from each treatment on following characters.

3.4.1. Growth parameters

3.4.1.1. Plant height: The plant height was recorded from the ground to the tip of the youngest leaf at the time of flowering and expressed in centimeters.

3.4.1.2. Number of leaves per shoot: The total number of leaves per shoot of the plant were counted and recorded.

3.4.1.3. Leaf area: Leaf area per plant was found out using the formula, length x breadth x factor and expressed in cm².

Factor: The factor was computed by finding out the leaf area of about 50 bulk leaves by length x breadth method by using leaf area meter.

$$\text{Factor} = \frac{\text{Leaf area measured by leaf area meter}}{\text{Functional leaf area (LxB)}} = 0.66$$

3.4.1.4. Number of side shoots per plant: The total number of shoots arising from the corm other than the main pseudostem were counted and recorded for each plant.

3.4.1.5. Days to spike emergence: Number of days taken from the date of planting of sprouted corms to the date of flower spike initiation was counted as days taken for spike emergence.

3.4.1.6. Days for opening of the first floret of the spike: Number of days taken from the date of planting of sprouted corms to the date of opening of the first floret was recorded.

3.4.2. Yield parameters

3.4.2.1. Number of florets per spike: Total number of florets on the spike were counted and recorded as number of florets per spike.

3.4.2.2. Durability of spike: Durability of flower spike from day of opening of first floret to the day of closing or fading of floret present at the tip of the spike was counted and expressed in days.

3.4.2.3. Spike length: It was measured from the ground to the tip of the flower spike and expressed in centimeters.

3.4.2.4. Rachis length: It was measured from point of emergence of first floret to the last floret in centimeters.

3.4.2.5. Floret length: Length of the bottom five florets was measured and their mean recorded as length of floret in centimeters.

3.4.2.6. Floret diameter: Diameter of bottom five florets was measured and their mean was recorded as the maximum spread of the floret in centimeters.

3.4.2.7. Longevity of individual floret: The longevity of individual floret was measured by noting the day of opening and fading of the floret (Bottom 1 to 5 florets).

3.4.2.8. Number of florets open at a time: The number of florets that open at one time was counted and recorded.

3.4.2.9. Number of florets remain open on the spike: It was recorded by counting number of florets that remain fully open on the spike.

3.4.2.10. Number of side spikes per plant: The spikes which arise from the sides of the main spike were counted and recorded for each plant.

3.4.2.11. Number of capsules per shoot: Total number of capsules produced on the spike were counted for five

randomly selected plants and their mean was recorded as total number of capsules per shoot.

3.4.2.12. Number of seeds per capsule: The total number of seeds from all the capsules on each spike from five randomly selected plants were counted and their mean was recorded.

3.4.2.13. Number of daughter corms per corm: The number of daughter corms produced from the mother corm were counted and recorded.

3.4.2.14. Weight of daughter corm: Weight of individual daughter corm was recorded in grams.

3.4.2.15. Equitorial diameter of the corm: Equitorial diameter was measured from one end to the other end of the corm using slide calipers and expressed in centimeters.

3.4.2.16. Polar diameter of the corm: Thickness of the corm was measured as polar diameter of the corm using slide calipers and expressed in centimeters.

3.4.2.17. Number of cormels per plant: Total number of cormels per plant were counted and recorded as cormel yield in number per plant.

3.4.2.18. 10-cormel weight: Weight of ten randomly selected cormels per plant was recorded as weight of 10 cormels per plant in grams.

3.5. STATISTICAL ANALYSIS

The mean data computed from five randomly selected plants for each character in three replications were subjected to statistical analysis.

The estimates of Mean, variance and standard error were worked out by adopting the standard methods suggested by Panse and Sukhatme (1961).

3.5.1. Variability studies

3.5.1.1. Analysis of variance: The model of analysis of variance table adopted is given below.

Source	D.F.	M.S.S.	F Ratio
Replication	(r-1)	Mr	Mr/Me
Treatments	(t-1)	Mt	Mt/Me
Error	(r-1)(t-1)	Me	
Total	rt-1		

where, r = Number of replications.

t = Number of genotypes.

Mr = Mean sum of squares for blocks.

Mt = Mean sum of squares for treatments.

Me = Mean sum of squares for error.

The significance test was carried out by referring to the standard 'F' table given by Sundarraaj et al. (1972).

3.5.2. Estimation of genetic parameters

3.5.2.1. Phenotypic and genotypic variances: Phenotypic and genotypic variances were estimated using the formulae given by Singh and Choudhary (1979).

$$\text{Genotypic variance } (\sigma^2_g) = \frac{\text{MSS}(\text{treatment}) - \text{MSS}(\text{Error})}{\text{Number of replications}}$$

$$\text{Phenotypic variance } (\sigma^2_p) = \sigma^2_g + \sigma^2_e$$

where, σ^2_g = Genotypic variance

σ^2_p = Phenotypic variance

σ^2_e = Error variance

3.5.2.2. Coefficients of variability: Both genotypic and phenotypic coefficients of variability were computed by the method proposed by Burton and Devane (1953).

$$\text{Genotypic coefficient of variability (GCV)} = \frac{\sigma_g^2}{\bar{X}} \times 100$$

$$\text{Phenotypic coefficient of variability (PCV)} = \frac{\sigma_p^2}{\bar{X}} \times 100$$

3.5.2.3. Heritability (h^2): Heritability in the broad sense was calculated according to Hanson et al. (1956).

$$h^2 = \frac{\sigma_g^2}{\sigma_p^2} \times 100$$

3.5.2.4. Genetic advance: Genetic advance was worked out by adopting the formula given by Johnson et al. (1955) and Lush (1949).

$$\text{Genetic advance (GA)} = h^2 \times K \times \sigma_p$$

where, h^2 = Heritability estimated.

σ_p = Phenotypic standard deviation.

K = Selection differential which is equal to 2.06 at 5 per cent intensity of selection.

3.5.3. Association analysis

3.5.3.1. Correlation coefficients: The phenotypic and genotypic correlation coefficients were determined among all possible combination of characters by taking appropriate variance and co-variances. The significance of phenotypic and genotypic correlation co-efficients was tested against 'r' values given in Fisher and Yates table (1963) at (n-2) degrees of freedom at 0.05 and 0.01 levels of significance.

Phenotypic and genotypic correlations were computed by using the formulae given by Weber and Moorthy (1952).

$$r_{p_{12}} = \frac{p_{12}}{\sqrt{p_{11} \times p_{22}}}$$

$$r_{g_{12}} = \frac{g_{12}}{\sqrt{g_{11} \times g_{22}}}$$

where, $r_{p_{12}}$ = Phenotypic correlation coefficients between the characters x_1 and x_2 .

$r_{g_{12}}$ = Genotypic correlation coefficients between the characters x_1 and x_2 .

p_{11} and p_{12} = Phenotypic variances of x_1 and x_2 .

g_{11} and g_{12} = Genotypic variances of x_1 and x_2 .

3.5.4. Path coefficient analysis

Path coefficient analysis was carried out using the phenotypic correlation coefficients as suggested by Wright (1921) and illustrated by Dewey and Lu (1959).

Standard path coefficients which are the standardized partial regression coefficients were obtained by solving the following set of 'P' simultaneous equations through the use of abbreviated 'DOO-little technique' as described by Goulden (1959).

$$PO_1 + PO_2 r_{12} + \dots + PO_p r_{1p} = r_{01}$$

$$PO_2 r_{12} + PO_2 + \dots + PO_p r_{2p} = r_{02}$$

$$PO_p r_{1p} + PO_2 r_{2p} + \dots + PO_p = r_{0p}$$

where, $PO_1, PO_2, \dots, PO_p$ are the direct path coefficients of variables 1, 2, ..., p on the 'O' dependent variable $r_{12}, r_{13}, \dots, r_{1p}, \dots, r_{p(p-1)}$ are the possible independent correlation coefficients between various independent variables and $r_{01}, r_{02}, \dots, r_{0p}$ are the correlations between dependent and independent variables.

The direct effects of the i^{th} variable through j^{th} variable was worked out as $(p_{0j} \times r_{ij})$.

The contribution of the remaining unknown factors is measured as the residual factor which is calculated as given below.

$$P_{0x}^2 = 1 - (P_{01}^2 + 2P_{01}P_{02}r_{12} + 2P_{01}P_{03}r_{13} + \dots + P_{02}^2 + 2P_{02}P_{03}r_{23} + \dots + P_{0p}^2)$$

$$\text{Residual factor} = \sqrt{P_{0x}^2}$$

EXPERIMENTAL RESULTS

IV. EXPERIMENTAL RESULTS

Twenty five genotypes of Gladiolus grandiflorum L. were subjected to Biometrical analysis for twenty four characters and the results are presented under the following headings.

4.1. Variability, heritability and genetic advance.

4.2. Correlation and path coefficient analysis.

4.1. VARIABILITY, HERITABILITY AND GENETIC ADVANCE

Mean values of the observations recorded for growth and yield parameters with respect to individual genotypes are presented in Table 2. Significant differences between the genotypes were observed for most of the characters studied. The analysis of variance for these characters are presented in Table 3.

The range, grand mean, phenotypic and genotypic variance, phenotypic and genotypic coefficient of variability, heritability and predicted genetic advance as per cent of mean for the characters studied are presented in Tables 4 and 5 and illustrated in Fig.1 and Fig.2, respectively.

Table 2. Mean performance of twenty five genotypes of *Gladiolus grandiflorum* L. for growth and yield parameters

Sl. No.	Genotypes	Plant height (cm)	No. of leaves	Leaf area (cm ²)	Days to spike emergence	Days for opening of first floret	No. of florets per spike	Durability of spike (days)	Spike length (cm)	Rachis length (cm)	Floret length (cm)	Floret diameter (cm)	Longevity of individual floret (days)	No. of florets open at a time	No. of florets at a remain open
1	Friendship	81.167	6.33	1019.77	72.33	83.67	10.33	10.33	100.30	28.20	9.55	7.75	2.21	2.00	4.57
2	Wedding bouquet	110.23	7.67	1244.96	74.67	90.00	8.67	7.33	122.50	29.23	9.89	8.13	2.22	1.44	3.00
3	Agniresha	90.50	8.33	1163.14	114.00	121.67	15.00	12.00	123.87	39.43	9.35	7.62	2.89	1.75	3.11
4	Moon magio	105.70	8.67	1498.14	146.00	161.00	13.00	12.33	118.85	32.50	11.55	9.45	3.00	2.00	3.78
5	Oscar red	105.23	7.33	1347.75	109.00	118.00	12.00	10.00	126.05	29.90	10.71	8.92	3.33	2.00	3.56
6	Red charm	68.33	6.33	689.69	84.00	92.00	7.33	7.33	90.33	17.83	7.70	5.64	2.33	1.56	3.33
7	Powder puff	79.37	6.33	671.99	90.67	99.33	10.33	10.33	82.07	17.90	7.47	6.44	2.33	2.00	4.67
8	Shirley	93.23	8.67	1407.01	79.00	88.67	11.57	9.00	115.63	31.07	8.67	7.35	3.11	2.50	4.57
9	Water melon pink	80.77	6.67	1010.18	70.33	78.33	9.67	8.33	101.53	23.07	8.31	6.57	2.45	2.01	3.56
10	G.S.Porter	91.90	10.00	1827.67	105.00	117.00	9.67	13.67	112.20	29.57	9.74	7.58	2.78	2.00	1.56
11	Pink pixola	76.17	7.67	1145.69	85.00	95.00	10.57	13.33	97.03	28.33	9.53	8.05	2.45	1.94	4.11
12	Mansoor red	98.00	7.67	1413.02	98.00	109.67	14.33	13.00	137.97	41.77	10.33	7.84	2.00	2.00	5.33
13	Flemingo	66.40	6.33	741.16	62.00	71.67	7.67	8.33	92.17	34.60	9.41	7.57	2.00	2.67	3.44
14	Yellow frilled	89.17	7.00	1225.79	87.00	118.00	7.33	10.00	98.17	16.40	9.09	7.88	3.56	1.67	3.44
15	Cherry blossom	86.77	6.33	991.83	66.00	78.00	8.67	12.00	104.85	24.05	8.66	7.54	2.00	1.72	2.89
16	Bakes dozen	60.50	7.00	662.09	92.67	100.67	6.33	7.57	61.60	9.73	7.32	5.27	2.00	2.22	1.78
17	Han-Van magreen	72.93	7.33	1023.19	82.67	97.00	8.00	11.00	90.43	24.17	9.47	7.49	2.45	3.94	3.00
18	Dr. Fleming	67.33	7.00	906.37	91.00	92.67	8.33	8.33	84.23	20.17	9.71	6.35	2.45	2.67	3.89
19	Beauty spot	74.47	7.00	987.23	82.67	92.00	10.00	11.67	100.13	27.40	9.60	6.57	4.22	2.00	2.89
20	Wild Rose	71.27	7.00	1115.44	95.33	111.67	11.33	10.33	84.90	24.90	9.06	7.52	2.11	2.22	3.78
21	Ariate	81.93	6.67	1251.95	76.67	83.33	9.67	8.67	107.40	30.63	10.31	7.49	2.22	1.78	3.89
22	Little pencey	80.20	7.00	859.63	109.33	118.67	10.33	10.67	97.57	24.47	7.97	6.98	2.00	2.89	4.22
23	White prosperity	79.17	6.67	1035.66	80.33	97.00	7.33	8.33	95.97	18.40	9.00	7.72	2.78	1.64	3.56
24	Navalux	67.07	7.00	701.99	84.33	96.67	7.00	9.00	80.20	16.33	9.54	7.42	3.11	1.22	3.11
25	Piccardy	59.67	7.00	481.76	93.00	106.33	11.33	8.67	101.77	17.40	11.59	8.89	2.00	1.67	3.00
	Mean	81.49	7.24	1056.92	89.24	100.72	9.84	10.11	101.11	25.49	9.35	7.45	2.55	2.06	3.48
	S.E.m.+	4.05	0.30	117.26	5.23	5.23	0.78	0.95	5.09	3.04	0.24	0.35	0.15	0.18	0.27
	C.D. at 5 per cent	11.23	0.85	325.04	14.48	14.50	2.16	2.65	14.13	8.42	0.66	0.96	0.42	0.51	0.75
	C.V.	8.61	7.29	19.22	10.14	8.99	13.69	16.37	8.73	20.64	4.39	8.08	10.33	15.50	13.39

Table 2 (Contd.)

Sl. No.	Genotypes	Number of capsules*	Number of seeds per capsule*	Number of side shoots*	Number of side spikes*	Number of corms	Weight of corm (g)	Equatorial diameter of corm (cm)	Polar diameter of corm (cm)	Number of corms*	10-corm weight (g)*
1	Friendship	1.90	1.24	1.00	1.00	1.00	47.93	5.62	2.11	3.36	2.15
2	Wedding bouquet	1.00	1.00	1.13	1.14	1.33	70.98	6.54	2.28	1.72	1.88
3	Agni rekha	3.78	1.83	1.24	1.00	2.00	22.48	4.24	1.93	4.76	2.51
4	Moon magic	1.00	1.00	1.00	1.00	1.00	29.79	4.44	2.11	1.00	1.00
5	Oscar red	1.00	1.00	1.00	1.00	1.33	64.28	5.89	2.44	6.38	2.27
6	Red charm	2.36	3.72	1.38	1.00	2.00	32.09	4.63	2.25	5.10	2.18
7	Power puff	2.00	2.62	1.27	1.00	1.33	44.89	5.45	2.26	4.04	2.36
8	Shirley	1.82	1.84	1.14	1.00	2.00	49.73	5.88	2.34	6.71	2.23
9	Water melon pink	3.11	3.32	1.00	1.00	1.00	51.04	6.02	2.20	6.75	2.73
10	G.S. Porter	1.00	1.00	1.15	1.27	1.33	105.29	6.54	2.76	4.05	2.36
11	Pink pixola	1.00	1.00	1.00	1.00	1.00	67.46	6.22	2.45	6.26	2.23
12	Monsoor red	1.67	2.30	1.00	1.24	1.00	61.71	5.96	2.31	2.04	5.65
13	Flemingo	2.16	1.00	1.00	1.00	2.00	37.24	6.09	2.07	3.58	3.26
14	Yellow frilled	1.00	1.00	1.27	1.00	1.00	46.47	4.72	2.52	9.79	2.86
15	Cherry blossom	1.55	1.81	1.00	1.00	1.33	34.25	4.98	1.96	1.33	1.76
16	Bakes dozen	1.48	2.87	1.38	1.00	1.00	19.25	3.81	1.43	2.69	1.59
17	Han-Van magreen	1.24	1.37	1.27	1.00	2.00	51.96	5.42	2.34	6.09	2.41
18	Dr. Fleming	2.48	3.32	1.00	1.00	1.33	51.84	5.96	2.37	3.99	1.96
19	Beauty spot	1.73	2.67	1.14	1.00	2.67	53.20	6.16	2.52	5.73	3.02
20	Wild rose	1.00	1.00	1.14	1.00	2.00	41.39	5.31	1.75	5.48	2.47
21	Ariate	1.00	1.00	1.00	1.00	1.00	66.16	6.29	2.21	3.21	2.21
22	Little pencey	2.27	2.69	1.00	1.00	1.00	41.97	5.58	1.88	3.33	2.21
23	White prosperity	1.14	1.24	1.00	1.00	1.00	47.94	5.71	2.16	2.59	1.72
24	Navalux	1.67	2.54	1.00	1.00	1.00	31.12	5.09	2.11	2.28	2.06
25	Piccardy	2.14	3.86	1.52	1.00	3.33	32.43	4.19	2.34	3.96	2.81
	Mean	1.69	1.93	1.12	1.06	1.48	48.12	5.47	2.21	4.25	2.39
	S.E.m.*	0.41	0.79	0.11	0.09	0.36	9.87	0.38	0.10	0.44	0.27
	C.D. at 5 per cent	0.80	1.54	0.31	0.17	1.01	27.36	1.07	0.29	1.23	0.73
	C.V.	29.58	50.20	17.39	9.89	42.61	35.53	12.17	8.11	18.04	19.16

*Indicates square root transformed values.

Table 3. Analysis of variance for twenty four characters in twenty-five genotypes of Gladiolus grandiflorum L.

Sl. No.	Characters	Mean sum of squares	
		Treatments (d.f=24)	Error (d.f=48)
1	Plant height (cm)	582.09**	49.18
2	Number of leaves	2.38**	0.28
3	Leaf area (cm ²)	289805.00**	41252.50
4	Days to spike emergence	957.90**	81.92
5	Days for opening first floret	1062.33**	82.15
6	Number of florets per spike	15.39**	1.82
7	Durability of spike	10.66**	2.74
8	Spike length (days)	867.89**	77.99
9	Rachis length (cm)	175.54**	27.69
10	Floret length (cm)	3.62**	0.17
11	Floret diameter (cm)	2.69**	0.36
12	Longevity of individual floret (days)	1.03**	0.07
13	Number of florets open at a time	0.92**	0.10
14	Number of florets remain open	1.95**	0.22
15	Number of side shoots	0.072*	0.038
16	Number of side spikes	0.017*	0.011
17	Number of capsules	1.59**	0.25
18	Number of seeds per capsule	2.86**	0.94
19	Number of corms	1.14**	0.39
20	Equitorial diameter of corm (cm)	1.78**	0.44
21	Polar diameter of corm (cm)	0.24**	0.03
22	Weight of corm (g)	1003.39**	292.26
23	Number of cormels	12.79**	0.59
24	10-cormel weight (g)	2.06**	0.211

*Significant at P=0.05 level.

**Significant at P=0.01 level.

4.1.1. Growth parameters

4.1.1.1. Plant height: The analysis of variance was highly significant and the genotypes exhibited a wide range of variation for plant height. The values ranged from 59.67 cm to 110.23 cm, with an overall mean of 81.49 cm. Wedding bouquet exhibited maximum height (110.23 cm) and the minimum was recorded by piccardy (59.67 cm).

The phenotypic variance was 226.82 with genotypic variance of 177.64. The phenotypic and genotypic coefficient of variation were 18.48 and 16.36 per cent respectively. This trait recorded high heritability estimate of 78.32 per cent with an high estimate of genetic advance of 24.29, indicating that environmental factors have played negligible role in deciding the character. The genetic advance over mean was 29.81 per cent.

4.1.1.2. Number of leaves: Test of significance revealed that the genotypes differed significantly for this trait at 1 per cent level of significance (Table 3). Genotypes displayed a less range of variation for this character, which varied from 6.33 to 10.00, with a mean of 7.24.

Table 4. Phenotypic and genotypic variability in *Gladiolus grandiflorum* L.

Sl. No.	Characters	Range	Mean±S.Em	Variance		Coefficient of variability(%)	
				Phenotypic	Genotypic	Phenotypic	Genotypic
1	Plant height (cm)	59.67-110.23	81.49±4.05	226.82	177.64	18.48	16.36
2	Number of leaves	6.33-10.00	7.24±0.30	0.98	0.70	13.67	11.56
3	Leaf area (cm ²)	481.76-1827.67	1056.92±117.26	124103.33	82850.83	33.33	27.23
4	Days to spike emergence	62.00-146.00	89.24±5.23	737.91	291.99	21.67	19.15
5	Days for opening of first floret	71.67-161.00	100.72±5.23	408.88	326.73	20.08	17.95
6	Number of florets per spike	6.33-15.00	9.84±0.78	6.34	4.52	25.59	21.61
7	Durability of spike	7.33-13.67	10.11±0.95	5.38	2.64	22.94	16.07
8	Spike length (cm)	61.60-137.97	101.11±5.09	341.29	263.30	18.27	16.05
9	Rachis length (cm)	9.73-41.77	25.49±3.04	76.97	49.28	34.42	27.54
10	Floret length (cm)	7.32-11.59	9.35±0.24	1.32	1.15	12.29	11.47
11	Floret diameter (cm)	5.27-9.45	7.45±0.35	1.14	0.78	14.33	11.85
12	Longevity of individual floret (days)	2.00-4.22	2.55±0.15	0.39	0.32	24.49	22.18
13	Number of florets open at a time	1.22-3.94	2.06±0.18	0.37	0.27	29.53	25.22
14	Number of florets remain open	1.67-5.33	3.48±0.27	0.79	0.58	25.54	21.88
15	Number of capsules	1.00-3.78	1.69±0.41	0.69	0.45	49.15	39.69
16	Number of seeds per capsule	1.00-3.86	1.93±1.12	1.58	0.64	65.13	41.45
17	Number of side shoots	1.00-1.52	1.12±1.11	0.049	0.011	19.76	9.36
18	Number of side spikes	1.00-1.27	1.06±0.09	0.013	0.002	10.76	4.22
19	Number of corms	1.00-3.33	1.48±0.36	0.64	0.25	54.05	33.78
20	Number of cormels	1.00-9.79	4.25±0.44	4.66	4.07	50.79	47.47
21	Equitorial diameter of corm (cm)	3.81-6.54	5.47±0.38	0.89	0.45	17.25	12.26
22	Polar diameter of corm (cm)	1.43-2.76	2.21±0.10	0.10	0.07	14.31	11.97
23	Weight of one daughter corm (g)	19.25-67.46	48.12±9.87	529.30	237.04	47.81	31.99
24	10-cormel weight (g)	1.00-5.65	2.39±0.27	0.83	0.62	38.12	32.95

LEGEND



CHARACTERS

- X₁ - Plant height
- X₂ - No. of leaves
- X₃ - leaf area
- X₄ - Days to spike emergence
- X₅ - Days for opening of first floret
- X₆ - No of florets per spike
- X₇ - Durability of spike
- X₈ - spike length
- X₉ - Rachis length
- X₁₀ - floret length
- X₁₁ - floret diameter
- X₁₂ - longevity of individual floret
- X₁₃ - No. of florets open at a time
- X₁₄ - No. of florets remain open
- X₁₅ - No. of capsules
- X₁₆ - No. of seeds per capsule
- X₁₇ - No. of side shoots
- X₁₈ - No. of side spikes
- X₁₉ - No. of daughter corms
- X₂₀ - No. of cornels
- X₂₁ - Equitorial diameter of corn
- X₂₂ - polar diameter of corm
- X₂₃ - wt. of daughter corm
- X₂₄ - 10 - cornel weight

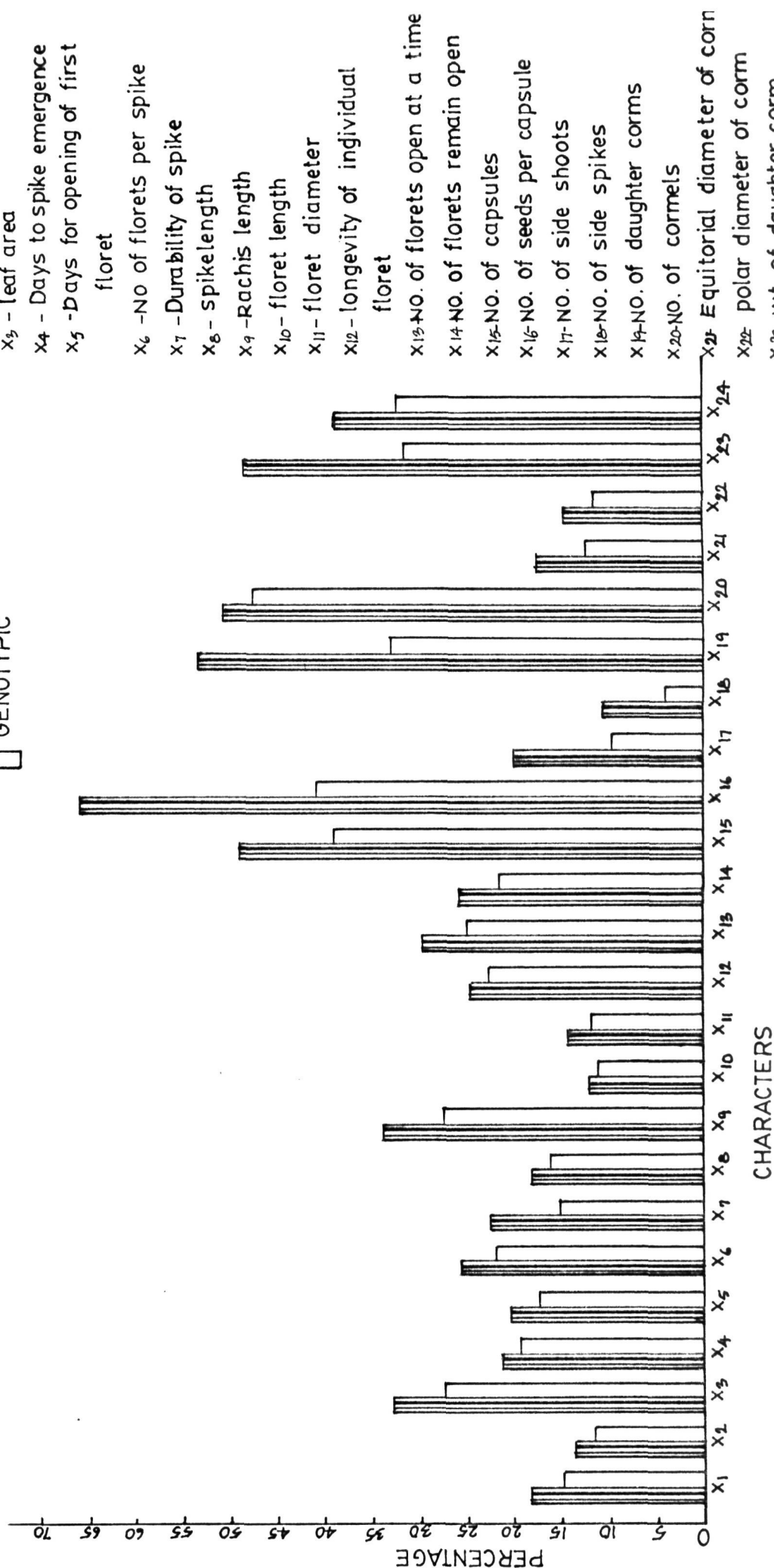


FIG.1. PHENOTYPIC AND GENOTYPIC CO EFFICIENTS OF VARIABILITY FOR 24 CHARACTERS IN GLADIOLUS grandiflorum

Table 5. Heritability and genetic advance in Gladiolus grandiflorum L.

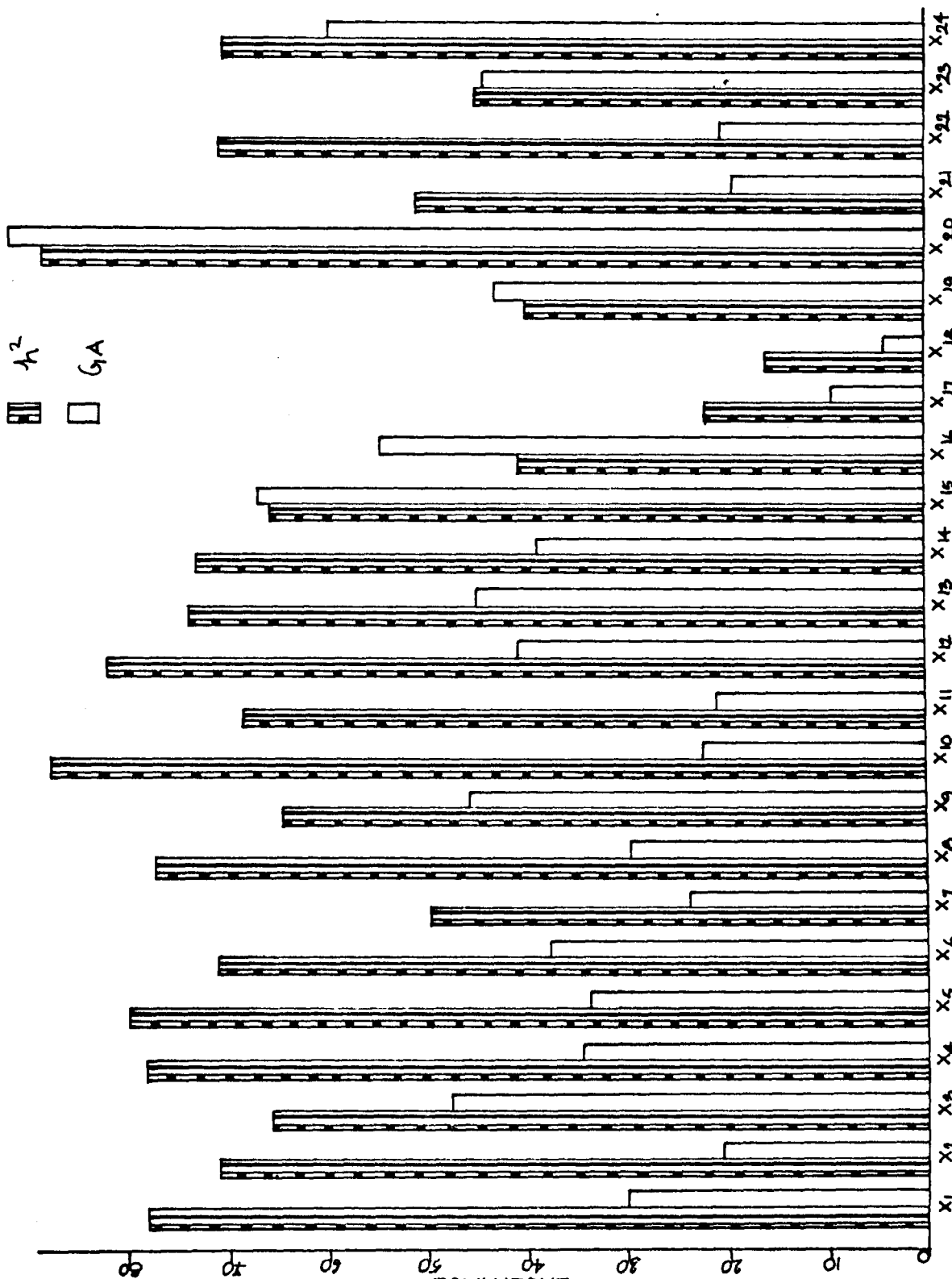
Sl. No.	Characters	Heritability (%)	Genetic advance	Genetic advance over mean (%)
1	Plant height (cm)	78.32	24.29	29.81
2	Number of leaves	71.43	1.47	20.30
3	Leaf area (cm ²)	66.76	484.48	45.84
4	Days to spike emergence	78.09	31.10	34.85
5	Days for opening of first floret	79.91	33.29	33.05
6	Number of florets per spike	71.29	3.69	37.50
7	Durability of spike (days)	49.07	2.34	23.15
8	Spike length (cm)	77.15	29.37	29.05
9	Rachis length (cm)	64.02	11.58	45.43
10	Floret length (cm)	87.12	2.06	22.03
11	Floret diameter (cm)	68.42	1.50	20.13
12	Longevity of individual floret (days)	82.05	1.06	41.57
13	Number of florets open at a time	72.97	0.91	44.17
14	Number of florets remain open	73.42	1.34	38.51
15	Number of capsules	65.22	1.12	66.27
16	Number of seeds per capsule	40.51	1.05	54.40
17	Number of side shoots	22.44	0.10	8.93
18	Number of side spikes	15.38	0.04	3.77
19	Number of corms	39.06	0.64	43.24
20	Number of cormels	87.34	3.88	91.29
21	Equatorial diameter of corm (cm)	50.56	0.99	18.09
22	Polar diameter of corm (cm)	70.00	0.45	20.36
23	Weight of one daughter corm (g)	44.78	21.22	44.09
24	10-cormel weight (g)	74.70	1.40	58.58

LEGEND



CHARACTERS

- X₁ - Plant height
- X₂ - No. of leaves
- X₃ - leaf area
- X₄ - Days to spike emergence
- X₅ - Days for opening of first floret
- X₆ - NO of florets per spike
- X₇ - urability of spike
- X₈ - spike length
- X₉ - Rachis length
- X₁₀ - floret length
- X₁₁ - floret diameter
- X₁₂ - longevity of individual floret
- X₁₃ - NO. of florets open at a time
- X₁₄ - NO. of florets remain open
- X₁₅ - NO. of capsules
- X₁₆ - NO. of seeds per capsule
- X₁₇ - NO. of side shoots
- X₁₈ - NO. of side spikes
- X₁₉ - NO. of daughter corms
- X₂₀ - NO. of cormels
- X₂₁ - Equitorial diameter of corm
- X₂₂ - polar diameter of corm
- X₂₃ - wt. of daughter corm
- X₂₄ - 10 - cormel weight



CHARACTERS

FIG. 2 HERITABILITY [Broad sense] AND GENETIC ADVANCE [Percent of mean] FOR 24 CHARACTERS IN GLADIOLUS grandiflorum

Very low phenotypic variance (0.98) and genotypic variance (0.70) were recorded. The coefficient of variation values in terms of phenotypic and genotypic levels were 13.67 and 11.56 respectively, suggesting less environmental effect on the expression of the character which was indicated by high heritability estimate of 71.43 per cent, with a low expected genetic advance of 1.47. Genetic advance over mean was moderate (20.30 per cent).

4.1.1.3. Leaf area: A wide range of variation was observed which varied from 481.76 cm² (piccardy) to 1827.67 cm² (G.S.Porter) with a overall mean of 1056.92 cm².

High phenotypic variance (124103.33 cm²) and less genotypic variance (82850.83 cm²) were recorded for leaf area per plant (Table 4). The phenotypic and genotypic coefficient of variability were 33.33 and 27.33 per cent respectively. Heritability was moderate (66.76 per cent) with moderately high genetic advance (484.48) indicates that this character was less influenced by environmental factors. A moderately high per cent mean genetic advance (45.84 per cent) was observed (Table 5).

4.1.1.4. Days taken for spike emergence: F test indicated highly significant variation for this character. It

varied from 62.00 days (Flemingo) to 146.00 days (moon magic) with a mean value of 89.24 days (Table 2).

A difference of 81.92 days was observed between phenotypic variance (373.91) and genotypic variance (291.99). The phenotypic and genotypic coefficients of variability were 21.67 and 19.15 per cent respectively. Heritability estimate was 78.09 with high Genetic advance (31.10). Genetic advance over mean was (34.85 per cent) moderate in this trait (Table 5).

4.1.1.5. Days taken for opening of first floret: Genotypes displayed a wide range of variation for this character with mean of 100.72 days. The range in the collection varied from 71.67 days (Flemingo) to 161.00 days (Moon magic). The analysis of variance was highly significant (Table 2).

Moderately high phenotypic and genotypic variance (408.88 and 326.73 respectively) were accompanied by PCV of 20.08 per cent and GCV of 17.95 per cent (Table 4). Environmental factors appeared to have fairly less influence as indicated by high heritability of 79.91 per cent. High genetic advance (33.29) and moderate per cent mean genetic advance (33.05) were recorded (Table 5).

4.1.2. Yield parameters

4.1.2.1. Number of florets per spike: A wide range of variation was observed for this character among the genotypes. The number of florets per spike varied from 6.33 (Red charm) to 15.00 (Agnirekha) in the collection with an overall mean of 9.84. Analysis of variance showed highly significant differences among the genotypes.

Low phenotypic variance of 6.34 and genotypic variance of 4.52 were observed. Narrow difference between PCV (25.59 per cent) and gcv (21.61 per cent) reveals interference of environmental factors to a lesser extent. This was accompanied by high heritability estimate of 71.29 per cent and per cent mean genetic advance of 37.50. However, genetic advance was low (3.69).

4.1.2.2. Durability of spike: Significant difference was observed among the genotypes in the F test for this character (Table 3). Durability of spike ranged from 7.33 (Red charm) days to 13.67 days (G.S.Porter) with a mean value of 10.11 days.

The values of phenotypic and genotypic variances were 5.38 and 2.64 respectively. Pcv and gcv were low

with 22.94 and 16.07 per cent respectively. This with moderate heritability value of 49.07 per cent indicated moderate influence of environmental factors. Low genetic advance (2.34) and per cent mean genetic advance (23.15) were recorded.

4.1.2.3. Spike length: Genotypes showed a wide range of 61.60 cm to 137.97 cm, with a mean of 101.11 cm for this character. The lowest was recorded in cv. Bakes dozen and highest in Mansoor red. Test of significance revealed highly significant difference between the genotypes.

High phenotypic variance and genotypic variance (341.29 and 263.30 respectively) were accompanied by pcv of 18.27 per cent and gcv of 16.05 per cent. The heritability estimate was high with 77.15 per cent implying less influence of environmental factors (Table 5). The expected genetic advance was moderate with 29.37 but the per cent mean genetic was low (29.05 per cent).

4.1.2.4. Rachis length: The range for Rachis length varied from 9.73 cm (Bakes dozen) to 41.77 cm (Mansoor red) indicating quite a large amount of variability. The average length of Rachis in the collection was 25.49 cm.

The analysis of variance performed indicated that varieties differed significantly at 1 per cent level of significance.

Moderate phenotypic variance of 76.97 and genotypic variance of 49.28 were observed. The difference of 6.88 between pcv and gcv indicated influence of environmental factors on this trait, to certain extent. Moderate values of PCV (34.42 per cent) and gcv (27.54 per cent) were accompanied by moderate heritability estimate of 64.02 per cent. Moderate values for genetic advance (11.58) and genetic advance over mean (45.43 per cent) were recorded.

4.1.2.5. Floret length: The analysed data revealed that the genotypes differed significantly at one per cent level of significance. The collections had the floret length (Table 2) ranging from 7.32 cm (Bakes dozen) to 11.59 cm (Piccardy).

Very low phenotypic variance (1.32) and genotypic variance (1.15) were recorded. The small difference of 0.17 indicated less influence of environmental factors on this trait. The coefficient of variation at phenotypic and genotypic level were 12.29 per cent and 11.47 per cent respectively. The heritability estimate

was high (87.12 per cent) with low genetic advance of 2.06. The per cent mean genetic advance was low (22.03 per cent).

4.1.2.6. Floret diameter: The variation for floret diameter ranged from 5.27 cm to 9.45 cm in Bakes dozen and Moon magic respectively, with an overall mean of 7.45 cm. F test showed highly significant difference between the genotypes (Table 3).

Very low phenotypic variance (1.14) and genotypic variance (0.78) were observed. The difference between phenotypic and genotypic coefficients of variation were moderate (14.33 and 11.85 per cent, respectively), indicating moderate effect of environmental factors on the character expression. This was confirmed by moderate heritability estimate (68.42 per cent) (Table 5). But both genetic advance (1.50) and genetic advance over mean (20.13 per cent) were low.

4.1.2.7. Longevity of individual floret: The character exhibited wide range of variation with values ranging from 2.00 days to 4.22 days with an average value of 2.55 days. There was a significant difference among the varieties at one per cent level of significance as indicated by the analysis of variance.

The phenotypic and genotypic variances were low (0.39 and 0.32 respectively). The observed genotypic and phenotypic coefficient of variability for this character were separated by a narrow gap (24.49 and 22.18 respectively). This implies that the environmental influence is less. This further resulted in very high estimate of heritability of 82.05 per cent. The expected genetic advance was low (1.06) but the per cent mean genetic advance was moderate (41.57 per cent).

4.1.2.8. Number of florets open at a time: The genotypes showed a range of 1.22 to 3.94 with an overall mean of 2.06. The lowest number of floret open at a time was recorded in a Nawalux and highest in Han-Van magreen.

The values of phenotypic and genotypic variances were 0.37 and 0.27 respectively. The character had the phenotypic and genotypic coefficient of variation, which were 29.53 and 25.22 per cent respectively (Table 4). Since the estimate of heritability was high with 72.97 per cent, indicating less influence of environmental factors. It had low genetic advance (0.91) and moderate per cent mean genetic advance (44.17).

4.1.2.9. Number of florets remain open at a time: The germplasm showed wide variability for number of florets

remain open at a time with a mean of 3.48. The genotype G.S.Porter (1.67) and Mansoor red (5.33) recorded lowest and highest values respectively.

Low values of phenotypic (0.79) and genotypic variance (0.58) were observed. Moderate coefficients of variation were indicated by the values of pcv (25.54 per cent) and GCV (21.88 per cent). Environmental factors appeared to have fairly less influence which was pointed out by high heritability of 73.42 per cent (Table 5). Low genetic advance (1.34) and moderate genetic advance of 38.51 per cent over mean was recorded.

4.1.2.10. Number of capsules per plant: Number of capsules varied from 1.00 to 3.78 with a mean value of 1.69. Highly significant differences were observed among genotypes for this trait.

Phenotypic and genotypic variances were 0.69 and 0.45 respectively. Phenotypic and genotypic coefficient of variability were 49.15 per cent and 39.69 per cent respectively, which differed by each other by 9.46. Heritability was moderate (65.22 per cent) accompanied with high genetic advance over mean (66.27 per cent) but genetic advance was low (1.12).

4.1.2.11. Number of seeds per capsule: This trait exhibited considerable variation which ranged from 1.00 to 3.86 with a mean value of 1.93. Analysis of variance indicated highly significant difference in this trait among the genotypes.

The observed phenotypic and genotypic variances were low (1.58 and 0.64 respectively). The phenotypic and genotypic coefficient of variability were 65.13 and 41.45 per cent respectively with a large difference (23.68) between them. This was supported by moderate heritability estimate of 40.51 per cent (Table 5), ascertaining moderate influence of extraneous factors on expression of this character. The genetic advance over mean was high (54.40 per cent) but genetic advance was low (1.05).

4.1.2.12. Number of side shoots: Number of side shoots ranged from 1.00 to 1.52 with a overall mean of 1.12 and are significant. Highest number of side shoots was present in a Piccardy and lowest in Nawalux. F test showed significant differences among the genotypes.

Very low phenotypic variance (0.049) and genotypic variance (0.011) were observed. A difference

of 10.83 between PCV (19.76 per cent) and GCV (9.36 per cent) suggesting that the character was greatly influenced by environment (Table 4). This was conformed by low heritability value of 22.44 per cent. Both genetic advance (0.10) and genetic advance over mean (8.93 per cent) were low.

4.1.2.13. Number of side spikes: A narrow range of variation, which ranged from 1.00 to 1.27 with a mean value of 1.06. Analysis of variance showed significant difference among the genotypes.

Phenotypic and genotypic variances were very low (0.013 and 0.002 respectively). Phenotypic and genotypic coefficients of variability were 10.76 and 4.22 per cent respectively (Table 4). Low heritability estimate of 15.38 per cent pointed out the influence of extraneous factor on this trait to a greater extent. Low genetic advance (0.04) and per cent mean genetic advance (3.77) were recorded.

4.1.2.14. Number of daughter corms: The analysed data showed highly significant difference for this character. The number of corms ranged from 1.00 (Nawalux) to 3.33 (Piccardy) with a mean value of 1.48.

The phenotypic and genotypic variances were 0.64 and 0.25 respectively. A difference of 20.27 was noticed between PCV (54.05 per cent) and GCV (33.78 per cent), which infers the environmental influence to a greater extent. This was supported by moderate heritability estimate of 39.06 per cent and moderate genetic advance over mean (43.24 per cent) with low genetic advance (0.64).

4.1.2.15. Number of cormels per corm: Number of cormels per corm ranged from 1.00 to 9.79 with mean value of 4.25 (Table 2). The maximum value was exhibited by yellow frilled and minimum by Moon magic. The character exhibited highly significant difference among genotypes.

A narrow difference of 0.59 between phenotypic variance (4.66) and genotypic variance (4.07) displayed environmental influence on character expression to a lesser extent. The pcv and gcv were 50.79 and 47.47 per cent respectively. The heritability was high (87.34 per cent) with very high genetic advance over mean (91.29 per cent). However, the genetic advance was low (3.88).

4.1.2.16. Equitorial diameter of corm: The genotypes exhibited highly significant differences for this

character. A range of 3.81 cm (Bakes dozen) to 6.54 cm (Wedding bouquet) was recorded among genotypes with a mean value of 5.47 cm (Table 2).

A moderate difference of 4.99 between PCV (17.25 per cent) and GCV (12.26 per cent) were observed. Phenotypic and genotypic variances were 0.89 and 0.45 respectively. A moderate heritability estimate of 50.56 per cent accompanied with low genetic advance of 0.99. Per cent mean genetic advance was low (18.09).

4.1.2.17. Polar diameter of corm: This character also showed highly significant variation among genotypes. The range was from 1.43 (Bakes dozen) to 2.76 (Pink Pixola).

The phenotypic and genotypic variances were 0.10 and 0.07 respectively, with a difference of 0.03 between them (Table 4). Heritability estimate was high (70.00 per cent) with low genetic advance (0.45) and genetic advance over mean (20.36 per cent).

4.1.2.18. Weight of single daughter corm: The genotypes exhibited highly significant differences for this character. It ranged widely from 19.25 g (Bakes dozen) to 67.46 g (Pink Pixola) with a mean value of 48.12 g indicating great amount of variability existing for this character.

High phenotypic variance (529.30) and genotypic variance (237.04) were observed for this character (Table 4). The PCV and gcv were 47.81 and 31.99 per cent respectively. Heritability was moderate (44.78 per cent) with moderate genetic advance over mean (44.09 per cent) (Table 5). Genetic advance was moderately low (21.22).

4.1.2.19. 10-cornel weight: Analysis of variance showed highly significant differences among the genotypes for this character. A range of 1.00 (Moon magic) to 5.65 g (Mansoor red) with mean value of 2.39 g was recorded (Table 2).

This character showed phenotypic variance of 0.83 and genotypic variance of 0.62. A moderate difference between pcv (38.12 per cent) and gcv (32.95 per cent) showed a moderate influence on environment. This was concluded by high heritability estimate value of 74.70 per cent (Table 5). The genetic advance over mean was 58.58 per cent while genetic advance was low (1.40).

4.2. CORRELATIONS AND PATH COEFFICIENT ANALYSIS

CORRELATIONS

The phenotypic and genotypic correlation coefficients were computed in all possible combinations

for 17 quantitative characters. The phenotypic and genotypic correlation coefficients are given in Tables 6 and 7 and graphical representation are depicted for spike length, floret diameter and number of floret per spike in Figs.3, 4 and 5, respectively. In general genotypic correlation coefficients were found to be higher than the phenotypic correlations.

4.2.1. Phenotypic correlations

Plant height is positively and highly significantly correlated with spike length (0.7977), leaf area (0.7395), Rachis length (0.4708), number of florets per spike (0.4704), floret diameter (0.4519), number of leaves (0.4361), weight of single daughter corm (0.3546), durability of spike (0.3330) and floret length (2964).

Plant height was found to be significant at 5% level of significance for equitorial diameter of daughter corm (0.2928), days for opening of first floret (0.2897) and days to spike emergence (0.2483). The association was significant and negative for number of daughter corms (-0.2549).

Number of leaves was positively and significantly associated with leaf area (0.6889), days to spike

Table 6. Phenotypic correlation coefficients for 17 quantitative characters in *Gladiolus grandiflorum* L.

X ₁	X ₂	X ₃	X ₄	X ₅	X ₆	X ₇	X ₈	X ₉	X ₁₀	X ₁₁	X ₁₂	X ₁₃	X ₁₄	X ₁₅	X ₁₆	X ₁₇
1.0000	0.4361**	0.7395**	0.2483*	0.2897*	0.4704**	0.3330**	0.7977**	0.4708**	0.2964**	0.4519**	-0.2239	-0.2549*	0.3546**	0.2928*	-0.0432	-0.1377
	1.0000	0.6889**	0.4751**	0.4721**	0.3797**	0.3368**	0.4223**	0.3845**	0.3032**	0.2441*	-0.0268	-0.0378	0.3459**	0.1022	-0.0109	0.0041
		1.000	0.2546*	0.2863*	0.4062**	0.4872**	0.6177**	0.4657**	0.3233**	0.3496**	-0.2329*	-0.2420*	0.5654**	0.3852**	0.0885	-0.0714
			1.0000	0.9454**	0.4415**	0.3179**	0.2352*	0.1750	0.3624**	0.3542**	0.0890	-0.0671	-0.0463	-0.2637*	-0.1168	-0.0993
				1.0000	0.3866**	0.3110**	0.2325*	0.1324	0.3597**	0.4114**	0.1307	-0.0824	-0.0414	-0.3122**	-0.0444	-0.1787
					1.0000	0.5484**	0.6682**	0.6867**	0.4034**	0.4070**	-0.0829	0.0387	0.1232	0.1021	-0.0497	0.1619
						1.0000	0.3674**	0.4190**	0.2250	0.2569*	-0.0893	-0.1142	0.3253**	0.1965	0.0088	0.0260
							1.0000	0.7283**	0.5364**	0.5458**	-0.1374	-0.0298	0.3404**	0.2901*	-0.0401	0.1406
								1.0000	0.4035**	0.3738**	-0.2521*	-0.1017	0.2979**	0.3153**	-0.1127	0.2624*
									1.0000	0.7757**	-0.0911	0.1766	0.1853	0.1108	-0.1681	0.0861
										1.0000	-0.1174**	0.0334	0.1675	0.0823	-0.0917	-0.1531
											1.0000	0.4383**	-0.1761	-0.3943**	0.2408*	-0.0332
												1.0000	-0.3325**	-0.2667*	0.1658	-0.0283
													1.0000	0.7755**	0.1427	0.1034
														1.0000	0.0482	0.1774
															1.0000	-0.0563
																1.0000

*Significant at 5 per cent level. **Significant at 1 per cent level.

X₁=Plant height (cm)
X₂=Number of leaves
X₃=Leaf area (cm²)
X₄=Days to spike emergence
X₅=Days for opening of first floret
X₆=Number of florets per spike

X₇=Durability of spike (days)
X₈=Spike length (cm)
X₉=Rachis length (cm)
X₁₀=Floret length (cm)
X₁₁=Floret diameter (cm)
X₁₂=Number of side shoots

X₁₃=Number of daughter corms
X₁₄=Weight of one daughter corm (g)
X₁₅=Equatorial diameter of the daughter corm (cm)
X₁₆=Number of corms per corm
X₁₇=10-corm weight (g)

emergence (0.4751), days for opening of first floret (0.4721), plant height (0.4361), spike length (0.4223), Rachis length (0.3845), number of florets per spike (0.3797), weight of single daughter corm (0.3459), durability of spike (0.3368) and floret length (0.3032). Association of number of leaves with floret diameter (0.2441) was positive and significant.

The association of leaf area was positive and highly significant with spike length (0.6177), weight of single daughter corm (0.5654), durability of spike (0.4872), Rachis length (0.4657), number of florets per spike (0.4062), equitorial diameter of the corm (0.3852), floret diameter (0.3496) and floret length (0.3223). Its association with days for opening of first floret (0.2863), days to spike emergence (0.2546) and was positive and significant at 5 per cent level of significance while the association was negative and significant with, number of daughter corms (-0.2420) and number of side shoots (-0.2329).

Days to spike emergence recorded a highly positive and significant association with days for opening of first floret (0.9454), number of florets per spike (0.4415), floret length (0.3624), floret diameter (0.3542) and durability of spike (0.3179). While it had

a positive and significant association with spike length (0.2351). It was found to be significantly and negatively correlated with equitorial diameter of the corm (-0.2637).

Days for opening of first floret had a highly significant and positive association with floret diameter (0.4114), number of florets per spike (0.3866), floret length (0.3597) and durability of spike (0.3110). The association was positive and significant with spike length (0.2325). It recorded significant and negative association with equitorial diameter of the daughter corm (-0.3122).

Number of florets recorded highly significant and positive association with Rachis length (0.6897), spike length (0.6682), durability of spike (0.5484), floret diameter (0.4070) and floret length (0.4034).

Durability of spike showed highly significant and positive association with number of florets (0.5484), leaf area (0.4872), Rachis length (0.4190), spike length (0.3674), number of leaves (0.3368), plant height (0.3330), weight of single daughter corm (0.3253), days to spike emergence (0.3179) and days for first floret opening (0.3110). The correlation was positive and significant with floret diameter (0.2569).

Spike length had a highly significant and strong positive association with plant height (0.7977), Rachis length (0.7283), number of florets per spike (0.6682), leaf area (0.6177), floret diameter (0.5458) and floret length (0.5364). It had strong to moderate association with number of leaves (0.4223), durability of spike (0.3674) and weight of single daughter corm (0.3404), further it also had a significant, positive correlation with equitorial diameter of corm (0.2901), days to spike emergence (0.2351) and days for opening of first floret (0.2325).

Rachis length recorded highly significant positive association with spike length (0.7283), number of florets per spike (0.6867), plant height (0.4708), leaf area (0.4657), durability of spike (0.4190), floret length (0.4035), number of leaves (0.3845), floret diameter (0.3738), equitorial diameter of corm (0.3153) and weight of single daughter corm (0.2979). It showed positive significant association with 10-cormel weight (0.2624) while it had significant negative association with number of side shoots (-0.2521).

Floret length had highly significant and positive correlation with floret diameter (0.7757), spike length (0.5364), Rachis length (0.4035), number of florets per

spike (0.4034), days to spike emergence (0.3624), days for first floret opening (0.3597), leaf area (0.3233), number of leaves (0.3032) and plant height (0.2964). However, the rest of the characters exhibited weak association.

Floret diameter was highly significant and positively correlated with floret length (0.7757), spike length (0.5458), plant height (0.4519), days taken for opening of first floret (0.4114), number of florets per spike (0.4070), Rachis length (0.3738) and days to spike emergence (0.3542). While it had a positive and significant correlation with durability of spike (0.2569) and number of leaves (0.2441).

Number of side shoots was highly significant and positively associated with number of daughter corms (0.4383). It was positively associated with number of cormels (0.2408). It was highly significantly and negatively associated with equatorial diameter of corm (-0.3943) while it had shown a significant and negative correlation with Rachis length (-0.2521) and leaf area (-0.2329).

Number of daughter corms recorded highly significant positive correlation with number of side

shoots (0.4383), and had shown a highly significant negative association with weight of single daughter corm (-0.3325). It exhibited significant and a negative correlation with equitorial diameter of daughter corm (-0.2667) and plant height (-0.2549). While all the other characters showed non-significant and weak association with this character.

Weight of daughter corm showed highly significant and positive association with equitorial diameter of daughter corm (0.7755), leaf area (0.5654), plant height (0.3546), number of leaves (0.3459), spike length (0.3404), durability of spike (0.3253) and Rachis length (0.2979). It had highly significant and negative correlation with number of daughter corms (-0.3325).

Equitorial diameter of daughter corm recorded highly significant positive association with weight of daughter corm (0.7755), leaf area (0.3852) and Rachis length (0.3153). It showed significant and positive association with plant height (0.2928) and spike length (0.2901). The association was highly significant and negative for number of side shoots (-0.3943) and days for first floret to open (-0.3122). While it had a significant negative association with number of daughter corms (-0.2667) and days to spike emergence (-0.2637).

Number of cormels per corm had significant and negative association with number of side shoots (-0.2408). Rest of the characters had shown a non-significant and weak association between themselves and with number of cormels per corm.

10-cormel weight exhibited a significant and positive association with Rachis length (0.2624), while all other characters showed a weak and non-significant association with this character.

4.2.2. Genotypic correlations

Plant height recorded highly significant positive association with most of the characters studied viz., spike length (0.8479), leaf area (0.8173), Rachis length (0.6762), floret diameter (0.6054), number of leaves (0.5647), number of florets per spike (0.5160), days for opening of first floret (0.4803), weight of single daughter corm (0.4781), days to spike emergence (0.4274), durability of spike (0.3616), floret length (0.3576) and equitorial diameter of daughter corm (0.2985), but plant height exhibited a highly significant negative correlation with number of side shoots (-0.5455) and number of daughter corms (-0.4430).

Table 7. Genotypic correlation coefficients for 17 characters in *Gladiolus grandiflorum* L.

	X ₁	X ₂	X ₃	X ₄	X ₅	X ₆	X ₇	X ₈	X ₉	X ₁₀	X ₁₁	X ₁₂	X ₁₃	X ₁₄	X ₁₅	X ₁₆	X ₁₇
1	1.0000	0.5647**	0.8173**	0.4274**	0.4803**	0.5160**	0.3616**	0.8479**	0.6762**	0.3576**	0.6054**	-0.5455**	-0.4430**	0.4781**	0.2985**	-0.0987	-0.1081
2		1.0000	0.8047**	0.6290**	0.6133**	0.4981**	0.6605**	0.5525**	0.4902**	0.3912**	0.4310**	0.0418	0.0374	0.5483**	0.1382	0.0274	-0.0363
3			1.0000	0.4257**	0.4742**	0.4521**	0.5868**	0.7471**	0.7354**	0.4122**	0.5270**	-0.6181**	-0.3908**	0.7547**	0.4609**	0.0766	-0.0076
4				1.0000	0.9686**	0.6356**	0.5358**	0.3285**	0.2253*	0.3498**	0.3466**	0.0371	-0.0881	-0.1115	-0.4253**	-0.1390	-0.1555
5					1.0000	0.5525**	0.5553**	0.3417**	0.1593	0.3829**	0.4760**	0.0959	-0.1076	-0.1011	-0.4544**	-0.0444	-0.2184
6						1.0000	0.5757**	0.7418**	0.7539**	0.4874**	0.5435**	-0.1800	0.2731*	0.0216	-0.0787	-0.0141	0.2892*
7							1.0000	0.4410**	0.5862**	0.3058**	0.4478**	-0.4495**	-0.0656	0.3100**	0.0258	-0.0464	0.0859
8								1.0000	0.8550**	0.5957**	0.6958**	-0.4917**	0.0197	0.4537**	0.3101**	-0.0825	0.2172
9									1.0000	0.5090**	0.5326**	-0.7332**	-0.1484	0.3528**	0.4961**	-0.1321	0.3583**
10										1.0000	0.8596**	-0.2896**	0.2503*	0.2942*	0.0983	-0.1788	0.1168
11											1.0000	-0.4392**	0.0437	0.2395*	0.0692	-0.1095	-0.1765
12												1.0000	0.8596**	-0.5012**	-0.9404**	0.3482**	-0.0807
13													1.0000	-0.0420	-0.1257	0.3007**	0.1178
14														1.0000	0.8503**	0.1274	0.1632
15															1.0000	0.0529	0.2293*
16																1.0000	-0.0564
17																	1.0000

Significant at 5 per cent level. **Significant at 1 per cent level.

1=Plant height (cm)

2=Number of leaves

3=Leaf area (cm²)

4=Days to spike emergence

5=Days for opening of first floret

6=Number of florets per spike

X₇=Durability of spike (days)

X₈=Spike length (cm)

X₉=Rachis length (cm)

X₁₀=Floret length (cm)

X₁₁=Floret diameter (cm)

X₁₂=Number of side shoots

X₁₃=Number of daughter corms

X₁₄=Weight of one daughter corm (g)

X₁₅=Equatorial diameter of the daughter corm (g)

X₁₆=Number of cormlets per corm

X₁₇=10-cornal weight (g)

LEGEND



CHARACTERS

- x₁ - Plant height
- x₂ - NO. of leaves
- x₃ - leaf area
- x₄ - days to spike emergence
- x₅ - days for opening of first floret
- x₆ - NO. floret per spike
- x₇ - durability of spike
- x₈ - rachis length
- x₉ - Floret length
- x₁₀ - Floret diameter
- x₁₁ - NO. of side shoots
- x₁₂ - NO. of daughter corms
- x₁₃ - wt. of daughter corm
- x₁₄ - Equitorial dia of corm
- x₁₅ - NO. of cormels
- x₁₆ - NO. - cormel weight

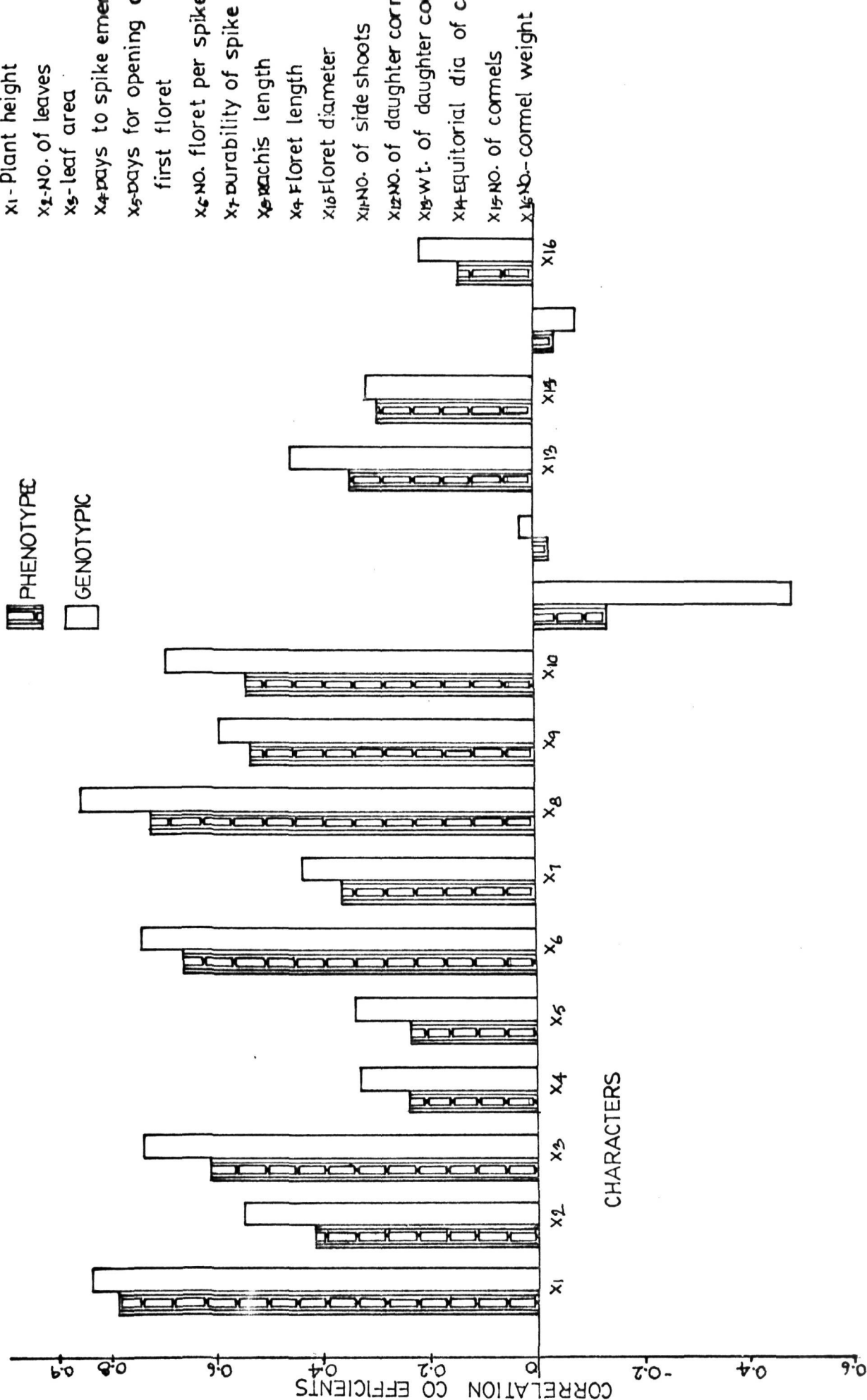


FIG. 3. PHENOTYPIC AND GENOTYPIC CORRELATION CO-EFFICIENTS OF DIFFERENT CHARACTERS WITH SPIKELENGTH IN GLADIOLUS grandiflorum

CHARACTERS

- x₁- Plant height
- x₂-NO. leaves
- x₃- leaf area
- x₄-days to spike emergence
- x₅-days for opening of first floret
- x₆- NO. of florets per spike
- x₇-Durability of spike
- x₈- spike length
- x₉-rachis length
- x₁₀ floret length
- x₁₁-No. side shoots
- x₁₂-No. of daughter corms
- x₁₃- wt. of daughter corm
- x₁₄- Equitorial dia. of corm
- x₁₅- NO. Of cormels
- x₁₆ lo-cormel weight

LEGEND

■ PHENOTYPIC

□ GENOTYPIC

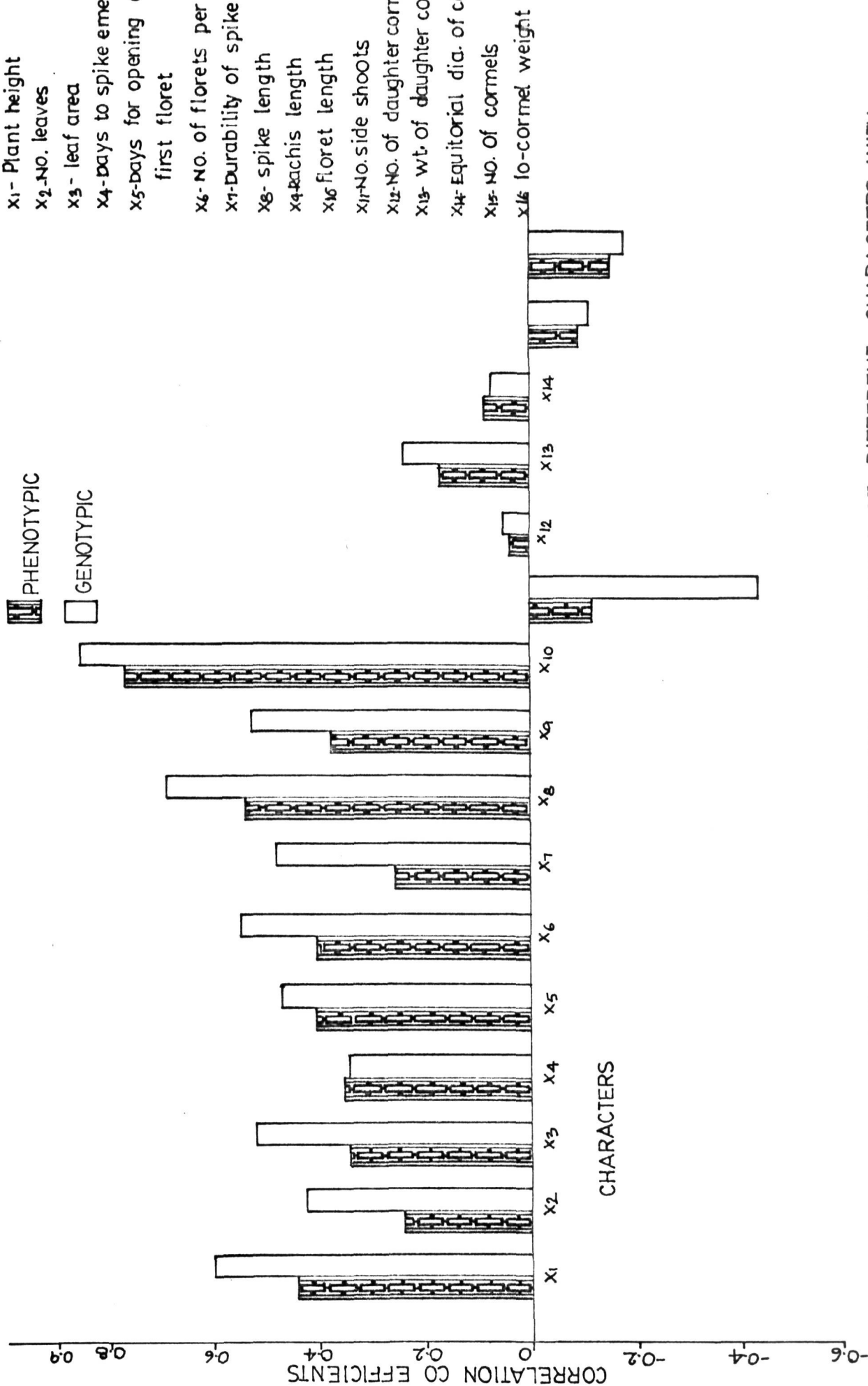
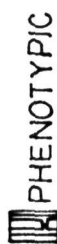


FIG.4. PHENOTYPIC AND GENOTYPIC CORRELATION COEFFICIENTS OF DIFFERENT CHARACTERS WITH FLORET DIAMETER IN GLADIOLUS grandiflorum

LEGEND



PHENOTYPIC



GENOTYPIC

CHARACTERS

x₁ - Plant height

x₂ - NO. of leaves

x₃ - leaf area

x₄ - Days to spike emergence

x₅ - Days for opening of first floret

x₆ - Durability of spike

x₇ - spike length

x₈ - Rachis length

x₉ - floret length

x₁₀ - floret diameter

x₁₁ - NO. of side shoots

x₁₂ - NO. of daughter corms

x₁₃ - wt. of daughter corm

x₁₄ - Equatorial dia. of corm

x₁₅ - NO. of cormels

x₁₆ - 10-cormel weight

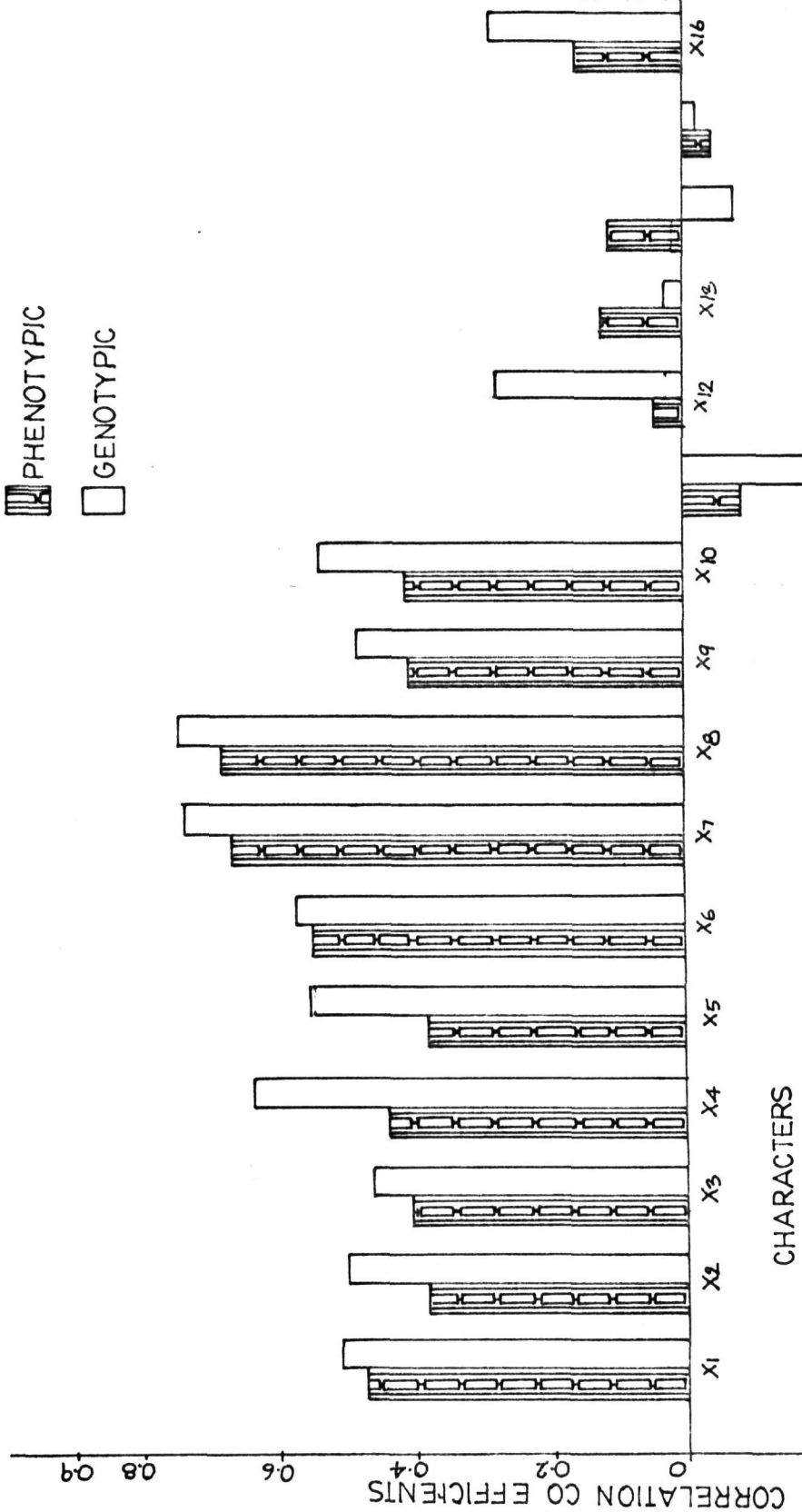


FIG.5. PHENOTYPIC AND GENOTYPIC CORRELATION CO EFFICIENTS OF DIFFERENT CHARACTERS WITH

NUMBER OF FLORETS PER SPIKE IN GLADIOLUS grandiflorum

The association of number of leaves was highly significant and positive for leaf area (0.8047), durability of spike (0.6605), days to spike emergence (0.6290), days for opening of first floret (0.6133), plant height (0.5647), spike length (0.5525), weight of daughter corm (0.5483), number of florets per spike (0.4981), Rachis length (0.4902), floret diameter (0.4310) and floret length (0.3912). Other remaining characters had a non-significant association.

Leaf area recorded highly significant and moderate to high positive association with plant height (0.8173), number of leaves (0.8047), weight of daughter corm (0.7547), spike length (0.7471), Rachis length (0.7354), durability of spike (0.5868), floret diameter (0.5270), days for opening of first floret (0.4742), number of florets per spike (0.4621), equitorial diameter of corm (0.4609) and days to spike emergence (0.4257). The association with number of side shoots (-0.6181) and number of daughter corms (-0.3908) was highly significant and negative.

Days to spike emergence had highly significant and positive relation with days for opening first floret (0.9686), number of florets per spike (0.6356), number of leaves (0.6290), durability of spike (0.5358), plant

height (0.4274), leaf area (0.4257), floret length (0.3498), floret diameter (0.3466) and spike length (0.3285), while it exhibited a highly negative association with equitorial diameter of the corm (-0.4253).

Days for opening of first floret showed highly significant strong to moderate association with days taken for spike emergence (0.9686), number of leaves (0.6133), durability of spike (0.5553), number of florets (0.5525), plant height (0.4803), floret diameter (0.4760), leaf area (0.4742), floret length (0.3829) and spike length (0.3417). Its relation with equitorial diameter of the corm (-0.4544) was highly significant and negative.

Number of florets per spike recorded highly significant and strong association with Rachis length (0.7539), spike length (0.7418), days for spike emergence (0.6356), durability of spike (0.5757), days for opening first floret (0.5525), floret diameter (0.5435), plant height (0.5160), number of leaves (0.4981), floret length (0.4874) and leaf area (0.4621). The relation was significant and negative with number of daughter corms (-0.2731).

The correlation of durability of spike with number of leaves (0.6605), leaf area (0.5868), Rachis length (0.5862), number of florets (0.5757), days for first floret to open (0.5553), days to spike emergence (0.5358), floret diameter (0.4478), floret length (0.3058) and weight of daughter corm (0.3100). Its correlation was highly significant and negative with number of shoots (-0.4495).

Spike length was highly significant and positively associated with Rachis length (0.8550), plant height (0.8479), leaf area (0.7471), number of florets per spike (0.7418), floret diameter (0.6958), floret length (0.5957), number of leaves (0.5525), weight of daughter corm (0.4537), durability of spike (0.4410), days for opening first floret (0.3417), days for spike emergence (0.3285) and equitorial diameter of daughter corm (0.3101). It recorded a highly significant and negative association with number of side shoots (-0.4917).

Rachis length recorded highly significant positive association with spike length (0.8550), number of florets (0.7539), leaf area (0.7354), plant height (0.6762), durability of spike (0.5862), floret

diameter (0.5326), floret length (0.5090), equitorial diameter of corm (0.4961), number of leaves (0.4902) and weight of daughter corm (0.3528). Rachis length showed highly significant and strong negative correlation with number of side shoots (-0.7332) but recorded a significant and positive relation with days taken to spike emergence (0.2253).

Floret length showed highly significant positive association with floret diameter (0.8596), spike length (0.5957), Rachis length (0.5090), number of florets (0.4874), leaf area (0.4122), number of leaves (0.3912), days for opening first floret (0.3829), plant height (0.3576), days to spike emergence (0.3498) and durability of spike (0.3058). The association was highly significant and negative with number of side shoots (-0.2896), while it exhibited significant positive association with number of daughter corms (0.2503).

Floret diameter had highly significant positive association with floret length (0.8596), spike length (0.6958), plant height (0.6054), number of florets (0.5435), Rachis length (0.5326), leaf area (0.5270), days for opening of floret (0.4760), durability of spike (0.4478), number of leaves (0.4310) and days to spike emergence (0.3466). The correlation was highly

significant and negative with number of side shoots (-0.4392). The association was significant and positive with weight of daughter corm (0.2395).

Number of side shoots exhibited highly significant and positive association with number of daughter corms (0.8596) and 10-cormel weight (0.3482). While it showed highly significant negative association with equitorial diameter of corm (-0.9404), Rachis length (-0.7332), leaf area (-0.6181), plant height (-0.5455), weight of daughter corm (-0.5012), spike length (-0.4917), durability of spike (-0.4495) and floret diameter (-0.4392).

The association of number of corms was highly significant and positive with number of side shoots (0.8596) and number of cormels (0.3007). It showed highly significant negative association with plant height (-0.4430) and leaf area (-0.3908). It also showed significant positive correlation with number of florets (0.2731) and floret length (0.2503).

Weight of daughter corm recorded highly significant positive relation with equitorial diameter of corm (0.8503), leaf area (0.7547), number of leaves (0.5483), plant height (0.4781), spike length (0.4537),

PATH COEFFICIENT ANALYSIS

The path coefficient analysis was carried out to obtain the information on the direct and indirect contribution of different quantitative characters on economically sound characters. The path coefficient analysis was done taking three most important characters namely, spike length, number of florets per spike and floret size as dependent variables individually with the remaining eight quantitative characters. The path coefficient were based on phenotypic correlations obtained. The data on direct and indirect effects of different characters on spike length, floret diameter and number of florets per spike are presented in Tables 8, 9 and 10 and phenotypic path diagrams are illustrated in Figs.6, 7 and 8 respectively.

4.2.3. Phenotypic path coefficient for spike length

Among the characters studied, plant height (0.6155) showed the greatest positive direct effect followed by Rachis length (0.3129), floret length (0.2626), number of florets per spike (0.1332) and weight of daughter corm (0.0440). But leaf area (-0.1084), floret diameter (-0.0719) and number of leaves (-0.0196) showed negative direct effects towards spike length (Table 8),

Table 8. Direct (Diagonal) and indirect (above and below diagonal) effects of eight characters on spike length in Gladiolus grandiflorum L. at phenotypic level

	Plant height	Number of leaves	Leaf area	Number of florets per spike	Rachis length	Floret length	Floret diameter	Weight of daughter corm	Correlation with spike length
Plant height	<u>0.6155</u>	-0.0085	-0.0802	0.0627	0.1473	0.0778	-0.0325	0.0156	0.7977
Number of leaves	0.2684	<u>-0.0196</u>	-0.0747	0.0506	0.1203	0.0796	-0.0175	0.0152	0.4223
Leaf area	0.4552	-0.0135	<u>-0.1084</u>	0.0541	0.1457	0.0849	-0.0251	0.0249	0.6177
Number of florets per spike	0.2895	-0.0074	-0.0440	<u>0.1332</u>	0.2149	0.1059	-0.0293	0.0054	0.6682
Rachis length	0.2898	-0.0075	-0.0505	0.0915	<u>0.3129</u>	0.1060	-0.0269	0.0131	0.7283
Floret length	0.1824	-0.0059	-0.0351	0.0537	0.1263	<u>0.2626</u>	-0.0558	0.0081	0.5364
Floret diameter	0.2782	-0.0048	-0.0379	0.0542	0.1170	0.2037	<u>-0.0719</u>	0.0074	0.5458
Weight of daughter corm	0.2183	-0.0068	-0.0613	0.0164	0.0932	0.0487	-0.0120	<u>0.0440</u>	0.3404

Residual effect=0.1508.

CHARACTERS

- X1-Plant height
- X2-No. of leaves
- X3-Leaf area
- X4-No. of florets per spike
- X5-Rachis length
- X6-Floret length
- X7-Floret diameter
- X8-Wt. of corm
- Y - Spike length

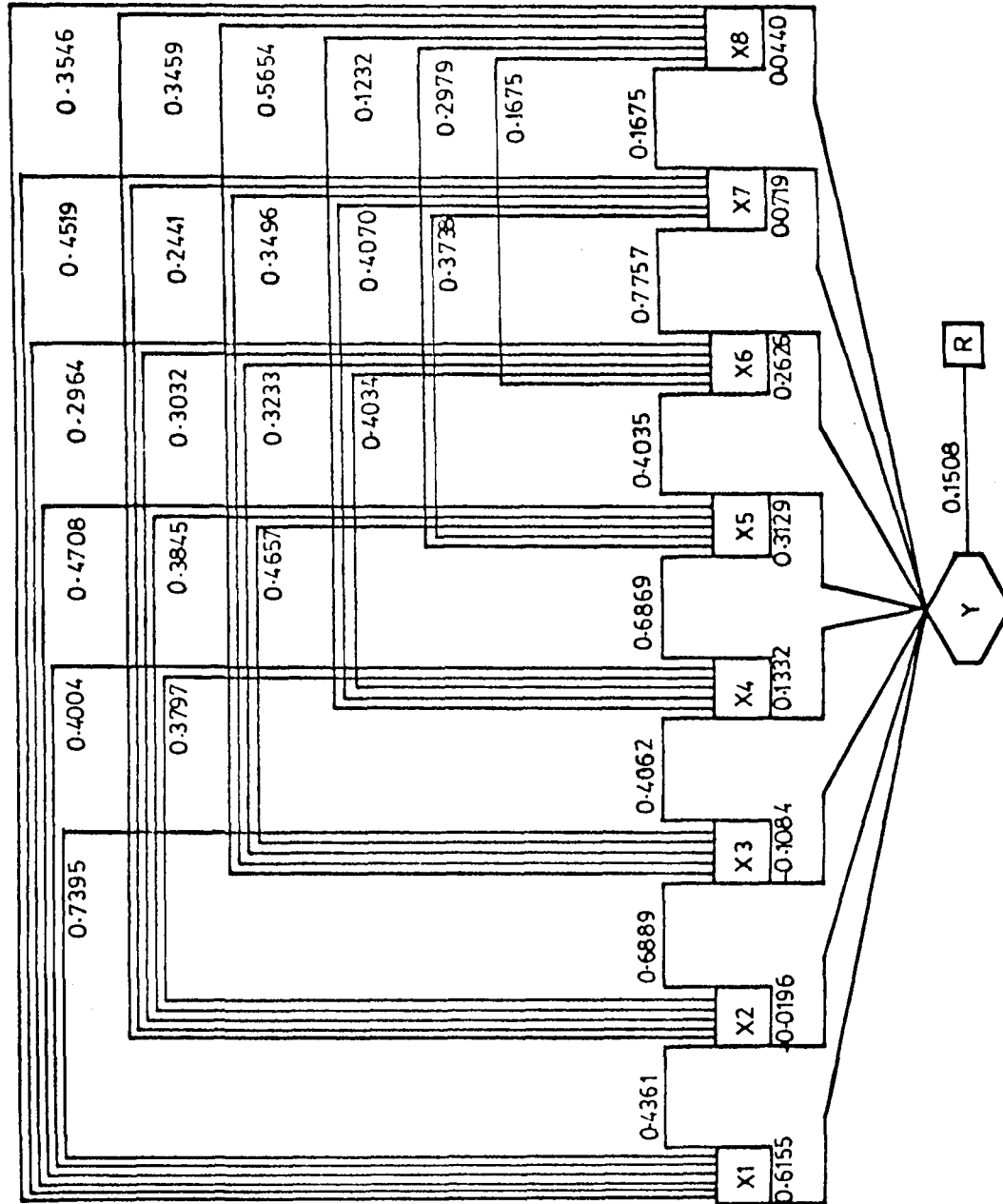


FIG. 6. PHENOTYPIC PATH DIAGRAM SHOWING INFLUENCE OF DIFFERENT CHARACTERS ON SPIKELENGTH IN GLADIOLUS grandiflorum

Indirect effect of plant height through Rachis length (0.1473) was relatively high compared to low indirect effects of floret length (0.0778), number of florets per spike (0.0627) and weight of daughter corm (0.0156). But its indirect effects through number of leaves, leaf area and floret diameter were negative and negligible.

The indirect contribution of Rachis length through plant height (0.2898), and floret length (0.1060) were positive and relatively high, further it showed positive but low indirect effects with number of florets per spike, and weight of daughter corm. Low and negative indirect effects were recorded with number of leaves, leaf area, and floret diameter.

The trait floret length showed positive indirect effects with plant height (0.1824), Rachis length (0.1263) followed by number of florets per spike (0.0537) and weight of daughter corm (0.0081). The indirect contribution of floret length through number of leaves, leaf area and floret diameter were negative and low.

Number of florets per spike exhibited positive indirect effects with plant height (0.2895), Rachis length (0.2149), floret length (0.1059) followed by

weight of daughter corm (0.0054), which showed low positive indirect effects. While leaf area, number of leaves and floret diameter, exhibited negative indirect effects. Weight of daughter corm exhibited high indirect positive effect through plant height (0.2183) and low positive indirect effects via., number of florets, Rachis length and floret length; however, it showed negative indirect effects with floret diameter, leaf area and number of leaves.

Floret diameter showed relatively higher positive indirect effects with plant height (0.2782), floret length (0.2037) and Rachis length (0.1170). The indirect contribution through weight of daughter corm was positive but, rest of the characters exhibited low and negative association (Table 8).

Number of leaves exhibited direct negative effect (-0.0196) on spike length and its indirect effect through plant height (0.2684) and Rachis length (0.1203) was remarkably high. Its indirect effect on other characters was low on spike length.

Leaf area showed negative direct effect (-0.1084) on spike length. It contributed positively through plant height (0.4552) and Rachis length (0.1457) but its

effect through remaining components was negligible and insignificant towards spike length. Unknown factors accounted for 15.08 per cent of variability in spike length at phenotypic level.

4.2.4. Phenotypic path coefficient for floret diameter

Among the characters studied, floret length (0.7042) exerted the highest direct effect followed by plant height (0.3396) and days for first floret to open (0.1521) (Table 9).

Low positive direct effects were obtained for number of florets per spike (0.0014) and Rachis length (0.0458). Direct effect was found to be negative for number of leaves (-0.1402), leaf area (-0.0454) and spike length (-0.0852).

Floret length showed positive direct effect with plant height (0.1007) but through spike length (-0.0457), number of leaves (-0.0425) and leaf area (-0.0147) showed negative indirect effects. Effect of floret diameter with rest of the characters on floret length were very low even though it was positive.

Days for opening of first floret exhibited direct positive effect (0.1521) on floret diameter. Its

Table 9. Direct (Diagonal) and indirect (above and below diagonal) effects of eight characters on floret diameter in *Gladiolus grandiflorum* L. at phenotypic level

	Plant height	Number of leaves	Leaf area	Days for 1st floret to open	Number of florets per spike	Spike length	Rachis length	Floret length	Correlation with floret diameter
Plant height	0.3396	-0.0611	-0.0336	0.0441	0.0007	-0.0680	0.0216	0.2087	0.4519
Number of leaves	0.1481	-0.1402	-0.0313	0.0718	0.0005	-0.0360	0.0176	0.2135	0.2441
Leaf area	0.2511	-0.0966	-0.0454	0.0435	0.0006	-0.0526	0.0213	0.2277	0.3496
Days for opening of first floret	0.0984	-0.0662	-0.0130	0.1521	0.0006	-0.0198	0.0061	0.2533	0.4114
Number of florets per spike	0.1598	-0.0532	-0.0185	0.0588	0.0014	-0.0570	0.0316	0.2841	0.4070
Spike length	0.2709	-0.0592	-0.0281	0.0354	0.0010	-0.0852	0.0333	0.3777	0.5458
Rachis length	0.1599	-0.0539	-0.0212	0.0201	0.0010	-0.0621	0.0458	0.2841	0.3738
Floret length	0.1007	-0.0425	-0.0147	0.0547	0.0006	-0.0457	0.0185	0.7042	0.7757

Residual effect=0.3166.

CHARACTERS

- X1- Plant height
- X2- No. of leaves
- X3- Leaf area
- X4- Days for opening of first floret
- X5- No. of florets per spike
- X6- Spike length
- X7- Rachis length
- X8- Floret length
- Y - Floret diameter

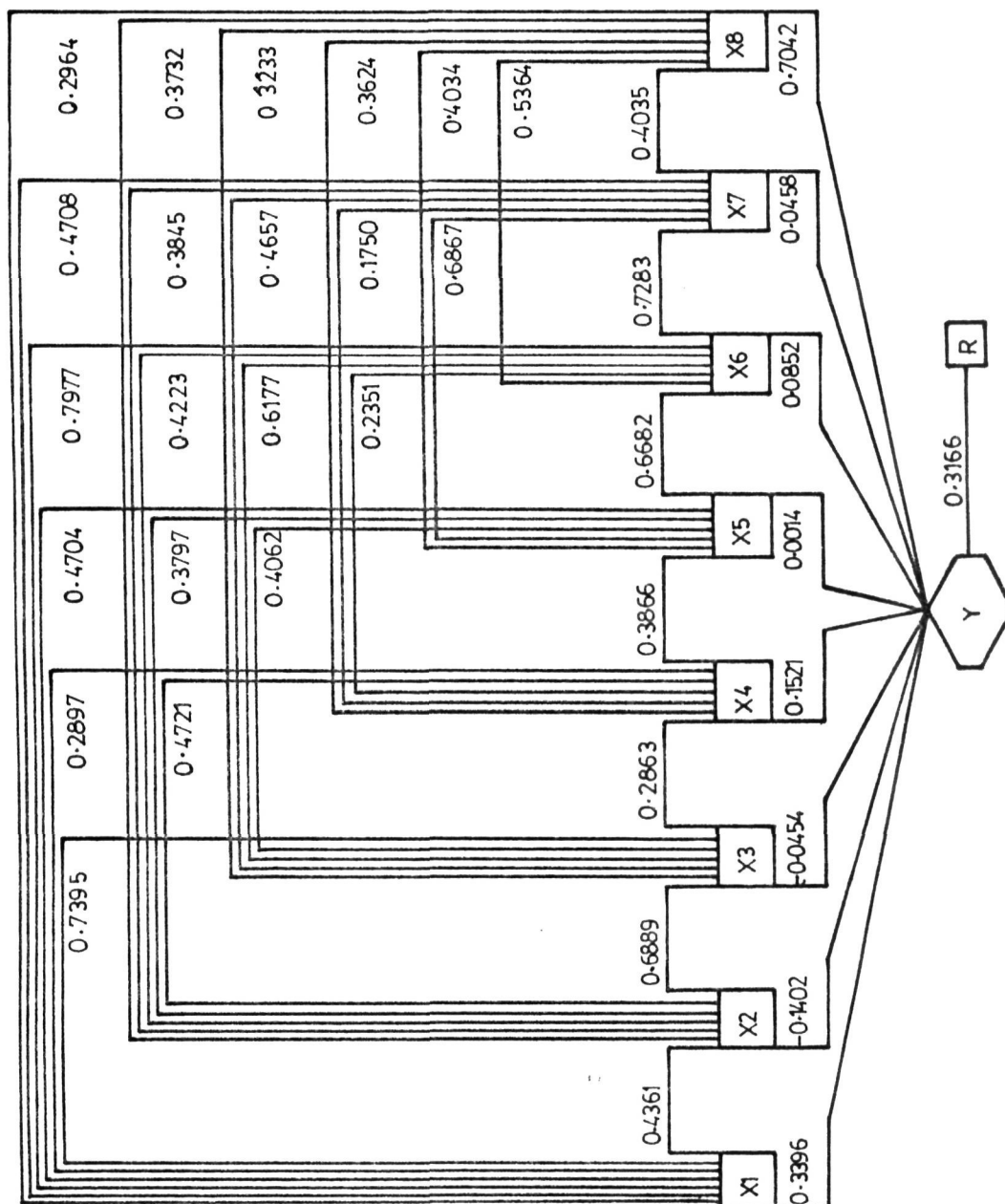


FIG.7. PHENOTYPIC PATH DIAGRAM SHOWING INFLUENCE OF DIFFERENT CHARACTERS ON FLORET DIAMETER IN GLADIOLUS grandiflorum

contribution through floret length (0.2533), and plant height (0.0984) was remarkably high.

The direct effect of number of florets per spike on floret diameter was meagre (0.0014), whereas its indirect effect through floret length (0.2841) and plant height (0.1598) were remarkably high and exceeded the direct effect. Effect of number of florets through days for opening of first floret and Rachis length were 0.0588 and 0.0316 respectively. Indirect effect of the remaining characters were low and negative.

Plant height showed direct, positive effect of 0.3396 on floret diameter. Its indirect effect via., floret length (0.2087) was quite high. It showed negative indirect effect through spike length (-0.0680) and number of leaves (-0.0611).

Negative direct effect of spike length (-0.0852) towards floret diameter were observed. This trait also showed negative indirect effects with number of leaves (-0.0592) and leaf area (-0.0281). However this trait contributed positively through floret length (0.3777), plant height (0.2709), days for opening of first floret (0.0354) and Rachis length (0.0333).

Rachis length (0.0458) exhibited positive but low direct effect on floret diameter. It exhibited positive indirect effects through floret length (0.2841) and plant height (0.1599).

Number of leaves (-0.1402) and leaf area (-0.0454) exhibited direct negative effects. It was found that both number of leaves and leaf area had indirect positive effects through Rachis length and plant height. Through other characters, these traits showed insignificant effects. Unknown factors caused 31.66 per cent of variability in floret diameter at phenotypic level (Table 9).

4.2.5. Phenotypic path coefficient for number of florets per spike

Among the characters studied, spike length (0.4015), Rachis length (0.3398), durability of spike (0.2750) and days to spike emergence (0.2618) exerted positive direct effects. While, leaf area (-0.1685), floret diameter (-0.0809), plant height (-0.0269) and number of leaves (-0.0021) had negative direct influence on number of florets (Table 10).

Spike length exerted direct positive effect (0.4015) on number of florets per spike. But it also

Table 10. Direct (Diagonal) and indirect (above and below diagonal) effects of eight characters on number of florets per spike in Gladiolus grandiflorum L. at phenotypic level

	Plant height	Number of leaves	Leaf area	Days for spike emergence	Durability of spike	Spike length	Rachis length	Floret diameter	Correlation 'r' with number of flowers
Plant height	<u>-0.0269</u>	-0.0009	-0.1246	0.0650	0.0916	0.3202	0.1600	-0.0140	0.4704
Number of leaves	-0.0117	<u>-0.0021</u>	-0.1161	0.1244	0.0926	0.1695	0.1306	-0.0075	0.3797
Leaf area	-0.0199	-0.0015	<u>-0.1685</u>	0.0666	0.1340	0.2480	0.1582	-0.0108	0.4062
Days to spike emergence	0.0067	-0.0010	-0.0429	<u>0.2618</u>	0.0874	0.0944	0.0595	-0.0110	0.4415
Durability of spike	-0.0090	-0.0007	-0.0821	0.0832	<u>0.2750</u>	0.1475	0.1424	-0.0079	0.5484
Spike length	-0.0214	-0.0009	-0.1041	0.0615	0.1010	<u>0.4015</u>	0.2475	-0.0169	0.6682
Rachis length	-0.0127	-0.0008	-0.0785	0.0458	0.1152	0.2924	<u>0.3398</u>	-0.0116	0.6867
Floret diameter	-0.0121	-0.0005	-0.0589	0.0927	0.0707	0.2191	0.1270	-0.0309	0.4070

Residual effect=0.3255.

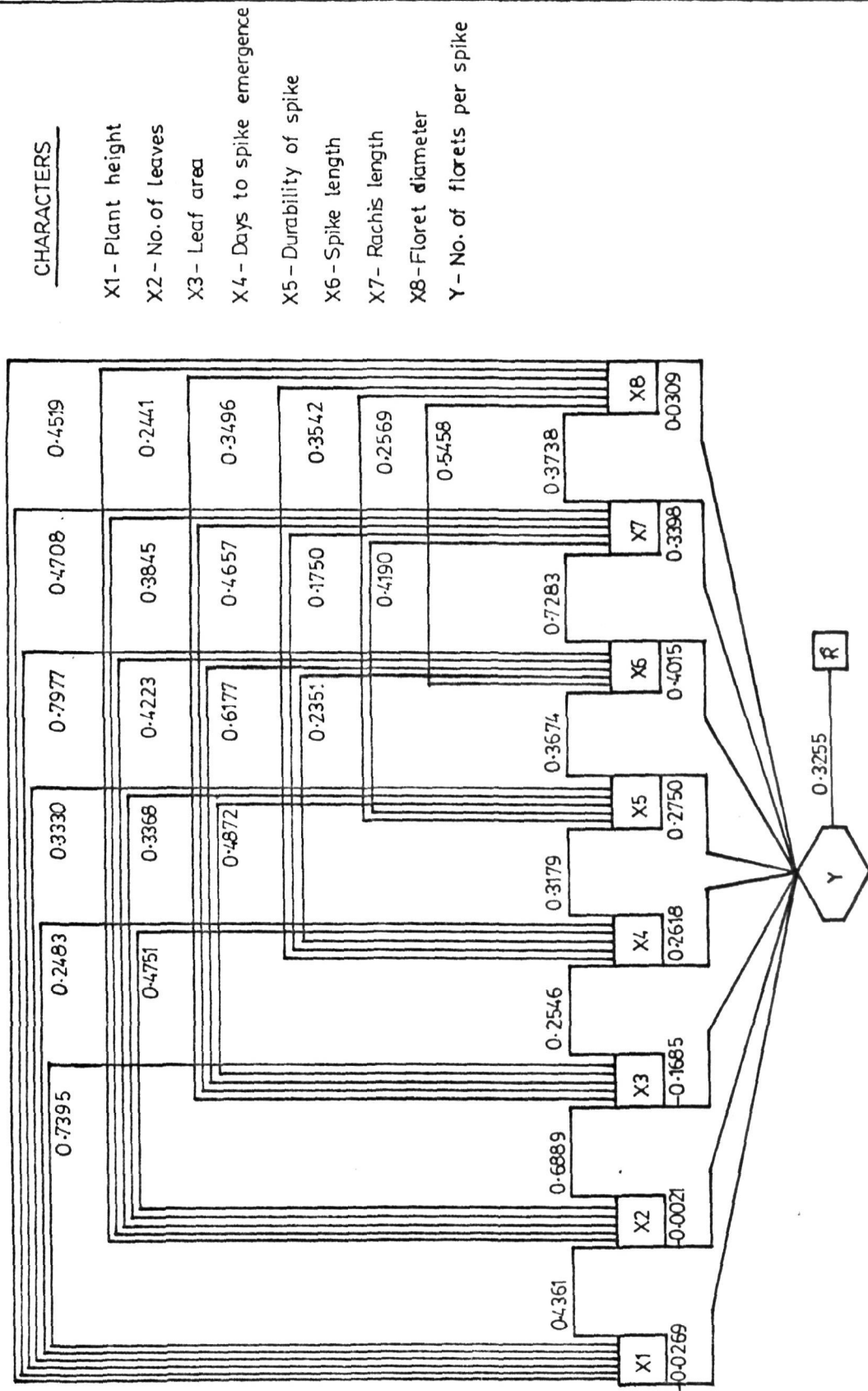


FIG. 8. PHENOTYPIC PATH DIAGRAM SHOWING INFLUENCE OF DIFFERENT CHARACTERS ON NUMBER OF FLORETS PER SPIKE IN *GLADIOLUS grandiflorum*

showed relatively higher positive indirect effect on Rachis length (0.2475), durability of spike (0.1010) and days to spike emergence (0.0615). Its indirect negative effect was relatively high for leaf area (-0.1041).

High positive direct effect of Rachis length (0.3398) on floret number was recorded. It also showed positive direct effects through spike length (0.2924) and durability of spike (0.1152). This trait also had negative indirect influence on leaf area (-0.0785) (Table 10).

Durability of spike exhibited positive direct effect (0.2750) on number of florets per spike. Its indirect contribution was positive through spike length (0.1475), Rachis length (0.1424), and days to spike emergence (0.0832). However, this trait was noticed to exert negative effects through leaf area (-0.0821).

Direct contribution of days to spike emergence with floret number was positive (0.2618) and its indirect influence was found to be positive for durability of spike (0.0874), spike length (0.0944) and Rachis length (0.0595) and its influence with others were low and negative.

Negative direct influence of leaf area (-0.1685) with number of florets was noticed. It showed positive indirect influence on days to spike emergence, durability of spike, spike length and Rachis length.

Negative direct effect of number of leaves (-0.0021), plant height (-0.0269) and floret diameter (-0.0309) on floret number were recorded. All the three characters had positive direct influence on days to spike emergence, durability of spike, spike length and Rachis length. Their indirect contribution was negative and negligible for plant height, number of leaves, leaf area and floret diameter.

FUTURE LINE OF WORK

The selection indices can be formulated for economically important characters viz., spike length, floret size and number of florets per spike, which give guidance for optimum weights to be assigned to different characters in a selection programme aimed at improving the above mentioned characters.

DISCUSSION

V. DISCUSSION

Information on the nature and magnitude of variability, association of various morphological and economic plant attributes with yield and the association among the yield components themselves is required for planning any crop improvement programme.

An understanding of the genetics of quantitative characters is most essential for systematic handling of the breeding material in any scientific crop improvement programme. This is essentially true in case of economic characters affecting yield in which the breeder is interested.

Twenty five genotypes of gladiolus representing different agro-climatic and geographical regions of the world were made use of in the study to identify the genotypes with desirable traits such as spike length, floret diameter and number of florets per spike. Hence, this study was undertaken to estimate phenotypic and genotypic coefficients of variability, and to determine the heritability in broad sense as well as the predicted genetic advance with respect to twenty four quantitative characters. The attempt was extended to understand the

association among various characters and to investigate the direct and indirect effects of certain morphological characters with spike length, floret diameter and number of florets per spike and ultimately among themselves.

The results of the experiment are discussed here under the following headlines.

1. Variability, heritability and genetic advance.
2. Correlation and path analysis.

5.1. VARIABILITY, HERITABILITY AND GENETIC ADVANCE

In the present study, variation in the mean performance of twenty five genotypes were observed for twenty four quantitative traits. Analysis of variance revealed significant differences for all the characters studied. The wide differences observed in these traits may be attributed to their genetic make up and different regions from which they were obtained.

A considerably wide range of variation was observed for all twenty four characters studied. The range in the values reflect the extent of phenotypic variability which is not very reliable since it includes genotypic, environmental and genotype environment

interaction components and does not reveal as to which character is showing higher degree of variability. Thus it is indispensable to split the overall variation into genetic and non-genetic components and to standardise these by obtaining coefficients of genotypic and phenotypic variability. Johansen (1909), Nilson Ehle (1909), East (1916) and Powers (1942) separated total variance into genetic and non-genetic (environmental) variances. Now, it is an accepted pattern in all biometrical studies as it helps in arriving at precise conclusions about the true breeding value of a genotype. Thus it is necessary to work out phenotypic and genotypic coefficients of variation, which indicate the extent of variability existing for various traits.

Previous investigations on *Gladiolus* have also brought out the presence of wide range of variability for plant height, spike length and number of days for flowering according to Gowda (1989), Lal et al. (1985a) and Singh and Singh (1987). Besides spike length, number of cormels, days to spike emergence and days for basal floret to open have also showed high variability (Arora and Khanna, 1986). Similarly high variability was reported for number of cormels (Negi et al., 1982;

Misra and Saini, 1988); weight of corm and weight of cormels produced per corm (Negi et al., 1982); number of side spikes per shoot and number of seeds per capsule (Misra and Saini, 1988).

In crops like gerbera, large variation was reported for duration of flowering period (Svojda, 1977) and seed yield and plant height (Harding et al., 1981a). In Nerium oleander. Ponnuswami et al. (1986) observed high variability for number of spikes. Jaswinder Singh and Arora (1980) reported maximum range of variation for plant height in Antirrhinum majus.

In the present investigation, the phenotypic coefficient of variation was higher than genotypic coefficient of variation for all the characters studied. High values of pcv and gcv were obtained for the characters viz., leaf area, Rachis length, number of capsules per shoot, number of daughter corms, number of cormels, weight of the daughter corm and 10-cormel weight. The present findings agree with the results obtained in gladiolus by Singh and Singh (1987), Arora and Khanna (1986), Negi et al. (1982), Misra and Saini (1988) for number of cormels, weight of cormels produced per corm and weight of daughter corm. Similarly high

pcv and gcv values were observed for weight of tubers (Choudhary, 1987) in Dahlia; length of flower spike (Rabinowitch et al., 1977) in Antirrhinum majus; stalk length (Negi et al., 1983) in China aster indicating the reliability of selection for the above characters based on the phenotypic performance.

Low pcv and gcv estimates were noticed for number of side spikes per shoot, floret diameter, floret length, and number of leaves. The results are in accordance with the findings of Misra and Saini (1988) and Negi et al. (1982) in Gladiolus, Lal et al. (1982) in Rose, where low pcv and gcv were recorded for diameter of the flower. Whereas low gcv were recorded for number of leaves per shoot in Gladiolus (Misra et al., 1988); flower bud diameter (Thangaraj et al., 1982) in Jasminum auriculatum. The above characters with low pcv and gcv indicate that they are too rigid for variation by the environment.

The report of contradictory results obtained by Misra et al. (1987) in Dahlia, Singh and Singh (1987) in Gladiolus, where high gcv was recorded for floret diameter. The reports by Ponnuswami et al. (1986) in Nerium oleander and Misra and Saini (1988) in Gladiolus

deviated from the present findings by recording high pcv and gcv for number of side spikes per plant. contradictory results reported by Lal et al. (1985a) and Gowda et al. (1989) in Gladiolus, where high pcv and gcv were reported for number of leaves per shoot.

A comparison of difference between pcv and gcv estimates showed much difference in respect of number of seeds per capsule, number of daughter corms, weight of single daughter corm, number of side shoots, number of capsules per shoot, Rachis length, durability of spike, number of side spikes and leaf area indicating greater environmental influence on expression of these characters.

Narrow difference between pcv and gcv were noticed for plant height, number of days to spike emergence, spike length, longevity of individual floret, polar diameter of daughter corm, floret diameter indicating the negligible role of environmental factors influencing expression of these characters. A similar trend of less environmental influence has been reported for number of tubers per plant, flower diameter and size of tubers by Choudhary (1987) in Dahlia; plant height, length of the spike and size of floret by Singh and Singh (1987) in Gladiolus. The characters showing the

least difference between pcv and gcv may be utilised in the selection programme.

The effectiveness of selection for any character depend not only on the amount of variability but also on the extent to which the variability is transferred from parent to offspring. The heritability estimates offers such a measure. It separates the environmental influence from the total variability and indicate the accuracy with which a genotype can be identified by its phenotypic performance thus making selection more effective. The heritable values were estimated in broad sense as suggested by Falconer (1964). As the values were estimated in the broad sense they include additive, dominance and epistatic gene effects. Its importance has been emphasised by Lush (1940) in animals and Johnson et al. (1955) in plants.

In the present study, there was high heritability for number of cormels, floret length, longevity of individual floret, days to spike emergence, plant height, spike length and 10-cormels weight. These results are in conformity with the findings of Arora and Khanna (1986), Singh and Singh (1987) and Negi et al. (1982) in *Gladiolus*, where high heritability was observed for

number of cormels per corm. Similarly high heritability was reported for days to spike emergence by Arora and Khanna (1986) in *Gladiolus*; number of days taken for bud initiation by Jaswinder Singh and Arora (1980) in *Antirrhinum majus*. High heritability was noticed for plant height and days for first floret to open by Negi et al. (1982), Gowda (1989) and Lal et al. (1985a) in *Gladiolus*; plant height and days to flowering by Sandha et al. (1977) in *Lotus corniculatus*, Hussein and Misiha (1979) in *Petunia hybrida*, Choudhary (1987) in *Dahlia*, Morgner and Horn (1970) in *Phlox paniculata* and Swarup et al. (1973) in *Hollylock*.

High heritability was obtained for the characters such as cormel weight by Negi et al. (1982) in *Gladiolus*; stalk length by Negi et al. (1983) in *China aster* and Wricke et al. (1982) in *Gerbera jamesonii*; spike length by Lal et al. (1985a) and Arora and Khanna (1986) in *Gladiolus*. Similarly high heritability was noticed for corolla tube length by Thangaraj et al. (1982) in *Jasminum auriculatus*, mean length of corolla tube by Drennan et al. (1986) in *Gerbera* and flower length and longevity of flower by Wahi and Bhattacharjee (1986) in *Hippeastrum hybridum*.

Contradictory results of low heritability were reported for petal length by Katsuyoshi and Harding (1969) in Portulaca grandiflora and floret length by Negi et al. (1982) in Gladiolus.

Heritability was moderate for number of florets remain open, number of florets open at a time, number of florets per spike, number of leaves, polar diameter of daughter corm, leaf area, floret diameter, Rachis length and number of capsules. The results are line with the findings of Negi et al. (1978) in Gladiolus where moderate heritability was noticed for size of the corm. Similar results were noticed for flower disc diameter by Wricke et al. (1982) and for petal width by Katsuyoshi and Harding (1969) in Portulaca grandiflora.

But the contrasting results were obtained by various workers for polar diameter of the corm, diameter of foremost flower and number of capsules (Misra and Saini, 1988), number of florets per spike (Lal et al., 1985a; Gowda, 1989) in Gladiolus, number of ray florets (Schiva, 1973) in Gerbera, flower size (Hussain and Misiha, 1979) in Petunia hybrida, flower diameter (Wahi and Bhattacharjee, 1986) in Hippeastrum, number of flowers per plant by Wricke et al. (1982) in Gerbera and Ponnuswami et al. (1985) in chrysanthemum, where

heritability was high for above mentioned characters. The characters like floret size by Negi et al. (1978), number of florets open at a time by Misra and Saini (1988) in *Gladiolus*, number of pods per inflorescence by Sandha et al. (1977) in *Lotus corniculatus*, cut flower yield by Harding et al. (1981b) in gerbera, where low heritability was noticed for above mentioned characters.

Low heritability was observed for number of side spikes, number of side shoots, number of corms, number of seeds per capsule, weight of daughter corm, equitorial diameter of daughter corm and durability of spike. Similar results were reported for bulb number and bulb weight by Weber and Horn (1978) in Tulip, number of spikes per plant by Jaswinder Singh and Arora (1980) in Snap dragon and Ponnuswami et al. (1986) in *Nerium oleander* and lasting quality of flowers by Alpi et al. (1968) in carnation.

The results obtained by other workers are quite opposite as Negi et al. (1982) for number of spikes and weight of corm produced, Singh and Singh (1987) for number of corms and number of side shoots, Misra and Saini (1988) for number of spikes in *Gladiolus* observed

high heritability whereas number of spikes (Negi et al., 1982) in *Gladiolus*, seeds per spike (Sandha et al., 1977) in *Lotus corniculatus* showed moderate heritability estimates.

Heritability estimates in broad sense alone donot serve as true indicators of the genetic potentiality of the genotypes since their scope is restricted by their interaction with the environment (Johnson et al., 1955). Hence, heritability values considered along with predicted genetic gain increases, the reliability of this parameter as a tool in selection programme (Panse, 1957).

In the present study, high genetic advance was noticed for number of cormels, followed by number of capsules, 10-cormel weight and number of seeds per capsule. The results are in conformation with the observations made in *Gladiolus* by Arora and Khanna (1986), Singh and Singh (1987), Negi et al. (1982), Misra and Saini (1988) where high genetic advance were recorded for number of cormels per corm. Similar results were recorded by Negi et al. (1982) in *Gladiolus* and Choudhary (1987) in *Dahlia* for weight of corms and weight of tubers respectively. The supporting results were recorded by Singh and Singh (1987) for number of corms and

Negi et al. (1982) for weight of cormels where above mentioned characters recorded high genetic advance over per cent mean.

Moderate per cent mean genetic advance was noticed for days to spike emergence, days for first floret to open, number of florets per spike, number of florets remain open and longevity of individual floret. Supporting results were reported by Misra and Saini (1988) for days to flowering in *Gladiolus* and number of flowers on main stem by Swarup et al. (1973) in hollyhock.

Low genetic advance was noted for number of side spikes, number of side shoots, equitorial diameter of corm, number of leaves, polar diameter of corm, floret diameter, floret length, durability of spike, plant height and spike length indicating non-additive gene effects. Low genetic advance were recorded for floret size by Negi et al. (1982), diameter of foremost flower by Misra and Saini (1988) in *Gladiolus*; flower diameter by Thangaraj et al. (1982) in *Jasminum auriculatum* and flower diameter by Lal et al. (1982) in Rose. Arora and Khanna (1986) reported similar results for spike length, Misra and Saini (1988) and Negi et al. (1982) obtained

supporting results for polar diameter of corm and size of corm respectively. Lal et al. (1985a) reported similar findings in *Gladiolus* for plant height and number of leaves. Thangaraj et al. (1982) also reported low genetic advance for corolla tube length and flower bud diameter. Similar results were reported by Ponnuswamy et al. (1985) plant height in *chrysanthemum*.

Contradictory results were obtained by Negi et al. (1982) for days taken to flower and Misra and Saini (1988) for number of capsules, where high genetic advance was encountered in *Gladiolus*.

In the present investigation, high heritability with high genetic advance were exhibited by the traits, number of cormels and 10-cormel weight. Selection based on phenotypic observations would be effective for these traits, which appears to be controlled by additive gene effects. These findings are in line with the earlier work of Misra and Saini (1988), Negi et al. (1982), Arora and Khanna (1986), Singh and Singh (1987) where high heritability combined with high genetic advance was obtained for number of cormels and weight of cormels in *gladiolus*. This indicates that high heritability obtained in these characters is probably due to additive gene effects (Panse, 1957).

High heritability with moderate genetic advance were observed for days to spike emergence, days for opening of first floret, number of florets per spike, longevity of individual floret, number of florets open at a time, and number of florets remain open. Similarly Misra and Saini (1988) obtained moderate to high heritability with moderate high genetic advance for days to flowering in *Gladiolus*. Singh and Singh (1987) obtained similar results for days to first floret open and total number of florets per plant in *Gladiolus*.

Contrasting results were reported by Lal et al. (1985a) and Gowda (1989) for number of florets per spike, Arora and Khanna (1986) for days to flowering in *Gladiolus* where high heritability with high genetic advance were encountered. Whereas Choudhary (1987) obtained high heritability coupled with low genetic advance for days to flowering in *Dahlia*.

High heritability with low genetic advance were obtained for plant height, spike length, floret length and polar diameter of corm. Similar results were obtained for polar diameter of corm by Misra and Saini (1988) and size of the corm by Negi et al. (1982) in

Gladiolus. Lal et al. (1985a) obtained high heritability with moderate genetic advance for plant height in Rose.

Moderate heritability with high genetic advance was recorded for leaf area, Rachis length, number of capsules and number of seeds per capsule. While moderate heritability with moderate genetic advance was noticed for number of corms and weight of corms. Similar results were reported by Misra and Saini (1988) for weight of the corm in Gladiolus.

Moderate heritability with low genetic advance were recorded for equitorial diameter of corm, durability of spike and floret diameter whereas low heritability with low genetic advance were noticed for number of side shoots and number of side spikes. Low heritability with low genetic advance is an indication of non-additive gene effects (Johnson et al., 1955) suggesting limiting scope for selection in respect of these characters from the available genotypes.

5.2. CORRELATION AND PATH ANALYSIS

Although variability estimates provide information on the extent of improvement possible in different characters, they donot throw light on the

extent and nature of relationship prevalent between the contributory characters and economically important characters. This could be obtained from simple association analysis that determine the direction of action of different characters. The estimate of genotypic correlations along with phenotypic correlations not only display a clear picture of the extent of inherent association, but also indicate the extent to which these phenotypically expressed correlations are influenced by the environment. Based on this analysis the traits that can be selected in improving the desired variables can be ascertained.

In the present investigation, the genotypic correlation coefficients were higher than the phenotypic correlation coefficients for most of the characters studied.

A similar trend has been observed in *Gladiolus* by Lal et al. (1985b) and Gowda (1989); Irulappan and Rao (1980a) and Lal et al. (1983) in Rose. These findings indicate that though there is strong inherent association between various characters the phenotypic expression is lessened under the influence of environment.

The present correlation studies revealed that number of florets per spike was positively and

significantly associated with Rachis length, spike length, durability of spike, plant height, days to spike emergence, days for opening of first floret, leaf area and number of leaves at both phenotypic and genotypic levels. There was a significant, negative association with number of side shoots, diameter of corm, weight of corm, and number of cormels produced per corm. Number of florets per spike recorded positive and significant association with number of corms and 10-cormel weight only at genotypic level.

Positive association of number of florets per spike with leaf number and days to flower was confirmed by Lal et al. (1985b) and Gowda (1989) in *Gladiolus*. Shanmugam et al. (1972) noticed significant positive correlation of flower yield with duration of flowering, number of days for first flowering and size of flower in *chrysanthemum*. Negative correlation of early flowers with number of stems was reported in carnations by Ozawa (1962). Swarup et al. (1973) reported positive correlation of the flowers on main stem and side branches with plant height in *Althea rosea*. Negi et al. (1982) in *Gladiolus* reported positive association of number of florets per spike with Rachis length, floret size and contradictory results for weight of corm produced.

Similar positive inter-relationship between number of flowers per plant and days to flower has been reported by Misra et al. (1987) in Dahlia. Positive association of number of flowers with number of leaves was reported by Wahi and Bhattacharjee (1986) in Hippeastrum hybridum.

Contradictory results were obtained for number of flowers on main and side branches with days to flowering in Althea rosea; number of flowers with number of side shoots by Horn et al. (1983) in Gerbera jamesonii, Singh and Singh (1974) in Gladiolus; number of flowers with number of shoots by Wahi and Bhattacharjee (1986) in Hippeastrum hybridum, where positive correlation was noticed in above recorded characters.

Spike length was positively and strongly associated with Rachis length, plant height, number of florets per spike, floret diameter, floret length, leaf area, days for opening of first floret, weight of corm and equitorial diameter of corm at both genotypic and phenotypic levels. It was found to be significantly associated with number of side shoots at genotypic level only. Similar results were obtained by Negi et al. (1978) where positive correlation was encountered for spike length with Rachis length, number of florets per

spike, weight of corm, size of corm and breadth of leaves in *Gladiolus*. Lal et al. (1985b) in *Gladiolus* got supporting results, where spike length was positively correlated with plant height, Negi et al. (1983) and Manjunath Rao (1982) reported positive association of stalk length with flower size, plant height and days taken to flower in *China aster*.

Floret diameter was positively and strongly correlated with floret length, spike length, plant height, number of florets per spike, Rachis length, days for opening of first floret at both genotypic and phenotypic levels. The association was significant and negative for number of shoots at genotypic level.

Positive correlation of floret size with plant height and days to flower was conformed by Negi et al. (1983) and Manjunath Rao (1982) in *China aster*. Positive correlation between days to flowering with flower size was reported by Swarup et al. (1973) in *Althea rosea*.

Positive inter-relationship of number of flowers, stalk length and floret diameter between themselves and with plant height and days to flower was conformed by Manjunath Rao (1982). In *Portulaca grandiflora*,

Katsuyoshi and Harding (1969) had also found that selection for larger flowers was not expected to reduce the number of flowers produced.

Plant height was significantly and positively correlated with days to flowering reported by Vemato (1964) in Antirrhinum majus was in conformity with the present investigation. Similarly Vries and Dubois (1977) found positive and significant correlation of length of seedlings at first flowering with shoot lengths of the same plant in hybrid tea rose.

In the present study, floret diameter is highly significantly and positively correlated with floret length, which was conformed by Katsuyoshi and Harding (1969) in Portulaca grandiflora. Wahi and Bhattacharjee (1986) reported that number of bulbs positively associated with number of shoots, which is in conformity with the present findings. Weight of corms produced had significant positive correlation with breadth of leaves (Negi et al., 1978) in Gladiolus.

Path coefficient analysis

Though correlation coefficient measures the association between any two characters, it fails to give

a complete picture of the other characters involved in the complicated pathway leading to the endpoint. Therefore significant correlation is no proof of direct or causal relationship. Thus correlations together with path coefficient values will be more useful in finding out character associations. Path coefficient analysis furnishes a means of partitioning, the direct and indirect effects through other variables, and measures the relative importance of the causal factor involved. The utility of path analysis in plant selection was demonstrated by Dewey and Lu (1959) in crested wheat grass. In the present study, the characters showing high correlation coefficients at phenotypic level were selected and partitioned into direct and indirect effects through path coefficient analysis.

Path coefficient analysis for spike length as dependent variable showed that plant height had the maximum direct effect followed by Rachis length and floret length. Positive and highly significant phenotypic correlation of spike length with plant height and Rachis length were mainly due to their respective direct effects. Direct effect of number of florets per spike, and weight of daughter corm were low to medium but their phenotypic correlations were positive and significant indicating high indirect effects.

Though number of leaves, leaf area and floret diameter recorded negative direct effects, their phenotypic correlation with spike length was positive and significant indicating high indirect effects of the characters on spike length. Residual factor of 15.08 per cent obtained included all other factors affecting spike length in this study.

Similar results were obtained by Manjunath Rao (1982) in China aster, where plant height had direct effect on stalk length and number of flowers per plant had high total indirect effect on stalk length.

The results of path coefficient analysis with floret diameter as dependent variable indicated that among the characters studied, floret length showed the highest positive direct effect on floret diameter followed by plant height and days for opening of first floret. In spite of negligible positive direct effect of number of florets per spike and Rachis length, their phenotypic correlations were positive and highly significant. Spike length, number of leaves and leaf area had negative direct effect on floret diameter indicating high positive indirect effects.

The residual effect indicated that 31.66 per cent of variation in floret diameter was due to known

factors and 68.34 per cent of variation was contributed by the characters studied.

Contradictory results were reported by Manjunath Rao (1982), where negative direct effect was recorded by plant height on flower size in China aster.

Path coefficient analysis of number of florets per spike revealed that spike length and Rachis length were the major factors influencing number of florets per spike directly. The phenotypic correlation of spike length and Rachis length with number of florets per spike were mainly due to their direct effects. The direct effect of durability of spike and days to spike emergence on number of florets was moderate and positive, but their phenotypic correlation with number of florets per spike was positive and significant showing that these characters had high indirect effect on spike length. The direct influence of leaf area, plant height, floret diameter and number of leaves were low and negative but these characters had positive significant phenotypic correlation showing that these characters had purely indirect effects on number of florets per spike.

The residual effects indicated that the characters studied contributed 67.45 per cent of

variation in number of florets per spike while 32.50 per cent was due to known factors like other characters which were not included in the analysis.

Similar result was obtained by Singh and Singh (1983) in *Gladiolus* where spike length had a direct effect on number of florets per spike.

SUMMARY

VI. SUMMARY

A study to understand the nature and magnitude of variability, heritability and genetic advance, association of different characters, and direct and indirect effects of each component character on spike length, floret diameter and number of florets per spike was carried out in twenty five genotypes of Gladiolus grandiflorum L. at the Division of Horticulture, Gandhi Krishi Vignana Kendra, University of Agricultural Sciences, Bangalore during the year 1989-90.

The salient features of the experimental findings are summarised below.

The analysis of variance revealed significant differences among genotypes for all the twenty four characters studied. High degree of variability was recorded for all the characters except number of side shoots and number of side spikes.

Phenotypic and genotypic coefficient of variation estimates were closer for the characters such as floret length, number of leaves, plant height, days taken to spike emergence, spike length, longevity of individual floret, polar diameter of daughter corm, and floret

diameter. High pcv and gcv were observed for leaf area, Rachis length, number of capsules, number of seeds per capsule, number of daughter corms, number of cormels, weight of daughter corm and 10-cormel weight. Pcv and gcv were low for number of side spikes, floret diameter, floret length and number of leaves.

High broad sense heritability estimates were noticed for number of cormels, floret length, longevity of individual floret, days to spike emergence, spike length and 10-cormel weight. Heritability was moderate for number of florets open at a time, number of florets per spike, number of leaves, polar diameter of daughter corm, leaf area, floret diameter, Rachis length and number of capsules.

Genetic advance as percentage of mean was high for number of cormels, number of capsules, 10-cormel weight, and number of seeds per capsule. Genetic advance was moderate for leaf area, Rachis length, number of corms, weight of daughter corm, days to spike emergence, days for opening of first floret, number of florets per spike, number of florets remain open and longevity of individual floret.

Among the characters studied, number of cormels and 10-cormel weight exhibited high heritability combined

with high genetic advance while days to spike emergence, days for first floret to open, number of florets per spike, number of florets open at a time and number of florets remain open showed high heritability with moderate genetic advance. Leaf area, Rachis length, number of capsules and number of seeds per capsule had moderate heritability with high genetic advance while number of daughter corms and weight of daughter corm had medium heritability with medium genetic advance.

Correlation studies revealed positive and significant association of spike length with Rachis length, plant height, number of florets per spike, floret diameter, floret length, leaf area, days for first floret to open, weight of daughter corm and equitorial diameter of corm at both phenotypic and genotypic levels. Number of side shoots was negatively associated with spike length at genotypic level.

Floret diameter was positively and strongly associated with floret length, spike length, plant height, number of florets per spike, Rachis length, days for opening of first floret at both phenotypic and genotypic levels. The association of floret diameter with number of side shoots was significant and negative.

Number of florets per spike had significant positive association with Rachis length, spike length, durability of spike, plant height, days to spike emergence, days for opening of first floret, leaf area and number of leaves at both phenotypic and genotypic levels. It had a significant negative relation with number of side shoots, diameter of corm, weight of daughter corm and number of cormels produced per corm.

Among the intercomponental correlations all characters exhibited high positive correlations among themselves except number of cormels and 10-cormel weight, which had negative correlations with most of the characters studied.

Path coefficient analysis disclosed a high magnitude of positive direct effects of plant height, Rachis length and floret length on spike length. Number of florets per spike and weight of daughter corm also showed positive direct effects. The indirect effects of plant height, Rachis length were positive through all the characters.

Floret length and plant height exhibited a high magnitude of direct effect on floret diameter, while days for opening of first floret, number of florets per spike

and Rachis length showed considerable positive direct effect on floret diameter.

Spike length, Rachis length, durability of spike and days to spike emergence showed positive direct effects on number of florets per spike. These characters had positive indirect effects through all other characters such as plant height, number of leaves, leaf area, and floret diameter.

The genotypes Agnirekha, Mansoor red, Moon magic and Oscar red were found to be superior for cut flower purpose with spike length ranging from 118.85-137.97 cm, floret size ranging from 7.62-9.45 cm and number of florets per spike ranging from 12.00-15.00. These genotypes can be utilised as parent material in further breeding programme for obtaining superior hybrids.

REFERENCES

VII. REFERENCES

- Alpi,A., Buiatti,M. and Baroncelli,S., 1968, Some data on the polygenic control of two quantitative characters (traits) in a vegetatively propagated flower plant, the carnation. Theoret.Appl.Genet., 38:298-300.
- Anonymous, 1990, Package of practices for cultivation of flower crops, UAS, Bangalore, IIHR, Bangalore and Directorate of Horticulture.
- Arora,J.S. and Khanna,K., 1986, Variability studies in some quantitative characters in gladiolus. J.Res., 23(4):578-582.
- Bankar,G.J. and Mukhopadhyay,A., 1980, Varietal trial on tuberose (Polianthes tuberosa L.). South Indian Hort., 28(4):150-151.
- *Besscetnova,M.V., 1970, Correlation between some morphological features in Roses. Trudy Bot. Sadov.Akad.Nauk.Kuz.SSR., 11:89-92.
- Buch,P.O., 1972, The World of Gladiolus, North Amer.Glad. Conn., pp.3-7.
- Burton,G.W. and Devane,E.H., 1953, Estimating heritability in tall Fescue (Festuca arundinacea) from replicated clonal material. Agron.J., 45:478-481.
- Byrne,T., Drennan,D. and Harding,J., 1987, Genotype x environment interaction bias in heritability estimates for cut flower yield of greenhouse gerberas. J.Amer.Soc.Hort.Sci., 112(4):724-727.
- *Chang,K.V., 1977, Studies on the genus Paeonia II. Characteristics and correlations between various quantitative characters of Paeonia suffruticosa cultivars. J.Korean Soc.Hort. Sci., 18(2):181-186 (Hort.Abstr., 48:10724).
- Charles,D.R. and Smith,H.H., 1939, Distinguishing between two types of gene action in quantitative inheritance. Genetics, 24:34-48.

- Choudhary, M.L., 1987, Genetic variability in Dahlia. Prog. Hort., 19(1-2):58-60.
- *Cocozza, M., Porceddu, E. and Stellacci, P., 1980, (Genetic variability in gerbera), 163-177. Instituto di Agronomia, 70126 Bari, Italy.
- Dewey, D.R. and Lu, K.U., 1959, A correlation path coefficient analysis of components of crested wheat grass production. Agron. J., 51:515-518.
- Drennan, D., Harding, J. and Byrne, T.G., 1986, Heritability of inflorescence and floret traits in gerbera. Euphytica, 35(1):319-330.
- East, E.M., 1916, Studies on size inheritance in Nicotianum. Genetics, 1:164-176.
- Falconer, D.S., 1964, Introduction to quantitative genetics. Oliver and Boyd, Edinburgh.
- *Fisher, R.A., 1918, The correlation between relatives on the supposition of Mendelian inheritance. Trans. Roy. Soc. Edinburgh, 52:399-433.
- Fisher, R.A. and Yates, F., 1963, Statistical tables for Biological, Agricultural and Medical Research. Oliver and Boyd Ltd., Edinburgh.
- Galton, F., 1889, Natural inheritance. McMillan and Co., London.
- Goulden, C.H., 1959, Methods of Statistical analysis. John Wiley and Sons, Inc., New York.
- Gowda, J.V.N., 1989, Genetic and phenotypic variability and correlation in quantitative and qualitative characters in gladiolus. Crop Res., 2(2):235-237.
- Hanson, C.H., Robinson, H.F. and Comstock, R.E., 1956, Biometrical studies of yield in segregating populations of Korean Lespedeza. Agron. J., 48:268-272.
- Harding, J., Byrne, T.G. and Nelson, R.L., 1981a, Estimation of heritability and response to selection for cut-flower yield in gerbera. Euphytica, 26:113-122.

- *Jobson, M. and Hanan, J.J., 1977, Rose variability. Bulletin Colorado flower grower's association, No.328:5-6.
- *Johannsen, W.L., 1909, Elements des exatetes exblich Keitslehre Gustun Fisher.
- Johnson, H.W., Robinson, H.F. and Comstock, R.E., 1955, Estimates of genetic and environmental variability in soybeans. Agron.J., 47:314-318.
- Karmakar, P.G. and Srivastava, H.C., 1986, Correlation and path analysis in pin and thrum types of open pollinated progeny in Jasminum auriculatum Vahl. Herba Hungarica, 25(2):119-128.
- Katsuyoshi, K. and Harding, J., 1969, Genetic and environmental variation for corolla traits in Portulaca grandiflora. J.Hort.Sci., 44:37-47.
- Khan, W.M.A. and Muthuswamy, A., 1970, Some morphological variants of Jasminum auriculatum Vahl. South Indian Hort., 17:95-96.
- Lal, S.D., Seth, J.N., Yadav, J.P. and Dann, N.S., 1982, Genetic variability and correlation studies in Rose I - Phenotypic variability, heritability and genetic advance. Prog.Hort., 14(4):234-236.
- Lal, S.D., Seth, J.N. and Dann, N.S., 1983, Genetic variability and correlation studies in Rose II. Correlations of important quantitative characters. Prog.Hort., 15(1-2):116-118.
- Lal, S.D., Shah, A. and Seth, J.N., 1985b, Genetic variability in Gladiolus II. Correlations between important yield contributing characters. Prog.Hort., 17(1):31-34.
- Lal, S.D., Shah, A. and Seth, J.N., 1985a, Genetic variability in gladiolus I. Phenotypic variability and its heritable components in some important quantitative characters contributing towards spike weight. Prog.Hort., 17(1):28-30.
- *Lush, J.L., 1940, Inter-size correlation regression of offspring on dams as a method of estimating heritability of characters. Proc.Amer.Soc. Animal Prod., 33:293-301.

- Harding, J., Byrne, T. and Nelson, R.L., 1981b, Heritability of cut-flower vase longevity in gerbera. Euphytica, 30(3):653-657.
- Hazel, L.N., 1943, Genetic basis for constructing selection indices. Genetics, 28:476-490.
- *Horn, W., Wrickle, G. and Weber, W.E., 1974, Genotypic and environmental effects on character expression in Gerbera jamesonii. Gartenbauwissenschaft, 39(3):289-300.
- Horn, W., Bachthaler, E. and Dohm, M., 1979, Correlation between the seedling generation and the subsequent clonal generations in Pelargonium zonale hybrids. Zeitschrift fur Pflanzen-Zuchtung, 82(3):271-277.
- Hussein, H.A.S. and Misiha, 1979, Diallel analysis for some quantitative characters in Petunia hybrida Hort. Theoret. Appl. Genet., 54:17-25.
- Indiresh, K.M., 1982, Studies on the performance of open pollinated seedlings of Jasmine (Jasminum auriculatum Vahl.). M.Sc(Hort) Thesis submitted to UAS, Bangalore, India.
- Indiresha, K.M., Rao, J.V.R.B. and Prakash, K.S., 1986, Path analysis for floral traits in Jasminum auriculatum. South Ind. Hort., 34(5):355-357.
- Irulappan, I. and Rao, V.N.M., 1980a, Genotypic, phenotypic and environmental correlations of seven important quantitative characters in Edward Rose (Rosa bourboriana Desp). In "National Seminar on Production technology for commercial flower crops". pp.57-59, TNAU, Coimbatore.
- Irulappan, I. and Rao, V.N.M., 1980b, Path coefficient analysis of flower yield in Edward Rose (Rosa bourboriana Desp). In "National Seminar on Production Technology for commercial flower Crops". pp.60-62, TNAU, Coimbatore.
- Jaswinder Singh and Arora, J.S., 1980, Variability studies on some quantitative characters in Snap dragon (Antirrhinum majus). J. Res., 17(3):258-261.

- *Lush, J.L., 1949, Heritability of quantitative characters on Farm animals. Proc. 8th Congr. Genet. 1948, Hereditas Suppl., 356-375.
- Manjunath Rao, T., 1982, Studies on genetic variability and correlation in China aster (Callistephus chinensis L., nees). M.Sc(Ag) Thesis submitted to UAS, Bangalore, India.
- Misra, R.L., Verma, T.S., Thakur, P.C. and Singh, B., 1987, Variability and correlation studies in Dahlia. Indian J. Hort., **44**(3&4):269-273.
- Misra, R.L. and Saini, H.C., 1988, Genotypic and phenotypic variability in Gladiolus. Indian J. Hort., **45**(1&2):148-152.
- Mohamad, A.W., Muthuswamy, S. and Raman, K.R., 1970, An evaluation of morphological variations of economic values in Jasminum sambac Ait. South Ind. Hort., **18**:25-32.
- More, T.A., 1980, Studies on correlation, regression and path analysis in Jasminum sp. Haryana J. Hort. Sci., **9**(3-4):146-151.
- Morgner, F. and Horn, W., 1970, Biometric and Genetic investigations on clones and progenies of Phlox paniculata L. Theoret. Appl. Genet., **40**:130-137.
- Muthuswamy, S., Thangaraj, T. and Pappaiah, C.M., 1972, Variations in flower characters of Jasminum auriculatum Vahl. seedlings. South Indian Hort., **20**:87.
- Negi, S.S., Sharma, T.V.R.S., Raghava, S.P.S. and Ramachander, P.R., 1978, Studies on heritability and inter-relationship among various characters in Gladiolus. 20th Intern. Hort. Cong. held in Sydney, Australia in August 1978 (Abstr., 1883).
- Negi, S.S., Sharma, T.V.R.S., Raghava, S.P.S. and Srinivasan, V.R., 1982, Variability studies in gladiolus. Indian J. Hort., **39**(3):265-69.
- Negi, S.S., Raghava, S.P.S., Sharma, T.V.R.S. and Srinivasan, P.R., 1983, Studies on variability and correlation in China aster (Callistephus chinensis nees). Ind. J. Hort., **40**:102-106.

- *Nilson Ehle, H., 1909, Krenzung Untersun Chungen on Hayer and Weizen. Jundi Univ. Arsseter, N.F. Affel., 2:1-22.
- *Ober, D.E., 1955, The genetics of variants of the William Sim carnation. Diss. Abstr., 15:1298.
- *Ozawa, H., 1962, Studies on the perpetual carnation in the greenhouse 1. Correlation between leaf type and flowering habit of the variety "Peter Fisher" 2. Experiments on strain selection from the variety Peterfisher. Bul. Kanagaura Hort. Exp. Stat., No.10, pp.77-84.
- Panse, V.G., 1957, Genetics of quantitative characters in relation to plant breeding. Indian J. Genet., 17:318-328.
- Panse, V.G. and Sukhatme, P.V., 1961, Statistical methods for Agricultural workers, I.C.A.R., New Delhi.
- Ponnuswami, V., Chezhiyan, N., Khader, J.N.A. and Thamburaj, S., 1985, Genetic variability in chrysanthemum. South Ind. Hort., 33(3):211-213.
- Ponnuswami, V., Chezhiyan, N., Thamburaj, S., Abdul Khader, M.D.P. and Rangaswami, P., 1986, Biometrical studies in Nerium oleander. South Ind. Hort., 34(5):358-359.
- Power, L., 1942, The nature of the series of environmental variances and the geometric means of involving species of Lycopersicon. Genetics, 27:561-575.
- *Power, L., Locke, L.F. and Garret, J.C., 1950, Partitioning method of genetic analysis applied to quantitative characters of tomato crossess. USA Tech. Bull., 998:56.
- Rabinowitch, H.D., Arthur, A.E. and Hadley, C.L., 1977, Biometrical analyses of some economically important characters in Antirrhinum majus. Theoret. Appl. Genet., 49(1):35-42.
- Sandha, G.S., Twamley, B.E. and Christie, B.R., 1977, Analysis of quantitative variability for seed yield and related characters in Lotus corniculatus L. cv. Leo. Euphytica, 26:113-122.

- *Schiva, T., 1973, Analisi dei caratteri metrici di importanza commerciale Su "Gerbera jamesoni" conseguenze dell'incroci [Analyses of biometric characteristics of commercial importance in Gerbera jamesonii and the consequence of inbreeding]. Annali della Facoltà di Scienze Agrarie della università degli studi di Torino., 8:355-356 (Hort. Abstr., 45:7606).
- *Schiva, T., 1974, Breeding gerberas. Genetic analysis of quantitative characters of commercial importance and the results of inbreeding-II. Annali dell'Istituto Sperimentale per la Floricoltura, 5(2):27-36.
- Shanmugam, A., Muthuswamy, S. and Srinivasan, N., 1972, Interrelationship between yield and certain growth and floral attributes in two chrysanthemum varieties (Chrysanthemum indicum L.). South Indian Hort., 20:85-86.
- Singh, B. and Swarup, V., 1973, Inheritance of flowering, flower weight and flower number in African marigold. Indian J. Genet., 33(2):172-175.
- Singh, R.K. and Choudhary, B.D., 1979, Biometrical methods in quantitative genetic analysis. Kalyani Pub., Ludhiana.
- Singh, B. and Singh, M., 1983, Correlation and path coefficient studies in Gladiolus. XV Intern. Cong. Genet., Delhi, Pt. II(1112):616.
- Singh, B. and Singh, M., 1987, Studies on variability and genetic parameters in Gladiolus. Prog. Hort., 19(3-4):271-275.
- Srivastava, H.C. and Devaiah, R.A., 1988, Correlation and path analysis in Jasmine. Z. Pflanzenzucht., 100(3):235-237.
- Sundararaj, N., Nagaraju, S., Venkataramu, M.N. and Jagannath, M.K., 1972, Design and Analysis of field experiments, UAS, Bangalore.
- Svejda, F., 1977, Breeding for improvement of flowering attributes of winter hardy Rosa kardesii Wuff. hybrids. Euphytica, 26(3):697-701.

- Swarup,V., Raghava,S.P.S. and Balakrishnan,K.A., 1973, Genetical studies in Hollyhock. Indian J. Genet., 33:446-451.
- Thangaraj,T., Muthukrishna,C.R. and Muthuswamy,S., 1981, Studies on the evaluation and selection from open pollinated progenies of Jasminum auriculatum Vahl. South Indian Hort., 29(3):143-148.
- Thangaraj,T., Muthukrishnan,T.N. and Muthuswamy,S., 1982, Studies on the variability, Genetic advance and heritability in flower characters of open pollinated seedlings of Jasminum auriculatum Vahl. Indian J.Hort., 39:125-129.
- *Topalov, 1961, Variability in a population of the Kazantah essential oil Rose. Abstr.bulg.Sci. Lit., 7, No.1.
- Uemoto,S., 1964, Studies on F hybrids of the Snap dragon, Antirrhinum majus L. 1. On several ecological characteristics of various diploid hybrid forms. Sci.Bull.Fac.Agric.Kyushu.Univ., 21:185-213 (Hort.Abstr., 35:6067).
- Vries,D.P.D.E. and Dubois,L.A.M., 1977, Early selection in hybrid tea rose seedlings for cut stem length. Euphytica, 26:761-764.
- Wahi,S.D. and Bhattacharjee,S.K., 1986, Correlation and path coefficient analysis in Hippeastrum hybridum. South Indian Hort., 34(4):244-251.
- Weber,W.E. and Horn,W., 1978, Quantitative genetic investigations on production of tulip bulbs. Zeitschrift fur Pflanzenzuchtung, 81(2):176-187.
- Wricke,G., Weber,W.E. and Otteleben,R., 1982, Analysis of genetic variance of quantitatively inherited characteristics of Gerbera. Z.Pflanzenzucht, 89(4):329-336.
- Wright,S., 1921, Correlation and Causation. J.Agric. Res., 20:557-585.

*Original not seen.

APPENDIX

Appendix I. Meteorological data as recorded at the Horticultural Research Station, G.K.V.K., University of Agricultural Sciences, Bangalore, for the period from February to September 1990

Month	Mean temperature(°C)		Sunshine (hrs/day)	Mean relative humidity (%)	Total rainfall (mm)
	Maximum	Minimum			
February	30.33	14.24	10.28	60.68	0.00
March	31.85	18.02	8.60	55.65	5.89
April	34.57	20.46	8.89	50.60	2.61
May	30.75	19.22	6.88	63.90	116.25
June	28.99	18.00	5.32	67.73	53.10
July	28.08	17.14	4.56	69.16	31.20
August	26.60	17.11	4.21	74.71	63.90
September	28.20	19.39	5.55	68.30	92.60

అనువృత్తి నం. **Tn. 2557**
-1 నం.