FLORAL BIOLOGY AND COMPATIBILITY IN GLADIOLUS

By

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THESIS

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DECLARATION

I hereby declare that the thesis entitled **'Floral biology and compatibility in gladiolus'** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, fellowship or other similar title of any other University or Society.

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We, the undersigned members of the Advisory Committee of **Ms. V. JISHA,** a candidate for the degree of **Master of Science in Horticulture,** agree that the thesis entitled **'Floral biology and compatibility in gladiolus'** may be submitted by Ms. V. JISHA, in partial fulfilment of the requirement for the degree.

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DEDICATED TO

MY BELOVED

ACHHAN AND AMMA

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

Introduction

INTRODUCTION

Flowers symbolize purity, beauty, peace, love and passion. Floriculture is an intensive type of agriculture and the income per unit area from floriculture is much higher than any other branch of agriculture. Floriculture is fast emerging major venture in the world scenario. In India, floriculture is only a developing subject and as such offers much scope for improvement. Despite its diverse eco-geographical regions, varied climatic conditions, rich native flora and access to modern technology, India has yet to make dent in the international market.

Bulbous ornamentals constitute one of the most important groups of the floriculture wealth of the country. No garden is complete unless it has a patch of bulbous plants. The beauty, fragrance, long lasting spike, wide range of colour and form make them the most attractive group among flowers.

Gladiolus has a special position among the bulbous plants because of its attractive spike, having florets of different forms, sizes and longer keeping quality. It is called queen of the bulbous plants. Gladiolus belongs to the family iridaceae. The genus *Gladiolus* is represented by 180 species. Gladiolus is used commercially as a cut flower for interior decoration and for making bouquets.

It is one of the leading commercial bulbous flowers throughout the world and ranks next to tulip in Holland. Every year some 200 cultivars are

added to the existing list of cultivars and nearly the same number is relegated because of degeneration. Although the distribution of the crop is seen from north to south and east to west of the country, yet the acreage under the states is varied depending on the market demand and climatic suitability. The acreage under the flower seems to be much higher in the states like Karnataka, Punjab, Uttar Pradesh, Tamil Nadu, Delhi, Sikkim and Himachal Pradesh. In Karnataka the unique climatic condition providing opportunity to cultivate the flowers throughout the year and huge market demand have allured the farmers to grow the crop in larger area on a rotational basis.

The improvement in gladiolus has remained more or less stationary in India in the recent past due to non-availability of germplasm of divergent forms. However, the universal approach in its breeding has been unidirectional in most of the countries.

Gladiolus is a relatively new introduction to Kerala and the earlier trials in All India Co-ordinated Floriculture Improvement Project, Vellanikkara indicated the feasibility of this crop for commercial exploitation in Kerala and as such development of new varieties tailored to Kerala conditions assumes top priority.

Before starting any hybridization programme, the basic knowledge of floral biology of any plant is of utmost importance. The understanding of proper stage of pollination for efficient fertilization is another pre-requisite. If two varieties are non-synchronous in flower opening, the chances for using such combinations are rare in crossing programme. In such cases, stored pollen

will be beneficial. Moreover, to overcome the adversities, a knowledge of proper medium for quick germination of pollen grains will be of added advantage. For planning an effective selection strategy, understanding the interrelationships among yield and its component characters is of vital importance. The information on heritability with genetic advance for different parameters will help the breeder to identify the characters to be relied upon and to decide the breeding strategies to get quality blooms and maximum corm production. In order to select suitable parents for improvement programmes, compatibility between varieties are to be understood.

Keeping this in view, the present investigation was undertaken with the following objectives.

(1) To evaluate the gladiolus varieties for their vegetative and floral characters

(2) To study the floral biology of gladiolus varieties

(3) To estimate the pollen production, pollen fertility, germination and pollen viability during storage

(4) To study the extent of compatibility among different varieties of gladiolus along with the viability of hybrid seeds

Review of literature

REVIEW OF LITERATURE

The knowledge of floral biology, pollen and pollination has become indispensable in the field of breeding of ornamental plants owing to its potentialities in the breeding for improving various non-synchronous cultivars. Gladioli are improved for various characters like spike length, number of florets, colour of florets, number of corms and cormels per plant, etc. Moreover, to overcome the adversities, a knowledge on proper medium for quick germination of pollen grains will be of much advantage in gladiolus. A few outstanding varieties or strains are very healthy and sturdy but do not set seed. To overcome such adversities, aided pollination through certain effective chemicals may result in seed setting. The proper stage of pollination for efficient fertilization should also be known. For successful breeding programme, knowledge about the presence of adequate genetic advance and genetic divergence in a population and extension of association between characters is essential. To corroborate the work, an attempt has, therefore, been made to review the literature on floral biology, pollen and pollination studies in gladiolus and other plants, which has been presented below.

2.1 Floral biology

The particular type of inflorescence characteristic of gladiolus is a spike as such, the individual florets are attached directly to the axis. Like many monocotyledons, gladiolus florets also possess floral parts in threes. The

outermost three segments make up the calyx (sepals) and the next whorl of three segments comprise the corolla (true petals). Sepals and petals collectively form the perianth of the flower. The perianth surrounds three stamens and a tricarpellary pistil with three-forked stigma. The ovary has 75 to 150 ovules. Each flower bud is enclosed separately within its own spathe which consists of two green bracts (Randhawa and Mukhopadhyay, 1986).

Rao and Ram (1981) reported that in the tight bud stage the buds were nearly twice as heavy as in the younger green bud spikes. Flowers from green bud spikes were smaller and less coloured. The peduncle did not elongate between the green bud and tight bud stages but the flowering axis did so that spikes of any desired length could be harvested. It was reported that the inflorescence of gladiolus is spike with sessile hermaphrodite florets. The flower buds take, on an average, 16 days to reach the full bloom stage. The anther dehiscence is between 8.00 and 9.30 a.m. following the anthesis (Negi and Raghava, 1986).

Shah *et al.*(1988) reported the floral biology of gladiolus cv. Mother Fischer, Gospel Song, King Lear, Apple Blossom, Marie Gorette, Carmine, Her Majesty, Happy End, Spite and Glossy in Chaubattia of Uttar Pradesh. Number of days from planting to appearance of inflorescence, full emergence of inflorescence, first flower separation, colour appearance on the first tight bud, loosening of the first bud, and the complete opening of the first floret were

described along with the time of the day when anthesis and dehiscence occurred and also the period of stigma receptivity.

Sedal'-nikova (1989) reported that gladiolus normally with trilobed stigma showed anomalies in stigma structure with higher solar radiation i.e. 42-48 $kcal.cm^{-2}$. There were stigmas with four or six lobes alongside the flowers with normal three lobes in some foreign and local cultivars whereas in some cvs four or six lobed stigmas were found throughout the entire inflorescence.

2.1.1 Anthesis, anther dehiscence and stigma receptivity

Croat (1980) stated that modes of flowering behaviour probably have a direct influence on pollination biology and evolution. The process of emergence of anthers, their dehiscence and distribution of pollen is termed anthesis. The details of anthesis vary from one crop species to another. They are also greatly affected by environmental factors such as humidity and termperature (Singh, 1990).

Misra (1975) reported the optimum time for anther dehiscence as 11 a.m. in various cultivars of gladiolus, viz. Sans Souci, Vinks Glory, Ratna's Butterfly, Thunderbird and Pactolus. Roychoudhary (1980) observed that it took 16 days for full development of buds and anthesis and 20 to 24 hours for complete opening of flower. He observed anther dehiscence was taking place mostly between 8 and 9.30 a.m.. following the anthesis and stigma remaing receptive for 24 hours in *Gladiolus psittacinus.* Kumar and Nainan (1980) reported that

stigma becomes receptive after 24 hours of flower opening in *Gladiolus psittacinus* and three stylodia are forced apart, the cleft formed being filled in by mucilage derived from the inner secretory cells. Mature stigma was of dry type and became little shiny during receptive stage.

Ohri and Khoshoo (1981) reported that the anthesis occurred between 8.15 a.m. and 10.15 a.m., followed immediately by anther dehiscence in gladiolus under Lucknow conditions in India. Structure and placement of stamens and stigma suggests that gladiolus is essentially outcrossing. Stigma became receptive nearly 1.5 hours later. Maximum pod development was observed in hand-pollinated flowers, while bagged flowers produced no seed.

Singh and Singh (1985) observed the peak period for anthesis in cultivars George Mazure and Ratna's Butterfly was from 3 a.m. to 6 a.m. which continued up to 10 a.m. The peak period of anther dehiscence was from 7 to 10 a.m. for George Mazure and 8 to 11 a.m. for Ratna's Butterfly. Stigma was found to be receptive one day before anthesis and maximum receptivity was observed on the day of anthesis followed by one day after anthesis. They also described the days to first appearance of the inflorescence, days to full emergence of the inflorescence, days to first floret sepraration, days to tight bud colouring, days to first bud loosening, days to complete opening of the first floret.

As per Randhawa and Mukhopadhyay (1986) the stigma is at a distance above the anthers and does not become receptive until it is feathery. Shah *et al.* (1988) reported that the peak period for anthesis in many cultivars of gladiolus is

between 8 a.m. and 10 a.m. He observed that the anthesis is being completed the same day. It started between 4.00 and 5.00 a.m. and continued upto 11.30 a.m. in almost all the cultivars except in Spite, Carmine and Gospel Song where the anthesis started earlier at 3.00 to 4.00 a.m. and was over at 10.30 a.m. under U.P. hill conditions.

2.2 Pollination studies

Studies conducted by Misra and Singh (1989) revealed that in gladiolus the stigma generally becomes receptive on the third day of the opening of the flowers or anther maturity. So pollination done on the third day resulted in maximum capsule and seed set. Timchenko (1990) found Applance, Bibi, Buckeroo, Garnet Ruffles, Morocco, Priscilla, Sabre, Shell Pink, Swiss Chocolate, Gimkosmonvtam and Soyuz 20 as best pollinators in gladiolus where pollen viability was more than 80 per cent. However, Applance, Morroco, Shokoladnitra, Soyuz 20 and Swiss Chocolate were observed to be best maternal parents.

Mahawer and Misra (1993a) based on pollination studies of gladialus reported that the pollen used for pollination from just dehisced anthers were better over pollen taken from undehisced anthers without treatment, however, the pollination at bud stage and just at anthesis proved better over other stages.

Mahawer and Misra (1993b) described the floral biology of gladiolus using cvs American Beauty, Green Willow, Oscar and White Oak and *Gladiolus*

callianthus var. *murielae.* There was no significant difference in anthesis, anther dehiscence and stigma receptivity in these cvs. Initial heading was fastest in *G. callianthus* var. *murielae* and Oscar where American Beauty was the slowest. From heading to first clour showing White Oak was the fastest and *G. callianthus* was the slowest. Green Willow was the fastest from first colour to petal unfolding and Oscar the slowest. Anthesis and anther dehiscence both coincided very closely with flowers opening. Mahesh (1995) reported that in gladiolus capsule and seed set were obtained when pollination was done one day before opening or on the day of opening, the maximum seed set was observed in those flowers where pollination was done three days after flower opening with irradiated pollen.

2.3 Nature of stigma and stigma-pollen interaction

Clarke *et al.* (1977) observed the factors involved in pollen-stigma recognition in gladiolus. The stigma surface determinants are partially identical with determinants of other tissues of the same plant and the variation in the degree of identity of these components in pollen and stigma controlled the positive recognition in the pollen-stigma system. He reported that male-female recognition factors form a part of a wider system of recognition factors involved in basic functions as cell growth and differentiation which were reflected in economically imporotant problems such as scion-root stock incompatibility in fruit tree and other horticultural crops.

Clarke *et al.* (1977) observed that gladiolus has a dry type of stigma. Compatible pollen grain alighted and germinated on the receptive surface of the papillae, penetrated the cuticle and grew towards the style through sub-cuticular pollen tube guide or mucilage which was secreted from the epidermal cells of the stylodium and style canal. The cuticle, which covered the pollen tube guide mucilage, was continuous through the style canal to the ovary.

Ameele (1982) in gladiolus observed stigma papillae of the 'dry' type and cell wall of each papilla overlain by a distinctive cuticle possessing an irregular scalloped inner margin. A pollen grain would hydrate and germinate only on a papilla and not on any other portion of the stigma. The pollen tube penetrated the cuticle which was forced away from the papilla cell wall by subcuticular pollen tube growth.

2.4 Pollen germination

Schumucker (1935) found that 1 to 10 ppm boric acid stimulated pollen germination and tube growth. Thompson and Batjer (1950) reported that boron in low concentrations of 2.5 to 40.0 ppm had stimulative effects whereas at higher concentration, boron inhibited pollen germination and tube growth. Singh (1959) reported that in grapes good germination was obtained with a medium containing five per cent sucrose and two per cent agar. Munzer (1960) reported that 0.001 to 0.010 per cent of boric acid had a stimulating effect on pollen germination and tube growth in more than 60 angiosperm species. Rao and

Khader (1962) reported that the germination of sapota pollen was enhanced by the addition of 100 ppm boric acid to sucrose - agar media.

Singh (1961) found that papaya pollen gave 62.90 per cent germination in five per cent sucrose solution. When one per cent agar was added to the sucrose solution, higher germination of 67.60 per cent was obtained. Singh (1981) found that maximum pollen germination in George Mazure (47 %) was found in 7 per cent sucrose solution, whereas cultivar Ratna's Butterfly gave 60 per cent (maximum) pollen germination in 6 per cent solution along with 300 ppm $Ca(NO_3)_2$ + 200 ppm Mg SO_4 + 100 ppm KNO_3 + 100ppm boric acid.

Hoggart and Clarke (1984) reported that the pore size of cell walls of *G. gandavensis* pollen tube was 3.4 - 4.5 nm. Parfitt and Ganeshan (1989) found while comparing different procedures to estimate *Prunus* pollen viability that hanging drop slide and agar plate germination procedures were more effective than different staining methods.

Choudhary (1990) reported that pollen germination obtained was highest in the medium 15 per cent sucrose + 75 ppm boric acid. It was also found that in the same medium pollen tube length was maximum.

Wu and Zhou (1990) in *Gladiolus gandavensis* found an enzymatically isolated protoplast from mature pollen grains cultured *in vitro* on K_3 medium supplemented with 32 per cent sucrose and 0.1 mg 2,4-D, 1mg NAA and 0.2 mg benzyl adenine per litre. Cell wall regeneration and pollen tube germination

occured with a germination rate of up to 47.70 per cent. Zhou *et al.* (1990) reported the actin filament distribution in maize pollen and gladiolus pollen.

Choudhary (1990) reported maximum pollen germination in gladiolus cv. Melody in fresh pollen which decreased gradually on storage. He found 75 ppm boric acid with 15 per cent sucrose solution as the best medium for pollen germination. He obtained maximum percentage of seed set by pollinating the stigma with fresh pollen, however, the gradual decrease in germination was found when the same were stored.

Mahawer and Misra (1997) reported that when pollen germination in gladiolus was studied in different media, better germination was observed in White Oak (35.43 %) under 6 per cent sucrose + 100 ppm boric acid, 100 ppm potassium nitrate, 200 ppm magnesium sulphate and 300 ppm calcium nitrate followed by 6 per cent (32.00 %) and 5 per cent (29.73 %) sucrose alone in the same variety. Germination was observed to be high even in distilled water in White Oak and Oscar. Pollen tube growth was better in sucrose and 75 ppm boric acid solutions. There was varietal difference in per cent pollen germination and pollen tube growth in different solutions.

2.5 Pollen production

Brooks and Puri (1963) and Sharma and Singh (1970) reported variation in atmospheric conditions affected pollen production. The relative quanatity of pollen produced per blossom per anther varies from variety to variety within

species (Nair *et al.*, 1964). A precise measure of the amount of pollen produced by individual anthers, flowers or the plant itself is essential to evaluate the worth of a variety as a pollinator more accurately.

Srivastava (1982) found that pollen production depended on the number of anthers in individual flowers. Markose (1984) reported that the number of pollen grains per anther ranged from 87 to 500 in the thrity five different varieties and species of *Hibiscus* studied.

2.6 Pollen morphology

The form of pollen grains served best in distinguishing between and showing relationships among the higher groups of plants such as families, tribes, genera and some species. Erdtman (1952) reported that pollen morphology was the useful means in classification of plants. The analysis of pollen morphology has been used as an effective aid to throw light on taxonomy, phylogeny and evolution of angiosperms (Nair, 1970). Kovachev (1973) observed the pollen morphology of a range of *Gladiolus* spp. There was no marked difference between these species in pollen structure.

Kumar and Nair (1986) studied three tetraploid (2n = 44) species, *Gloriosa virescens, G. carsonii* and *G. richmondensis* and three of their hybrids and found the pollen in *Gloriosa* L. fundamentally of three types i.e. speroidal, ellipsoidal and spindle shape. Kosenko (1990) observed differences between species in aperture type and exine sculpturing, pollen grain shape and to a lesser

extent exine thickness and pollen grain size of the 2 section viz. *Eriostemones* and *Lieostemones* among 49 central Asian species of *Tulipa.*

Mahawer (1993) studied five varieties of gladiolus and found three types of pollen shape i.e., spheroidal in American Beauty, spindle shape in *G. callianthus* var. *murielae* and White Oak and spheriodal to oval in Green Willow and Oscar under unacetolysed set of experiment. Pollen morphological studies were also conducted in gladiolus by Cacao and Fernandez (1990).

2.7 Pollen storage

Koopowitz *et al.* (1984) reported that pollen from *Gladiolus alatus, G. debilis, G. guenzi, G. orchidiflorus, G. rodgersii, G. tristis* and *G.undulatus* frozen at -40°C and then thawed still retained its viabiliity. Pre-dried pollen was able to withstand repeated freezing and thawing better than pollen that was freshly frozen and viability started to decrease several days after thawing.

Rajasekharan *et al.* (1994) reported that there was no decline in the pollen viability levels after one and ten years of cryogenic storage and field pollination with this pollen induced different degrees of capsule and seed set. Seaton (1994) found that a proper combination of factors such as low temperature, relative humidity and light has great bearing on pollen storage.

2.8 Breeding

Hybridization work in gladiolus started in 1806 by William Herbert. The first hybrids to enter commerce were produced in 1823 by James Colville at

Chelsea in England. Since then more than 10,000 cultivars have been recorded (Wilfret, 1992).

Work on the improvement of gladiolus through hybridization was started in 1956 at Raj Niwas, Shimla. The varieties developed here are Bhadri Blue Beauty, Bhadri Bright Red, May blossom, Raj Niwas Pride and Zakir Hussain. A large number of hybrids were also developed at the Indian Institute of Horticultural Research, Bangalore. Some of the hybrids developed and released from here are Meera, Nazrana, Poonam, Sapna, Aarti and Apsara. Efforts made at the Indian Agricultural Research Institute, New Delhi for gladiolus breeding through hybridization have resulted in the development of new varieties, namely, Agnirekha, Mayur, Pusa Suhagin and Suchitra. Hybridization done at National Botanical Research Institute, Lucknow have resulted in the development of varieties like Archana, Arun, Gazel, Manhar, Manohar, Mohini, Mukta, Sadabahar etc.(Negi and Raghawa, 1995). The breeding of scented gladioli in various countries was reported by Misra (1977). Several cvs and hybrids were also described for their flower characteristics. Grabowska (1983) reported the crossing ability of the cultivars Bird of Dawning, West Point, Eurovision and Pres. de Gaulle. Hybrid seeds of Bird of Dawning gave more seedlings and corms than seeds of West Point.

Ohri and Khoshoo (1983) studied intra and interploidal crosses (using tetraploid, triploid and diploid hybrid and garden cvs) and one intergeneric cross (cv. La Paloma x *Acidanthera bicolor*). The progeny showed the same meiotic

behaviour as the parents. Hypertetraploids showed normal transmission of extra chromosomes. The 4x x 2x cross was successful only when the tetraploid was used as the female parent. *A. bicolor* var. *murielae* (2n = 30) could be crossed with gladiolus cvs La Paloma and Pacifica (2n = 60) when these were used as female parents.

Willfret (1986) reported a new cv Dr. Magie developed from a selection from a cross between 2 seedlings obtained from a breeding programme. It was with salmon pink florets and had good cut flower characteristics with tolerance to *Fusarium oxysporum* f. sp. *gladioli.*

Dhaduk *et al.* (1987) studied ten cultivars of gladiolus which were crossed in all possible combination by using different methods of pollination. They found that artificial self pollination generally gave the best results, with the cultiivars Melody and Patricia performing well under all methods of pollination, the pentaploid cultivars Sylvia and Psittacinus hybrid gave poor results.

Raamsdonk - LWD - van (1987) reported the multivariate techniques in breeding of gladiolus. Examples of the kinds of graphical information obtainable from principal component analysis, cluster analysis and Wells' hybrid analysis were described using 2 species of a fictitious genus i.e. *Dinellia* and their interspecific hybrids and back crosses and further examples gave actual results from principal components analysis and Wells' hybrid analysis for various gladiolus species and an interspecific cross.

Korolyuk & Sperpokrylova (1989) reported *G. impricatus* in the flora of the Chernovtsy province of the Ukraine and the possibility of using the species in breeding the cultivated *G. hybridus.* Bylov (1990) reported new hybrids of *G. hybridus* and *Acidanthera bicolor* var. *murielae* hybrids. The F_1 showed different capacities for selfing. When the F_1 was pollinated by various gladiolus varities, forms of high ornamental value were obtained. More than 45 promising hybrids were selected and they were Asteroid, Karmensita, Rodonit, Prometei, Brigantina, Maskarad and Strekoza.

Varietal studies

Most of the present day varieties of gladiolus have been developed in countries like the USA, the UK, Holland and the USSR. Some of these varieties were introduced at different research centres in India and were evaluated. At Regional Fruit Research Station, Shimla, some of the varieties Anne Virginia, Blaur Domino, Fenny Lind, Gold dust, Hawaii, Kenny, King Lear and Spic and Span were found to be promising. Indian Agricultural Research Institute, New Delhi reported eight varieties and Ratna's Butterfly, Snow Princess were some of the most promising varieties. At Indian Institiute of Horticultural Research, Bangalore, eleven varieties were found to be promising and Beauty Spot, Cherry Blossom, White Friendship, Melody and Wild Rose were some of them. (Negi and Raghava, 1986). Swarup and Raghava (1972) reported that the most promising varieties under Delhi conditions were George Mazure, Patricia, Goeff

Whiteman, Pfitzer's Sensation, Ratna's Butterfly, Snow Princess, Jo Wagenaar and Apple Blossom.

Weidner (1975) described the stem length, date and duration of flowering, the number of flowers per spike and general quality of 11 gladiolus cvs. Tamberg (1976) selected 11 early, 63 medium and 37 late cvs each with 19-23 florets per spike and found White Frosting, Earlybest, Pompeii, Antarctic and Happiness as most valuable cvs for breeding. Lal and Sing (1978) observed that the cvs House of Orange and Oscar had the spike length 66.5 and 66.0 cm respectively. House of Orange took 92.2 days to flower and produced 146 cormels per plant. Oscar produced 17 flowers per spike. Wilfret (1979) while studying in 38 Pixiola cvs for flower and corm production found that spike length ranged from 31.6 inches to 46.1 inches. Seventeen cvs had flower with maximum diameter i.e. 3 inches. Corm yield were proportional to number of flower spikes. Wilfret and Magie (1979) described a new gladiolus cv Jessie M. Conner intended for home or landscape use where an upright yellow flowered gladiolus is required. Flower, corm and cormel yield data for this cv. was reported.

Singh and Dohare (1980) reported new gladiolus cvs Agnirekha (fire red), Suchitra (rose with vermillion stripes) and Mayur (lilac purple). Varela - Nieto (1980) described 34 cultivars of gladiolus having 85 per cent corm sprouting and good quality flowers. Percentage flowering varied between 56.60 per cent and 88.00 per cent in Red Beauty and Happy End respectively. Groen and Lans (1981) described 59 early flowering large flowered, primulinus type and butterfly

type gladioli under glass house conditions. The earliness and quality of 44 gladiolus cvs were investigated by Loeser (1981) and he described the colours, spike length, number of flowers per spike, height of plants and time of harvesting of spikes. Then recommmended cvs were Eyecatcher, H.v.d. Mark, Continental Trader horn, My Love, Stuttgartia, Applause, Deciso, Sancerre and Mr.W. Cobley.

Raghava *et al.* (1981) reported that the cv Apsara took 45 days for flowering after planting with 107 cm long spikes and vase life of 8 days. Another cv Aarti flowered 70 days after planting which had 63 cm long spikes and vase life of 6 days. Whereas Shobha took 50 days for flowering with 97 cm long spikes and vase life of 7 days. Wilfret (1981) reported a *Fusarium* tolerant cv Florida Flame having maximum spike length of 160 cm with 13.8 - 14.4 florets per spike, 922-1098 g of corms and 181-218 g of cormels in one season. Negi *et al.* (1982) described the cvs. Meera, Nazrana and Poonam. Meera flowered at 58 days from planting whereas Nazrana took 57 days for flowering after planting. Another cv. Poonam flowered 121 days after planting and it had 98 cm long spikes. All of them had good cormel production

Misra (1983) described the health and vigour, flower diameter, total flower bud production, plant height and spike length of seven hybrids. The hybrid 71 SSy- RB- 273-18 had excellent health and vigour and produced the longest spikes with 130 cm length.

Arora and Khanna (1985) observed that the cvs Suchitra, Melody, Ratna's Butterfly and Snow Princess were superior with respect to spike lelngth, which is from 80 to 90 cm. Cormel production was the best in Emerald Queen, Mayur, Melody and Suchitra. Leinfelder and Gruber (1985) observed while studying flowering characters and plant performances that large flowered cultivars sprouted 10 days earlier than small flowered ones. Flowering duration was 17 days with a vase life of 8 days. Hosoki *et al.* (1986) reported that spring flowering hybrid cultivars had smaller leaves, flowers and pollen grains than summer flowering cultivars. Misra *et al.* (1987) found that Salmon Queen had the best propagation coefficient, plant height, spike length, number of florets and floret diameter whereas Katrain local and Psittacinus (*G. natalensis*) hybrids remained poor in all these characters. Misra *et al.* (1987) evaluated 12 varieties of gladiolus and found that Salmon Queen recorded best propagation coefficient (5.31), plant height (163.20 cm), spike length (104.64 cm) number of florets (18.50) and floret diameter (12.35 cm) in high hills of Himachal Pradesh.

Wilfret (1988) reported a violet-blue gladiolus cv. Morning Mist suitable for cut flower. It was a selection from a cross between two seedlings tolerant of *Fusarium oxysporum*. It had corm size of more than 3 cm diameter. Length of spike was from 91.40 to 170.80 cm and had 23.5 florets per spike and 7.5 florets were opened at a time. Corm and cormel production was excellent.

Goldblatt and Vlok (1989) reported two new species of gladiolus i.e. *G. aquamontanus* and *G. uitenhagensis* from southern cape, South Africa.

G. aquamontanus related to the *G. carneus* - *G. floribundus* alliance. *G. uitenhagensis* was allied to *G. permeabilis*. Discovery of another species *G. caryophyllaceus* led to the re-evaluation of the closely related *G. lewisiae.*

Lal and Pant (1989) reported four hybrids Chaubattia Arunima with spike length 89.20 cm, Chaubattia Ankur with average spike length of 85.80 cm, Chaubattia Tripti with 88.90 cm long spikes and Chaubattia Shobbit with 86.20 cm lonng spikes. Cordova - Ponce and Ponce (1990) reported six new species *G. camilae, G. curtilimbus, G. microspicatus, G. mitwabaensis, G. pungens* and *G. salmoneicolor* and one new combination i.e. *G. dalenli* var. *melleri*, combined from *G. melleri* and *G. natalensis* var. *melleri.* Cohen and Barzilay (1991) reported five new cultivars Adi, Nirit, Kinnereth, Yamit and Ronit which flowered in winter. They took only 70 to 100 days for flowering and had floret size 5 to 8 cm in diameter, inflorescence length 30 to 55 cm and 10 to 12 inflorescence per stem.

Ravidas *et al.* (1993) reported that American Beauty had the longest flowering period among the five cvs studied. American Beauty and White Friendship had better quality flowers, Agnirekha and Mansoer Red had longer vase life, True Yellow with heaviest corms but lower weight of cormels. The varieties showed significant variation in vegetative growth and flowering in different seasons. Banerji *et al.* (1994) found that when irradiation was attempted in gladiolus cv. White Friendship there was a reduction in survival, plant height, number of leaves and florets, spike lelngth and leaf and corm size.

It also resulted in delayed flowering. Morphological abnormalities in foliage and florets and chromosomal aberrations during root tip mitosis were also noted. Pink flower colour was detected in a few plants as a sectorial chimarac form in MV_2 population. In MV_3 one plant produced a spike with light pink florets which was isolated in pure form.

Mahanta and Paswan (1994a) reported that there was much differences between the cvs for all the important characteristics. Copper King and Tunias Classic were best for Assam conditions. Patil *et al.* (1994) found that cv Sancerre had longest spikes, largest number of florets per spike, corms and cormels per plant among nine exotic gladiolus cultivars while examining for export quality cut flower production. Goldblatt and Thulin (1995) reported a new species *G. Somaliensis* from northeastern Somalia which had small florets with short perianth tube. Aswath and Parthasarathy (1996) reported that when Blue Moon, Powder Puff, White Friendship and Red Majesty were superior in spike characters, local, Creamy white and Dressdon Doll were outstanding in cormel production. John *et al.* (1996) reported that Classic, Red Majesty, Rose Supreme, Oscar, Sunny Boy and White Prosperity were the most suiitable cvs for cut flower production for Shalimar, India. The spike length ranged from 106.06 cm for Oscar to 120.13 cm for White Prosperity and Buff Beauty, King Lear and White Prosperity were the best for cormel production.

2.10 Seed germination

Carpenter *et al.* (1991) reported that gladiolus seed germination was light dependent, but the temperature influenced the germination rate. A constant temperature of 20°C promoted higher total germination. Reducing seed moisture contents from 11.8 per cent to 4.2 per cent caused no reduction in total germination, but moisture content below 6.6 per cent delayed achieving 50 per cent of final germination. The optimum seed storage condition was reported to be 14°C and 26 per cent relative humidity.

2.11 Variability

Variability indicates the differences present among individuals belonging to a single species or among different species. Variation may be due to environment or due to genotype or both. For successful plant breeding programme, an insight into the magnitude of variability present in a crop species is of utmost importance as it provides the basis for effective selection. New gene pools are essential if higher levels of productivity and better quality are to be maintained.

Negi *et al.* (1982) reported the genotypic and phenotypic variability in 39 varieties of gladiolus for 13 characters. The range, coefficient of variation and phenotypic and genotypic coefficients of variation were high for weight of cormels proeduced per corm, number of cormels produced per corm and size of corms produced. Arora and Khanna (1986) evaluated 30 varieties in terms of

floral characters and corm production. Out of these cutivars, Suchitra, Melody, Ratna's Butterfly and Snow Princess were superior in respect of average spike length which varied from 80-90 cms. Number of cormels produced per plant was high in cv. Emeralled Queen, Mayur, Melody and Suchitra (87.0-139.0).

Lal *et al.* (1985b) reported genetic variability in 30 cultivars when studied for plant height, leaf number, days to flower, spike length, number of florets per spike and spike weight. Plant height was mostly correlated with spike length and leaf number was positively correlated with spike weight. Arora and Khanna (1986) reported the genotypic and phenotypic variability of six important characters. High heritability and high genetic advance were observed for cormel and corm production and number of days taken for spike emergence and low heritability for the number of days taken for the basal floret to show colour and for number of florets open at a time. PCV and GCV were maximum for cormels produced (55.4 and 55.2 % respectively) and lowest for length of spike (14.12 and 13.0 %, respectively) (Arora and Khanna, 1986).

Cohat (1988) studied the heritability of some characters in *G. grandiflorus*. There was large amount of variation among crosses, could be due to general combining ability. Heritability was high for flowering date, plant height, spike length and floret number and low for ornamental value of the spike and overall value.

Misra and Saini (1988) reported the GCV and PCV in 60 varieties of gladiolus for twenty characters. The characters like number of spikes per shoot,

number of cormels per plant and number of seeds per capsule showed high PCV and GCV and error variance. The GCV was high for spike length (68.87), number of cormels produced per plant (55.26), number of side spikes per shoot (51.46) and 10-cormel weight (41.29). Low GCV was observed for number of leaves per shoot, days to flowering, diameter of foremost flowers, diameter of daugther corms and spike durability.

The GCV was high in spike length (427.68) plant height (275.68), spike weight (215.75) and days for flowering (150.50) in 20 varieties of gladiolus (Gowda, 1989). Soorianathasundaram and Nambisan (1991) reported after studying 75 varieties of gladiolus that greater variability was observed for spike weight, number of florets per spike, spike length and floret size. Mahanta and Paswan (1993) reported that weight of daughter corms and number of shoot had high genetic variability and high heritability coupled with high genetic advance. High variation in 16 cultivars was observed for cormel, weight per plant, weight of main corm and weight of single cormel per plant (Aswath and Parthasarathy, 1994). Sarangi *et al.* (1994) reported that high genotypic variance was observed in spike length followed by corm weight per plant. Highest genotypic and phenotypic coefficients of variation were obtained in floret size. The weight of cormels per plant had the highest genetic advances.

2.12 Heritability and genetic advance

Heritability in broad sense provides a measure of relationship between real or genetic variance and the observed or phenotypic variance. It helps to separate

out that part of total variability which is environmental and hence unfixable. According to Lush (1940), heritability in broad sense concerns the functioning of the genotypes as a whole.

Burton and De Vane (1953) suggested that GCV together with heritability estimates, would give reliable indication of the amount of improvement to be expected from selection and further explained that expected genetic advance under particular system supplies a true practical information that is needed by a breeder. Johnson *et al.* (1955a) also found it more useful to estimate heritability value together with genetic advance in predicting the expected progress to be achieved through selection.

High heritability was observed for day taken to flower, corm weight, number of florets per spike, size of corm produced, weight of cormels produced per plant, rachis length and spike length (Negi *et al.*, 1978, 1982). High genetic advance was there as percentage of mean for weight of cormels produced per corm and cormweight. Lal *et al.* (1985) reported that plant height, leaf number, days to flower, spike length, number of florets per spike and spike weight exhibited high genetic advance and high heritability showing additive gene effects. High heritability along with high genetic advance was reported by Arora and Khanna (1986) for cormel productions per corm and number of days taken for spike emergence. Cohat (1988) reported estimates of high heritability in gladiolus for flowering date, plant height, spike length and floret number. Misra

and Saini (1988) reported high heritability and low genetic advance for diameter of foremost floret.

Gowda (1989) found that number of florets, spike length and spike weight showed high heritability together with high genetic advance with additive gene effects. Plant height, number of leaves and days to flowering showed lower genetic advance with no additive gene effects. It was found that there was positive correlations between plant height and spike length and between spike weight and number of leaves. Soorianathasundaram and Nambisan (1991) reported that spike weight and spike length had high heritability. Spike length, spike weight, number of florets per spike and floret size had high genetic advance and they were 45.3, 45.2, 35.5, 34.7, as percentage of mean, respectively. Aswath and Parthasarathy (1994) stated that length of spike and number of florets per spike showed neither high heritability nor high genetic advance. Anuradha and Gowda (1994) studied 25 genotypes of gladiolus and measured heritability, genetic advance and coefficients of variation. A narrow difference between phenotypic and genotypic coefficients of variation was noticed for floret length, leaf number, plant height, days to spike emergence and spike length. PCV and GCV were high for rachis length, number of seeds per capsule and number of capsule. High heritability was noticed for days to spike emergence and spike length. Prasad *et al.* (1994) studied fifteen exotic gladiolus varieties to measure the heritability, genetic advance and coefficients of variation for 14 characters. The neck diameter had a high heritability estimate. Days for blooming had high

heritability and genetic advance. Flower diameter had low heritability and genetic advance.

2.13 Correlation

Correlation coefficient analysis measures the mutual relationship between various plant characters and determines the component characters on which selection can be based for improvement in yield. Johnson *et al.* (1955b) reported that estimates of genotypic and phenotypic correlations among characters are useful in planning and evaluating breeding programme.

Negi *et al.* (1978) stated negative significant correlation of days to first flower with number of shoots per planted corm whereas floret size was negatively correlated to days to flowering and number of corms produced. However, number of florets per spike was positively correlated with rachis length, floret size, weight and size of corms planted and weight of corms produced in gladiolus. In dahlia, path coefficieint analysis indicated that the flower diameter, plant height, longevity of flower and number of branches were important component characters for the number of flowers per plant (Bhattacharjee and Wahi, 1982).

Lal *et al.* (1985) reported that plant height was correlated significantly with spike length. The leaf number exhibited a positive correlation with spike height. These findings showed that the genotypic correlation coefficients were higher than the phenotypic correlation coefficients.

Gowda (1989) reported that plant height significantly correlated with spike length while leaf number had a positive correlation with spike weight in gladiolus. Positive significiant correlation of number of florets per spike with plant height, number of florets remain open at a time, durability of spike indicated that single plant selection would be more effective for its improvement (Misra and Saini, 1990). Sandhu *et al.* (1990) reported that number of florets per spike was positively correlated to duration of flowering and size of floret. Pant and Lal (1992) stated significant positive correlation of spike weight with plant height, number of leaves, leaf size, floret length, floret width, number of florets and corm weight.

De *et al.* (1993) reported that number of florets per spike had significant and positive phenotypic and genotypic association with rachis length and plant height. Anuradha and Gowda (1994) found that spike length had a highly significant and strong positive association with plant height, number of florets per spike and rachis length. Floret diameter had a significant correlations with floret length, spike length and plant height. Number of florets recorded a positive and highly significant association with rachis length, spike length and spike durability.

Mahanta and Paswan (1994b) found that spike length had a positive association with days to shoot emergence, leaf breadth, florets per spike, rachis length, internodal length, size of floret and size and weight of daughter corms. Number of spikes per corm planted, florets per spike and rachis length had high

and positive direct effects on spike length and indicated that due emphasis should be given to these characters while selecting plants for greater spike length.

2.14 Path coefficient analysis

Path coefficient analysis is a standardized partial regression coefficient analysis and as such measures the direct influence of one variable upon other variables and permits the seperation of correlation coefficient into components of direct and indirect effects (Wright, 1921). This technique was first used for plant selection by Dewey and Lu (1959).

In *Hippeastrum hybridum* direct and indirect effects were studied on flower length, longivity of flowers and number of bulbs per plant. Residual effect has been reported to be high, so none of the characters can be used independently for the improvement of corresponding economic characters, inspite of their direct effects (Wahi and Battacharjee, 1986).

Misra and Saini (1990) in gladiolus reported that weight of one daughter corm had the maximum positive direct effect upon number of florets per spike followed by plant height, number of leaves per shoot, number of florets remained open, number of capsule per shoot, durability of whole spike and 10 - cormel weight. A poor or negative effect of number of seeds per capsule, spike length, number of shoots per planted corm, days to first flowering, flower diameter, durability of first floret, polar diameter and equatorial diameter of corms was observed upon the number of florets per spike.

De *et al.* (1993) reported that plant height, rachis length, days to first flowering number of cormels produced per plant and propagation coefficient in gladiolus had high order of direct effects upon numbr of florets per spike.

Desh Raj *et al.* (1998) reported while studying correlation and path coefficient analysis in 25 genotypes of gladiolus for 20 characters related to growth and flowering that location x treatment interactions were significant for all characters except propagation coefficient. Significant positive association of number of florets per spike was observed with rachis length and it also showed significant positive association with plant height. Number of florets per spike showed positive significant correlation with durability of spike. Path coefficient analysis showed a lot of differences from one environment to another due to presence of high genotype x environment interactions. Plant height, rachis length and durability of spike had direct effects on number of florets per spike. So single plant selection for these traits will be useful for improvement in number of florets per spike.

Desh Raj *et al.* (1997) reported that when character association and path coefficient studies were conducted on 25 genotypes of gladiolus grown at three locations, positive significant association of number of florets per spike with durability of whole spike, rachis length and plant height was obtained. This indicated that single plant selection would be more effective for gladiolus improvement, since these characters had also positive direct effects.

Materials and methods

MATERIALS AND METHODS

The study entitled 'Floral biology and compatibility in gladiolus' was carried out in the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara during the period from July 1997 to December 1998. The investigations on floral biology, pollen studies and compatibility among gladiolus varieties were done in the experimental field of All India Co-ordinated Research Project on Floriculture.

The varieties included in the study are White Friendship, Amal, Mansoer Red, American Beauty, Wedding Bouquet, Echo Saunder, Oscar, Tambri, True Yellow, Tiger Flame, Pacific, Accession - 1, Accession - 2, Agnirekha and Morocco. Accession - 1 and Accession - 2 are local collections from Thrissur and the rest being part of the germplasm collection of AICRP on Floriculture.

3.1 Layout of the experiment

Raised beds of size 1.2 m x 0.8 m were prepared. The experiment was laid out in RBD with fifteen varieties and three replications. Each replication had ten corms planted at a spacing of 30 cm x 20 cm.

3.2 Preparation of planting material

Uniform sized corms were taken as the planting material. These corms were soaked in 0.2 per cent Bavistin for half an hour before planting.

3.3 Planting

Corms were planted at a spacing of 20 cm between rows and 30 cm between plants in a row. After planting mulching was provided.

3.4 Cultural management

3.4.1 Fertilizer application

The beds were incorporated with dried farmyard manure at the rate of 25 t/ha during land preparation. A basal dressing of 17:17:17 complex was given at 15 g/m^2. Top dressing with the same fertilizer was done at 45 days after planting. This was repeated after the completion of flowering, for corm enlargement.

3.4.2 Plant protection

Soil drenching with Bavistin (0.20 %) was done periodically to control fusarium wilt. Regular spray of Nuvacron (0.15 %) was given to control leaf caterpillars.

3.4.3 Other cultural operations

The beds were daily irrigated. Staking of the plants was done at spike emergence. Earthing up was done along with fertilizer application. The plots were regularly weeded.

3.5 Harvesting

The spikes were harvested at the tight bud stage for recording the post harvest observations. When the leaves turned yellow and dried up the irrigation was withheld for two weeks and subsequently the corms and cormels were lifted and observations were recorded.

3.6 Observations

3.6.1 Vegetative characters of the varieties

3.6.1.1 Percentage of sprouting of corms

The number of corms sprouted was counted and expressed as a percentage of total corms.

3.6.1.2 Plant height

The height of the plant was measured from the collar region to the tip of the tallest growing leaf and expressed in centimeter.

3.6.1.3 Collar girth

The girth of the plant was measured at the collar region and expressed in centimeter.

3.6.1.4 Leaf number

The total number of leaves borne on the plant was counted and recorded

3.6.1.5 Leaf area

The length and width of each leaf was measured. Area of each leaf was computed using the following formula suggested by Rajeevan *et al.* (1992).

Leaf area = (l x b x 0.635) + 12.9, where l = length and b = breadth

3.6.2 Floral characters

3.6.2.1 Days to spike emergence

The number of days taken from planting to the appearance of spike was counted and recorded.

3.6.2.2 Days to first flowering

The number of days taken from planting to the opening of the lower most floret was counted and recorded.

3.6.2.3 Duration of flowering

The total number of days taken from the opening of the first floret to the opening of the last floret in the spike was recorded as the flowering period.

3.6.2.4 Length of the spike

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

3.6.2.5 Weight of the spike

The weight of the spike was taken immediately after the harvest and expressed in grams.

3.6.2.6 Number of florets per spike

The number of florets in a spike was counted and recorded.

3.6.2.7 Number of florets open at a time

The number of florets open at the time when the first floret started wilting was recorded.

3.6.2.8 Size of the floret

The width of the second floret was measured and expressed in centimeter (ICAR, 1989).

3.6.2.9 Yield of spikes per plant

The number of spikes present in a plant was counted and recorded.

3.6.2.10 Vase life of cut flowers

The number of days from the opening of the first floret to the drying of the last fully opened floret was recorded as the vase life of the spike.

3.6.2.11 Florets of each gladiolus variety were studied and observations were recorded on the following characteristics,

a) Colour
b) Shape (open or hooded)
c) Texture
d) Placement

3.6.3 Corm characters

3.6.3.1 Size of corms

The size of the harvested corms was recorded by taking the average diameter of the corms and was expressed in centimeter.

3.6.3.2 Number of corms per plant

The corms collected from each plant were counted and recorded

3.6.3.3 Weight of corms

After lifting of plants, the corms were cleaned, weighed and the weight was expressed in grams.

3.6.3.4 Size of cormels

The average diameter of the cormels was recorded and was expressed in centimeter.

3.6.3.5 Number of cormels per plant

The cormels collected from each plant were counted and recorded.

3.6.3.6 Weight of cormels

After lifting the plants, the cormels collected from each plant were counted and recorded.

3.6.4 Floral biology

The floral characteristics of the gladiolus varieties were studied.

3.6.4.1 Time of flower anthesis

Mature buds in each of the varieties selected for the study were tagged at full bud stage for observing the time of flower opening. The flower buds were observed at quarter hourly intervals from 6.30 a.m. to record the time of opening,

3.6.4.2 Anther dehiscence

Mature buds in each of the varieties were tagged on the previous day of flower opening and they were observed at half hourly intervals commencing from 6 a.m.

3.6.4.3 Stigma receptivity period

The flowers of each variety were hand pollinated at hourly intervals on the day of anthesis and once in subsequent days for the study. Percentage of pod set and number of seed set were estimated.

3.6.5 Pollen studies

Anthers were collected soon after anther dehiscence and kept in a desiccator for one hour so as to collect the pollen grains needed for the study. Pollen morphology was studied after staining the pollen grains using acetocarmine.

3.6.5.1 Pollen size and shape

Pollen grains were dusted on a drop of acetocarmine - glycerine medium on a clean microscopic slide and covered with zero cover glass and kept for 30 minutes. Diameter of the ten normal well shaped, plumpy and well-stained pollen grains from each variety was measured at random using a standardized ocular micrometer under low power of a microscope. The mean diameter was expressed in microns. Pollen diameter was taken for all the fifteen varieties. The shape of pollen grains was studied under high power magnification.

3.6.5.2 Pollen production

The number of pollen grains was estimated using a haemocytometer following the method suggested by Oberle and Georgtzen (1952) in grapes.

To the vials containing anther, 0.5 ml of water was added and the contents were shaken thoroughly. The anthers were crushed with the edge of a glass rod in

order to suspend all the pollen grains properly. A drop of the above suspension drawn in a fine pipette was transferred to each of the two counting chambers of the haemocytometer. Pollen grains in each of the four corner squares in both the counting chambers were counted and the mean number in eight corner squares were calculated. For each variety, three such estimates were made.

The number of pollen grains per anther was calculated as follows.

If X = average number of pollen grains counted per corner square and N = number of pollen per anther

$$X \times 0.5 / 0.00025 = 2000 X / 0.00025$$
$$= 2000 X$$

3.6.5.3 Pollen fertility

Fertility of pollen grains was estimated by acetocarmine staining technique. Micic *et al.* (1987) reported that staining with acetocarmine is the most suitable method of pollen fertility. Zirkle (1937) reported a method of mounting pollen grains in acetocarmine and pollen grains which looked plump and stained are viable and non-stained and shrivelled as non-viable.

Pollen grains were dispersed in a drop of acetocarmine - glycerine medium on a clean microscopic slide for 30 minutes, for proper staining and examined under low power of a microscope. Pollen fertility was estimated by counting fertile and sterile pollen grains separately. Pollen grains which stained well, looked plumpy and well shaped were considered as fertile and those unstained, small, shrivelled as sterile or

non - viable. The observations were made in five different microscopic fields and the mean percentage of viable pollen grain was arrived at.

3.6.5.4. Pollen viability during storage

The pollen grains of varieties White friendship and Accession - 1 were used for the study.

From flowers with dehisced anthers fresh pollen grains were used for pollen storage studies. They were stored under the following conditions;

a) At room temperature
b) Over Calcium chloride at room temperature in a desiccator
c) At 4^0C
d) Over Calcium Chloride at 4^0C in a desiccator
e) At 0^0C

Viability of the stored pollen grain was studied at weekly intervals by acetocrmine - glycerine staining technique.

3.6.5.5 Pollen germination

In vitro germination of pollen grains of two varieties, viz., White friendship and Accession –I was studied in sucrose-boric acid medium at different concentrations.

3.6.6 Compatibility studies

Ten different varieties of gladiolus, viz., White Friendship, Tambri, Echo Saunder American Beauty, Tiger Flame, Wedding Bouquet, Accession - 1, Accession-2, Amal and Pacific were selected for the study.

Pollen-pistil interaction was studied in Accession-1 while pollinated with Accession-2 at 6h, 12h,24h and 48h after pollination using Kho and Baer's procedure (Kho and Baer, 1968 and Kho *et al.*, 1980).

3.6.6.1. Self compatibility

Self compatibility was assessed in all the above ten varieties. Pollen grains from just dehisced anthers of same plant were used for pollination.

3.6.6.2. Cross compatibility

All the ten varieties selected were crossed in all possible combinations. Pollen grains from just dehisced anthers of the varieties were used for pollination.

3.6.6.3. Technique of artificial pollination

Mature buds of female parent were emasculated on the evening prior to expected date of flower opening. Pollination was done by brushing the stigma with an anther just dehisced with fresh pollen adhering to it.

After pollination covering the flower with butter paper cover and tagging were done. Observations were recorded on the following.

(a) Percentage of fruit set
(b) Number of days taken for maturity
(c) Number of seeds per pod
(d) Weight of seeds per pod

3.6.6.4. Seed germination

When the pods turned brown in colour and began to split, they were picked off the spike and put in paper bags for complete drying. The waxy covering of the seeds

were removed by rubbing the seeds between two layers of cloth. The seeds were sown in seedpans in 2 cm deep furrows with individual seed not closer than 2.5 cm.

3.7. Statistical analysis

The data were analysed using MSTAT-C package avialable at CCF, College of Horticulture, Vellanikkara. Cluster analysis was performed using the SPAR-I package developed by IASRI, New Delhi. The data were processed for analysis of variance, genotypic and phenotypic variance, heritability, genetic advance, genetic gain, genotypic and phenotypic coefficients of variation, genotypic and phenotypic correlation coefficients and path coefficients. The analysis techniques suggested by Fisher (1954) was employed for estimation of various genetic parameters.

3.7.1 Phenotypic and genotypic variance

Variance components were estimated using the formula suggested by Burton (1952).

Genotypic variance $(V_g) = (V_T - V_E) / N$

where, V_T = mean sum of squares due to treatment

V_E = mean sum of squares due to error

N = number of replications

Phenotypic variance $(V_p) = V_g + V_e$ where, V_g = genotypic variance

V_e = environmental variance

Environmental variance (V_e) = V_E

3.7.2 Phenotypic and genotypic coefficients of variation

The phenotypic and genotypic coefficients of variation were calculated as follows

Phenotypic coefficient of variation (PCV) = $(V_p^{1/2}/\bar{x}) \times 100$

Genotypic coefficient of variation (GCV) = $(V_g^{1/2}/\bar{x}) \times 100$

where, V_P = phenotypic variance, V_g = genotype variance, $\bar{x}$ = mean of characters under study

3.7.3 Heritability

Heritability in the broad sense was estimated as follows.

Heritability in broad sense (H) = $(V_g/V_p) \times 100$

where, V_g = Genotypic variance

V_p = phenotypic variance

3.7.4 Expected genetic advance

The genetic advance expected under five per cent selection pressure was calculated using the formula by Lush (1949) and Johnson *et al.* (1955).

Expected genetic advance GA= $K \times (V_g/V_p) \times V_p^{1/2}$

V_g = Genotypic variance

V_p = phenotypic variance

K = Selection intensity which is equal to 2.06 for selection of 5 % individuals

3.7.5 Genetic gain (Genetic advance as percentage of mean)

Genetic gain, GG = (GA/$\bar{x}$) x 100

where, GA = Genetic advance

$\bar{x}$ = Mean of character under study

3.7.6 Phenotypic and genotypic correlation coefficients.

Phenotypic and genotypic correlation coefficients were worked out to study the extent of association between the characters. The phenotypic and genotypic covariances were worked out in the same way as the variances were calculated. Mean product expectations of the covariance analysis are analogous to the mean square expectation of the analysis of variance. The different covariance estimates were calculated by the method suggested by Fisher (1954).

3.7.7 Path coefficient analysis

The principles and techniques suggested by Wright (1921) and Li (1955) for the analysis using the formula given by Dewey and Lu (1959). In path coefficient analysis the correlation among causes and effect are partitioned into direct and indirect effects of causal factors on effect factor.

Characters which showed significant correlation with yield at one per cent level alone were included in path coefficient analysis.

Results

RESULTS

The results of the present investigation 'Floral biology and compatibility in gladiolus' are presented under the following heads ;

1. Vegetative, floral and corm characters
2. Floral biology
3. Pollen studies
4. Heritability, genetic advance, genetic gain and genotypic and phenotypic coefficients of variation
5. Correlation studies
6. Genotypic path coefficient analysis
7. Compatibility in gladiolus varieties

4.1. Vegetative, floral and corm characters

4.1.1. Vegetative characters

Morphological description and their values of fifteen gladiolus varieties used in this study are presented in Table 1 and Table 2, respectively (Plates 2-14).

Maximum corm germination was observed in Accession –1 (94.89 %) and the minimum in Pacific (71.77 %). Accession-1 was the tallest variety (68.88cm) and True Yellow the shortest (52.10 cm). With regard to collar girth Amal registered highest value of 8.50 cm, while True Yellow had the minimum collar girth (5.07 cm). Leaf number was the highest in Accession-1(9.44) and the lowest in True Yellow (5.67). True Yellow had the maximum leaf area of 141.30 cm^2 and Accession-1 had the lowest leaf area (63.96 cm^2).

Table 1. Morphological description of fifteen gladiolus varieties

Name of variety	Colour of flower	Shape of flower	Texture	Placement
White Friendship	White with yellow throat with pink tinge	Open	Moderately fine	Alternate
Amal	Brick red colour with light yellow throat	Hooded	Fine	Alternate
Pacific	Lilac	Open	Moderately fine	Alternate
Wedding Bouquet	White	Open	Fine	Alternate
Echo Saunder	Bright pink with yellow throat	Open	Moderately fine	Alternate
American Beauty	Bright pink	Open	Moderately fine	Alternate
Oscar	Fire red	Open	Open	Alternate
Mansoer Red	Maroon with white line on the middle of petal	Open	Moderately fine	Alternate
Tiger Flame	Light peach colour with pale yellow throat	Open	Moderately fine	Alternate
Morocco	Pinkish red with yellow throat	Moderately open	Moderately fine	Alternate
Tambri	Dull red colour	Open	Nearly coarse	Alternate
True Yellow	Sulphur yellow	Moderately open	Fine	Alternate
Accession - 1	Dull pink with dark pink stripes	Hooded	Fine	Alternate
Accession - 2	Yellow with red stripes	Hooded	Fine	Alternate
Agnirekha	Fire red with yellow throat	Hooded	Fine	Alternate

Plate 1. General view of the field

Plate 2. White Friendship

Plate 3.	Amal

Plate 4.	Echo Saunder

Plate 5. American Beauty

Plate 6. Oscar

Plate 7.	Mansoer Red

Plate 8.	Tiger Flame

Plate 9. Morocco

Plate 10. Tambri

Plate 11.	True Yellow

Plate 12.	Accession -1

Plate 13. Accession -2

Plate 14. Agnirekha

Table 2. Morphological characters in fifteen varieties of gladiolus

Varieties	Corn germination (%)	Plant height (cm)	Collar girth (cm)	Leaf number	Leaf area (cm^2)
White Friendship	88.22 DEF	59.13 DEF	6.73 DE	8.44 ABC	95.65 E
Amal	92.83 ABC	59.78 DE	8.50 A	8.51 AB	82.32 H
Pacific	71.77 H	56.67 F	7.30 D	7.11 CD	112.20 C
Wedding Bouquet	90.89 BCD	61.44 CD	8.33 AB	8.67 AB	105.30 D
Echo Saunder	87.22 EFG	64.78 B	8.37 AB	8.33 ABC	110.20 C
American Beauty	89.89 CDE	63.54 BC	7.27 D	7.44 BCD	80.80 H
Oscar	91.66 ABCD	53.11 G	7.30 CD	7.44 BCD	70.08 J
Mansoer Red	90.78 BCD	65.22 B	7.47 BCD	7.56 BCD	89.32 F
Tiger Flame	84.22 G	57.11 EF	6.67 DE	6.44 DE	85.44 G
Morocco	85.84 FG	57.22 EF	7.20 D	7.44 BCD	107.00 D
Tambri	88.67 DEF	61.00 CD	8.20 ABC	8.33 ABC	121.00 B
True Yellow	84.32 G	52.10 G	5.07 G	5.67 E	141.30 A
Accession-1	94.89 A	68.88 A	5.17 FG	9.44 A	76.24 I
Accession-2	91.78 ABCD	67.89 A	5.97 EF	7.56 BCD	63.96 K
Agnirekha	93.67 AB	61.89 CD	6.00 EF	6.78 DE	75.45 I

The vegetative characters of varieties are given below in detail.

4.1.1.1 Corm germination percentage

There was significiant difference between varieties as regards to corm germination. The percentage of corm germination ranged from 71.77 to 94.89 with Pacific having the minimum and Accession-1, the maximum. Duncan's Multiple range test revealed that Accession-1 did not significantly vary from Accession-2, Agnirekha, Amal and Oscar. Likewise Amal could be grouped with Wedding Bouquet, Oscar and Mansoer Red. White Friendship was similar to Echo Saunder, Morocco, Tambri and American Beauty while Tiger Flame and True Yellow belonged to same group.

4.1.1.2 Plant height

There was significant difference among the varieties with regard to plant height. The plant height ranged from 52.10 cm to 68.88 cm. Accession-1 was the tallest and True Yellow, the shortest.

Here Accession-1 and Accession-2 were similar and were grouped together. Echo Saunder, Mansoer red and American Beauty were similar in plant height. Wedding Bouquet, Tambri, Agnirekha and White Friendship did not show any variation in plant height. Amal, Tiger Flame and Morocco belonged to the same group. Pacific was similar to Tiger flame and White Friendship.

4.1.1.3 Collar girth

This character showed significant variation among the varieties. The maximum collar girth was observed in Amal (8.50 cm) and the minimum in True Yellow (5.07 cm). Amal did not significantly differ from Wedding Bouquet, Echo Saunder and Tambri. Oscar, Mansoer Red and Tambri were alike. White Friendship, Tiger Flame and Pacific formed a group. Accession-1, Accession-2 and Agnirekha did not differ significantly.

4.1.1.4 Leaf number

There was significant variation among varieties in the leaf number. The maximum number of leaves was observed in the variety Accession-1 (9.44) and the variety with lowest number of leaves (5.67) was True Yellow. When grouped based on the similarity in leaf number all of them were almost alike. White Friendship, Amal, Wedding Bouquet Echo Saunder, Tambri and Accession-1 were alike. Tiger Flame, True Yellow and Agnirekha were grouped together. All other varieties formed one group.

4.1.1.5 Leaf area

There was significant variation among varieties in leaf area. Maximum leaf area was observed for True Yellow (141.30 cm^2) and lowest leaf area was observed in Accession-2(63.96 cm^2). When varieties were grouped based on leaf area, True Yellow, Tambri, White Friendship, Mansoer Red, Oscar, Accession-2 and Tiger Flame were no way similar to each other and came under separate

groups. Pacific and Echo Saunder were similar. Wedding Bouquet and Morocco were alike. While American Beauty and Amal formed one group, Accession-1 and Agnirekha were observed to be alike.

4.1.2 Floral characters

Studies on the floral characters of the varieties (Table 3) revealed that the time for spike emergence from planting ranged from 46.56 days in Accession-1 to 83.41 days in Echo Saunder. The variety which took maximum time for first flowering was Echo Saunder (98.88 days) and Accession-1 took only 60.44 days for first flowering which was the lowest. The flowering period lasted from 3.33 days in True Yellow to 12.44 days in American Beauty. Spike length was highest in Accession-1 (64.67 cm) and the lowest in Morocco (41.89 cm). American Beauty had the lowest spike weight (18.94 g) whereas Mansoer Red had the highest spike weight (25.63 g). True Yellow had the lowest number of 6.68 florets per spike. Agnirekha had the maximum number of florets per spike (15.00). In Pacific maximum number of florets opened at a time (4.22) whereas Oscar registered the least number of florets opened at a time (1.78). In Accession-2 the floret size was the lowest (7.59 cm) whereas in Wedding Bouquet it was highest (11.14 cm). Accession-1 and Accession-2 had the maximum yield of spike per plant, viz., 3.11 whereas in Pacific it was the lowest (1.56). Vase life was maximum in Wedding Bouquet (8.78 days) whereas Tambri and True Yellow had a vase life each of only 6.44 days, which was the minimum. The floral characteristics in each variety is given below in detail.

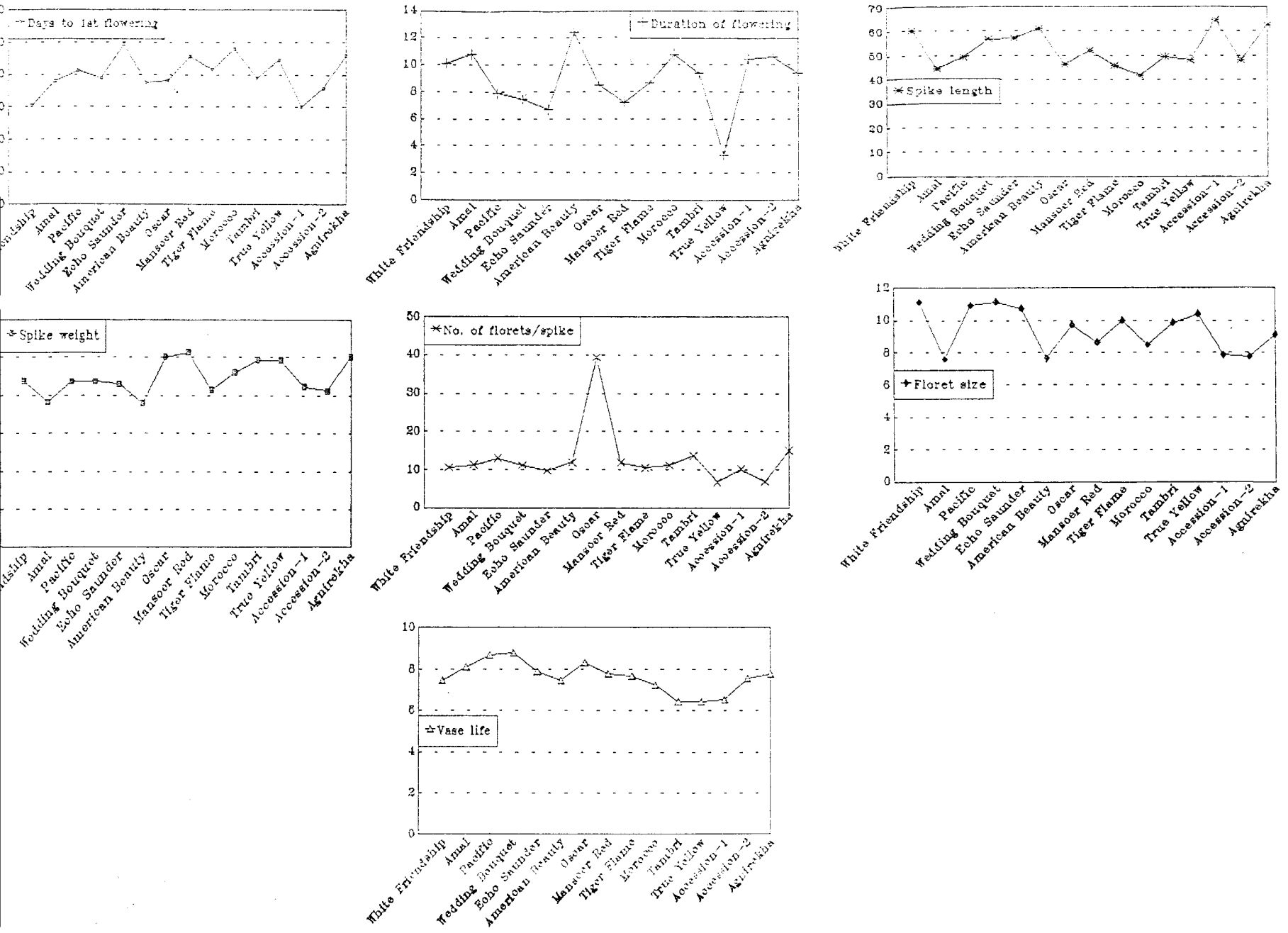


Fig.1. Variation in different characters in different gladiolus varieties

4.1.2.1 Days to spike emergence

Significant variation among varieties could be seen with respect to the time taken for spike emergence. The highest number of days for spike emergence was observed in Echo Saunder (83.41 days). The time taken for spike emergence was lowest for Accession-1 (46.56 days).

Pacific, Tiger Flame and Accession-2 were significantly different from each other and formed separate groups. Echo Saunder and Morocco were alike. Amal, American Beauty, Oscar and Tambri were grouped together. White Friendship and Accession-1 formed one group. Agnirekha, True Yellow and Mansoer Red were alike.

4.1.2.2 Days to first flowering

There was significant variation among varieties in this character. The earliest variety was Accession-1 which took 60.44 days and Echo Saunder was the most delayed one with 98.88 days. Echo Saunder, Mansoer Red, Agnirekha and Morocco did not differ significantly. Pacific and Tiger Flame were alike and were grouped together. Amal was similar to Wedding Bouquet American Beauty and Oscar. Tambri was related to Accession-1 also. White Friendship and Accession-2 were similar and grouped together.

4.1.2.3 Duration of flowering

Here the varieties showed significant variation. Flowering duration of American Beauty was the longest (12.44 days) and that of True Yellow, the

shortest (3.33 days). White Friendship, Amal, Morocco, Accession-1 and Accession-2 were alike. Oscar, Tiger Flame, Tambri and Agnirekha were similar. Pacific, Wedding Bouquet and Mansoer Red formed a group. True Yellow was not similar to other varieties in this character.

4.1.2.4 Length of spike

The varieties showed significant variation in spike length. Accession-1 had longest spike (64.67 cm) and Morocco had the shortest (41.89 cm) spike.

Accession-1 and Agnirekha were similar and formed one group. Likewise Agnirekha was similar to White Friendship and American Beauty also. Wedding Bouquet and Echo Saunder were similar and formed another group. Pacific, Tambri, True Yellow and Accession-2 could be grouped together but Accession-2 had similarities with Tiger Flame and Oscar also. Mansoer Red differed significantly from all other varieties

4.1.2.5 Weight of spike

Significant differences were observed among varieties. Mansoer Red had heaviest spikes with 25.63 g while American Beauty had lightest spikes (18.94 g).

Oscar, True Yellow, Tambri and Agnirekha were similar and formed one group. Morocco was similar to White Friendship, Pacific and Wedding Bouquet. Echo Saunder, Tiger Flame, Accession-1 and Accession–2 did not differ significantly.

Mansoer Red formed a separate group. Amal and American Beauty were similar.

4.1.2.6 Number of florets per spike

Agnirekha had the highest number of florets (15.00) and True Yellow had the lowest (6.68). Oscar and Tambri were alike. Accession-1 closely related to White Friiendship and Tiger Flame and also to Echo Saunder. American Beauty and Mansoer Red did not differ significantly while Amal, Wedding Bouquet and Morocco were alike and formed a group. Accession-2, True Yellow and Agnirekha were not similar to any other varieties when Oscar and Tambri formed one group.

4.1.2.7 Number of florets open at a time

The varieties varied significantly in number of florets open at a time. The values ranged from 4.22 to 1.78. Pacific had maximum number of florets open at a time while Oscar had the minimum.

White Friendship, Amal, Wedding Bouquet, Mansoer Red, Tiger Flame, Tambri and Agnirekha did not differ significantly. Morocco and Accession-2 were alike. Echo Saunder, True Yellow, Accession-1 and Oscar could be grouped together. True yellow and American Beauty was similar to Wedding Bouquet. Pacific was not similar to any other varieties.

4.1.2.8 Floret size

Varieties were significantly different in floret size (Plate 15). Maximum floret size was observed for Wedding Bouquet (11.14 cm) and minimum for Amal (7.59 cm). White Friendship, Pacific and Wedding Bouquet were similar. Echo Saunder was related to True Yellow. Tiger Flame, Oscar and Tambri could be grouped together. Mansoer Red, Agnirekha and Morocco formed one group. Amal, American Beauty, Accession-1 and Accession-2 did not differ significantly.

4.1.2.9 Yield of spike per plant

The varieties showed significant difference in spike yield per plant. Maximum yield was 3.11 and was for Accession-2 and lowest yield was recorded in Pacific (1.56). White Friendship, Wedding Bouquet, Echo Saunder, American Beauty, Oscar, Morocco, Agnirekha, True Yellow and Tiger Flame did not vary among themselves. Amal was similar to Mansoer Red, Tambri, Morocco and Agnirekha. Accession-1, Accession-2, Mansoer Red and Tambri could be grouped together.

4.1.2.10 Vase life

Vase life was significantly different for the varieties tested. Maximum vase life was for Wedding Bouquet (8.78) and minimum (6.44) in True Yellow. Oscar was similar to Amal, Echo Saunder, Mansoer Red, Tiger Flame and Agnirekha. Wedding Bouquet, Pacific and Oscar were alike. White Friendship

Plate 15. Variability in floret size

Plate 16. Corms and cormels

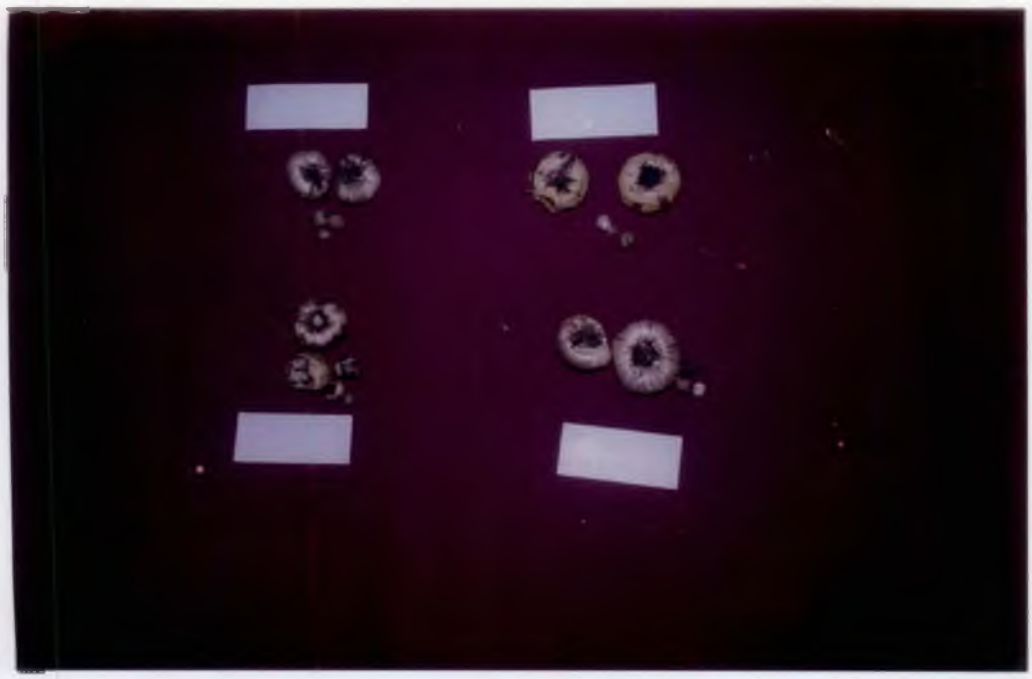


Table 3. Floral and corm characters in fifteen varieties of gladiolus

Varieties	Days to spike emergence	Days to first flowering	Duration of flowering (days)	Spike length (cm)	Spike weight (g)	Number of florets per spike	Number of florets open at a time	Floret size (cm)	Spike yield per plant
White Friendship	47.44 ^{H}	60.77 ^{G}	10.11 ^{BC}	60.22 ^{B}	21.87 ^{CD}	10.55 ^{G}	2.89 ^{CD}	11.13 ^{A}	2.00 ^{DEF}
Amal	62.11 ^{F}	75.78 ^{DE}	10.78 ^{B}	44.40 ^{G}	19.08 ^{E}	11.22 ^{F}	3.00 ^{CD}	7.59 ^{G}	2.56 ^{BC}
Pacific	67.18 ^{D}	82.63 ^{C}	7.88 ^{EF}	49.54 ^{E}	21.84 ^{CD}	13.00 ^{D}	4.22 ^{A}	10.94 ^{A}	1.56 ^{F}
Wedding Bouquet	64.89 ^{E}	77.89 ^{D}	7.44 ^{FG}	56.80 ^{C}	21.84 ^{CD}	11.11 ^{F}	3.11 ^{BCD}	11.14 ^{A}	2.11 ^{CDE}
Echo Saunder	83.41 ^{A}	98.88 ^{A}	6.66 ^{G}	56.83 ^{C}	21.53 ^{D}	9.67 ^{H}	2.11 ^{EF}	10.74 ^{AB}	2.22 ^{CDE}
American Beauty	63.11 ^{EF}	75.33 ^{DE}	12.44 ^{A}	60.87 ^{B}	18.94 ^{E}	11.89 ^{E}	3.67 ^{B}	7.65 ^{G}	2.00 ^{DEF}
Oscar	63.56 ^{EF}	76.22 ^{DE}	8.44 ^{DE}	45.99 ^{FG}	25.09 ^{B}	13.89 ^{B}	1.78 ^{F}	9.73 ^{D}	2.22 ^{CDE}
Mansoer Red	74.22 ^{B}	90.99 ^{AB}	7.22 ^{FG}	51.89 ^{D}	25.63 ^{A}	11.78 ^{E}	2.78 ^{CD}	8.62 ^{EF}	2.89 ^{AB}
Tiger Flame	70.66 ^{C}	83.00 ^{C}	8.66 ^{DE}	45.90 ^{FG}	20.73 ^{D}	10.44 ^{G}	2.89 ^{CD}	10.00 ^{CD}	1.78 ^{EF}
Morocco	80.56 ^{A}	95.78 ^{A}	10.77 ^{B}	41.89 ^{H}	23.05 ^{C}	11.11 ^{F}	2.56 ^{DE}	8.47 ^{F}	2.44 ^{BCD}
Tambri	62.11 ^{F}	74.11 ^{EF}	9.33 ^{CD}	49.29 ^{E}	24.67 ^{B}	13.67 ^{BC}	3.00 ^{CD}	9.85 ^{D}	2.78 ^{AB}
True Yellow	74.11 ^{B}	89.22 ^{B}	3.33 ^{H}	47.80 ^{EF}	24.63 ^{B}	6.68 ^{J}	2.00 ^{EF}	10.39 ^{BC}	1.89 ^{EF}
Accession-1	46.56 ^{H}	60.44 ^{G}	10.44 ^{B}	64.67 ^{A}	21.16 ^{D}	10.11 ^{GH}	1.89 ^{F}	7.84 ^{G}	3.11 ^{A}
Accession-2	57.56 ^{G}	71.55 ^{F}	10.55 ^{B}	48.00 ^{EF}	20.63 ^{D}	6.78 ^{I}	2.55 ^{DE}	7.76 ^{G}	3.11 ^{A}
Agnirekha	77.44 ^{B}	91.77 ^{AB}	9.33 ^{CD}	62.53 ^{AB}	25.17 ^{B}	15.00 ^{A}	3.11 ^{CD}	9.10 ^{E}	2.44 ^{BCD}

(Contd.....)

Table 3. (Contd.....)

Varieties	Vase life (days)	Corm size (cm)	Corm number	Corm weight (g)	Cormel size (cm)	Cormel number	Weight of cormel (g)
White Friendship	7.45 CD	4.98 ABC	1.22 CD	27.63 ABC	1.39 DE	7.00 B	2.52 F
Amal	8.11 ABC	4.64 CD	1.11 D	16.53 F	1.46 DE	5.67 CD	2.84 DEF
Pacific	8.67 A	5.19 A	1.78 A	29.86 ABC	1.64 BC	4.11 FG	3.51 CD
Wedding Bouquet	8.78 A	4.74 BCD	1.13 CD	28.00 ABC	1.84 A	6.56 BC	4.65 A
Echo Saunder	7.89 BC	3.78 E	1.11 CD	23.14 D	1.48 CD	4.78 DEF	2.91 DEF
American Beauty	7.44 CD	4.46 D	1.11 CD	28.17 ABC	1.69 AB	8.11 A	3.74 BC
Oscar	8.33 AB	4.48 D	1.56 AB	27.46 BC	1.66 ABC	5.00 DEF	3.63 BCD
Mansoer Red	7.78 BCD	5.13 AB	1.22 CD	18.30 EF	1.81 AB	5.33 DE	4.60 AB
Tiger Flame	7.67 BCD	5.14 AB	1.56 AB	20.66 DE	1.72 AB	4.44 EF	3.97 B
Morocco	7.22 D	4.67 CD	1.11 D	26.94 C	1.63 BC	7.33 AB	3.33 DE
Tambri	6.44 E	5.12 AB	1.44 BC	31.40 AB	1.71 AB	7.15 B	3.95 B
True Yellow	6.44 E	4.02 E	1.00 D	19.49 DEF	1.28 E	3.22 G	2.16 G
Accession-1	6.55 E	4.40 D	1.33 BCD	22.73 D	1.68 AB	4.78 DEF	3.71 BC
Accession-2	7.56 CD	4.66 CD	1.07 D	26.79 C	1.44 DE	4.67 DEF	2.67 EF
Agnirekha	7.78 BCD	4.46 D	1.11 CD	31.66 A	1.38 DE	3.22 G	2.47 FG

was similar to Echo Saunder, American Beauty, Mansoer Red, Tiger Flame, Morocco, Accession-2 and Agnirekha. Tambri, True Yellow and Accession-1 formed one group.

4.1.3 Corm characters

Values of corm characters are presented in Table 3 (Plate 16).

4.1.3.1 Corm size

Varieties were significantly different. Maximum corm size was for Pacific (5.19 cm) and minimum for Echo Saunder (3.78 cm). White Friendship was similar to Pacific, Mansoer Red , Tiger Flame, Tambri, Wedding Bouquet and Morocco. Accession-1 and Accession-2 did not differ from Morocco, American Beauty, Agnirekha and Amal. Echo Saunder and True Yellow were alike.

4.1.3.2 Corm number

There was significant variation among varieties. Maximum number of corms was observed in Pacific (1.78) and minimum for True Yellow (1.00). White Friendship, Wedding Bouquet, Echo Soundner, American Beauty, Mansoer Red, Tambri, Accession-1, Agnirekha were similar. Pacific was closely related to Oscar and Tiger Flame. True Yellow, Accession-1 and Accession-2 belonged to the same group.

4.1.3.3 Corm weight

There was significiant difference among varieties. Agnirekha had maximum corm weight (31.66g) and Amal had minimum (16.53g). White

Friendship was grouped with Pacific, Wedding Bouquet, American Beauty, Tambri, Oscar and Agnirekha. Morocco and Accession-2 were alike. Tiger Flame, True Yellow, Mansoer Red, Amal, Accession-1 and Echo Saunder did not differ significantly among themselves.

4.1.3.4 Cormel size

There was significant variation among varieties in cormel size. Wedding Bouquet produced largest cormels (1.84 cm) and True Yellow the smallest (1.28 cm). American Beauty, Oscar, Mansoer Red, Tiger Flame, Tambri and Accession-1 belonged to the same group. Amal, White Friendship, Accession-2, Agnirekha and Echo Saunder did not show much difference in cormel size.

4.1.3.5 Cormel Number.

Significant difference between varieties was observed. Number of cormels was highest for American Beauty (8.11) and Agnirekha had the lowest number of cormels (3.22). American Beauty and Morocco was similar and formed one group. But Morocco did not differ from White Friendship, Wedding Bouquet and Tambri. Amal, Echo Saunder, Oscar, Mansoer Red, Accession-1 and Accession-2 belonged to the same group.

4.1.3.6 Cormel Weight

Wedding Bouquet had cormels with maximum weight (4.65 g) and True Yellow had the lowest cormel weight (2.16 g). Wedding Bouquet was similar to Mansoer Red. American Beauty, Oscar, Mansoer Red, Tiger Flame, Tambri and

Accession-1 belonged to one group. Amal was similar to Pacific, Echo Saunder, Oscar and Morocco. Wedding Bouquet, White Friendship, Accession-2 and Agnirekha came under one group.

4.2 Floral Biology

The particular type of inflorescence characteristic of gladiolus is the spike. The individual florets are attached directly to the axis. The gladiolus florets possess floral parts in threes (Plate 17). The outermost three segments make up the calyx and the next whorl of three segments comprise the corolla (true petals). Sepals and petals collectively make up the perianth of the flower. The perianth surrounds three stamens and a tricarpellary pistil with a three-forked stigma. The ovary contains 75 and 150 ovals. Each flower bud is enclosed separately within its own spathe which consists of two bracts.

Data on anthesis and anther dehiscence are presented in Table 4.

4.2.1 Anthesis

In gladiolus varieties studied, full anthesis occurred during the daytime. The full anthesis was observed from 7.15 a.m. and peak time was 9.00 a.m. All the fifteen varieties studied were in full anthesis by 9.00 a.m.. In White Friendship, Echo Saunder and Morocco full anthesis started from 7.15 a.m. and lasted till 8.30 a.m. In Amal, Pacific, Wedding Bouquet and True Yellow full anthesis was from 7.30 a.m. to 9.00 a.m. In all other varieties it was from 7.45 a.m and lasted up to 9.00 a.m.

Table 4. Time of anthesis and anther dehiscence in fifteen gladiolus varieties

Varieties	Time of anthesis	Time of anther dehiscence
White Friendship	7.15 a.m. to 8.30 a.m.	9.30 a.m. to 10.30 a.m.
Amal	7.30 a.m. to 9.00 a.m.	9.00 a.m. to 10.30 a.m.
Pacific	7.30 a.m. to 9.00 a.m.	9.00 a.m. to 10.30 a.m.
Wedding Bouquet	7.30 a.m. to 9.00 a.m.	9.30 a.m. to 10.30 a.m.
Echo Saunder	7.15 a.m. to 8.30 a.m.	9.00 a.m. to 10.30 a.m.
American Beauty	7.30 a.m. to 8.30 a.m.	9.00 a.m. to 10.30 a.m.
Oscar	7.45 a.m. to 9.00 a.m.	9.00 a.m. to 10.30 a.m.
Mansoer Red	7.45 a.m. to 9.00 a.m.	9.30 a.m. to 10.30 a.m.
Tiger Flame	7.45 a.m. to 9.00 a.m.	9.00 a.m. to 10.30 a.m.
Morocco	7.15 a.m. to 8.30 a.m.	9.00 a.m. to 10.30 a.m.
Tambri	7.45 a.m. to 9.00 a.m.	9.00 a.m. to 10.30 a.m.
True yellow	7.30 a.m. to 8.30 a.m.	9.00 a.m. to 10.30 a.m.
Accession-1	7.50 a.m. to 9.00 a.m.	9.00 a.m. to 10.30 a.m.
Accession-2	7.50 a.m. to 9.00 a.m.	9.00 a.m. to 10.30 a.m.
Agnirekha	7.45 a.m. to 9.00 a.m.	9.30 a.m. to 10.30 a.m.

Plate 19.	Variability in stamens in different gladiolus varieties

Plate 20.	Variability in female reproductive organs in different gladiolus varieties

Plate 17.	Cross section of a typical gladiolus flower

Plate 18.	Anthers before and after dehiscence

Plate 21.	Stigma and style on the day of anthesis and one day after anthesis in variety White Friendship

4.2.2 Anther dehiscence

The anther dehisced within 2-3 hours after unfurling of perianth (Plates 18 and 19). Anther dehisced through the two longitudinal slits on it. In Agnirekha, Mansoer Red, Wedding Bouquet and White Friendship anther dehisced at 9.30 a.m. to 10.30 a.m. In all others anther dehiscence started from 9.00 a.m. to 10.30 a.m. in all the 15 varieties full anther dehiscence was observed.

4.2.3 Stigma receptivity

It was observed that the stigma became receptive only after it turned feathery. By 9.30 a.m. the stigma turned feathery and after that upto 2 days it remained receptive. Pollination from 9.30 a.m. on anthesis day to 2 more days after anthesis resulted in successful pod set irrespective of the time of pollination. In all the fifteen varieties studied stigma receptivity started from 9.30 a.m. of anthesis day and continued to be receptive up to 2 days after anthesis. Variability in female reproductive organs is given in Plate 20. In White Friendship from the day of anthesis the stigmatic end of style started splitting downwards (Plates 21).

4.3 Pollen studies

Pollen fertility, pollen diameter, pollen production per anther are given in Table 5 (Plates 22-29).

4.3.1 Pollen fertility

Varieties showed significant difference in pollen fertility which ranged from 75.56 percent to 85.90 per cent. White Friendship had maximum pollen fertility and

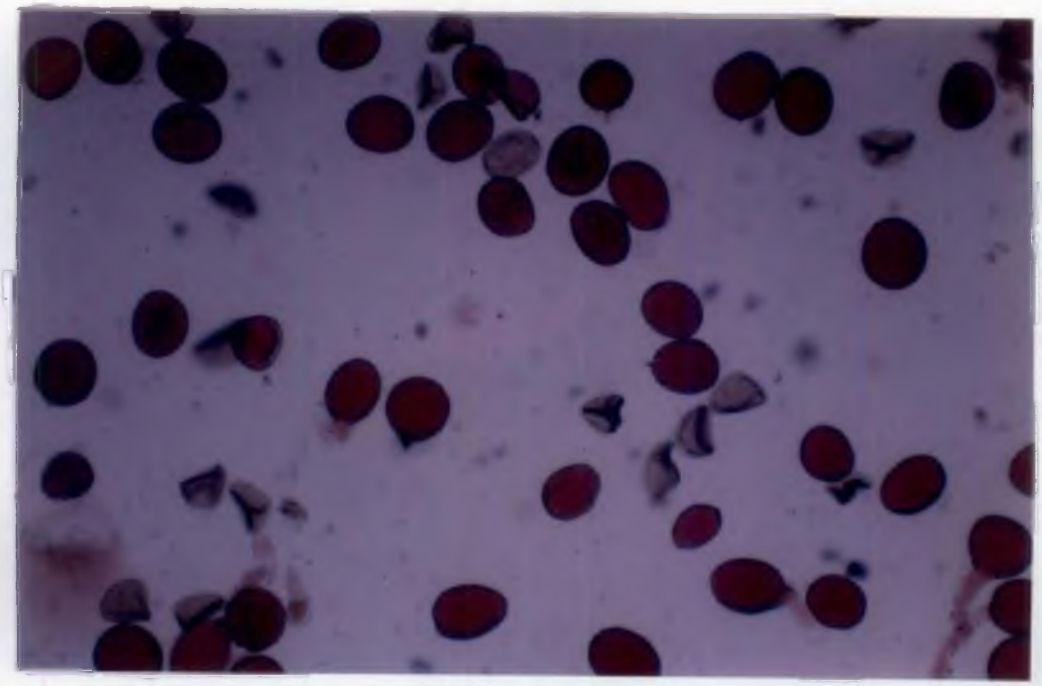
Table 5. Pollen characters of ten gladiolus varieties

Varieties	Pollen fertility (per cent)	Pollen diameter (μ)	Pollen production per anther
White Friendship	85.90 ^{A}	31.05 ^{DE}	39500 ^{A}
Tambri	75.56 ^{E}	36.27 ^{AB}	30670 ^{C}
Echo Saunder	81.44 ^{CD}	35.51 ^{AB}	36000 ^{B}
American Beauty	84.50 ^{ABC}	29.54 ^{EF}	35330 ^{B}
Tiger Flame	82.83 ^{BC}	30.98 ^{DE}	29670 ^{C}
Wedding Bouquet	78.10 ^{E}	35.18 ^{ABCD}	24000 ^{D}
Accession-1	83.69 ^{BC}	27.20 ^{F}	30830 ^{C}
Accession-2	84.53 ^{ABC}	36.26 ^{AB}	30730 ^{C}
Amal	77.28 ^{E}	33.94 ^{BCDE}	35500 ^{B}
Pacific	77.44 ^{E}	38.09 ^{A}	31000 ^{C}

Pollen grains of different gladiolus varieties (acetocarmine – glycerine staining technique)

Plate 22.	Accession –2

Plate 23.	Echo Saunder



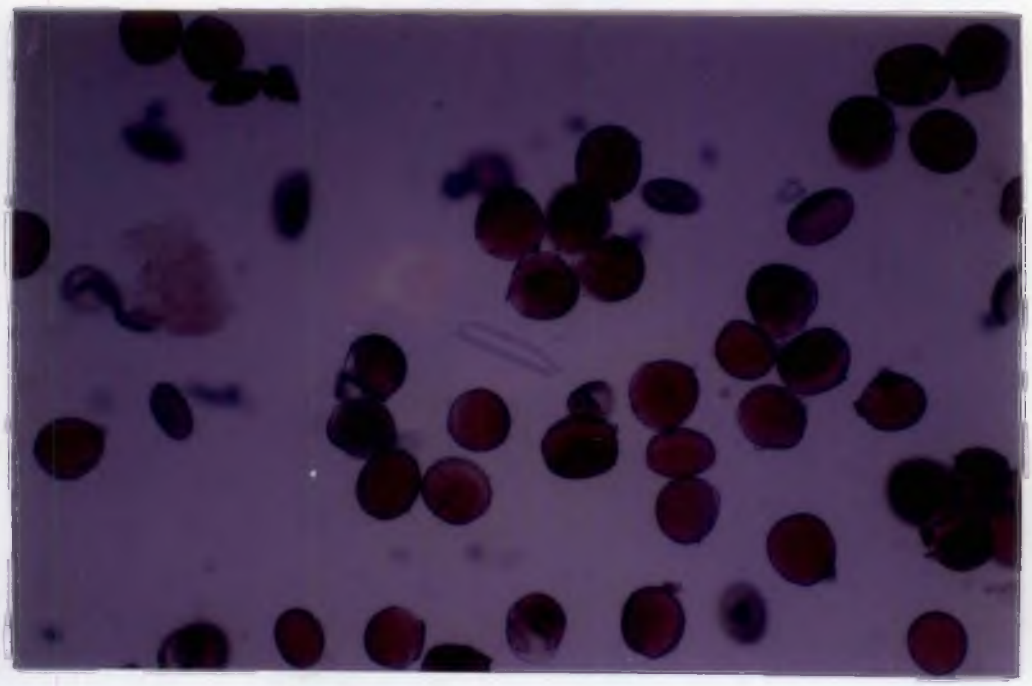


Plate 24. Wedding Bouquet

Plate 25. American Beauty

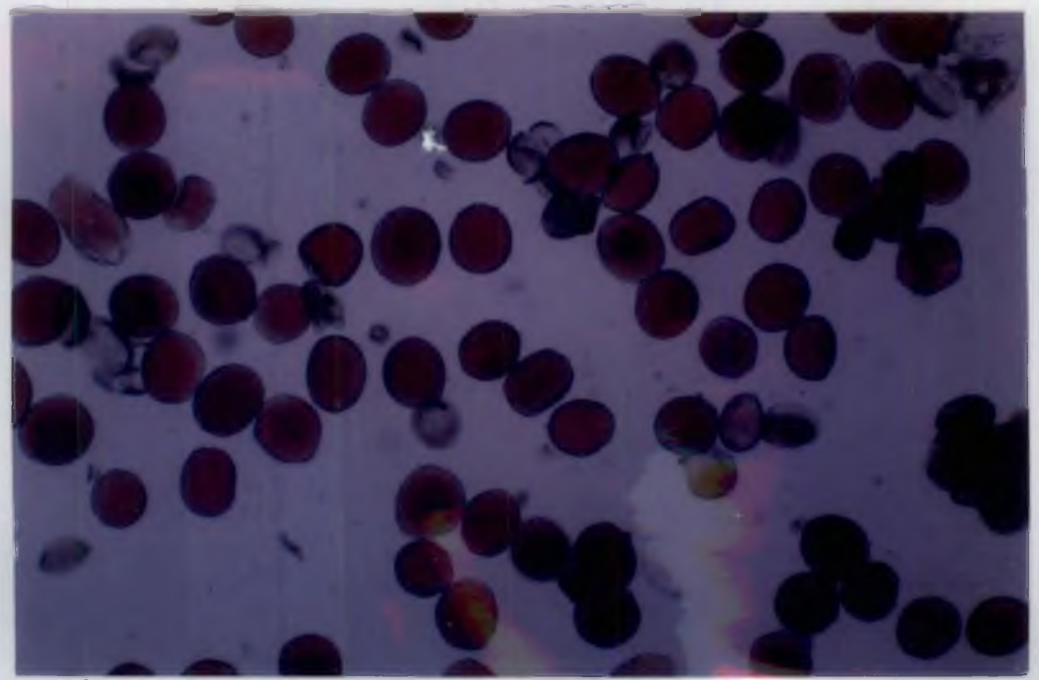
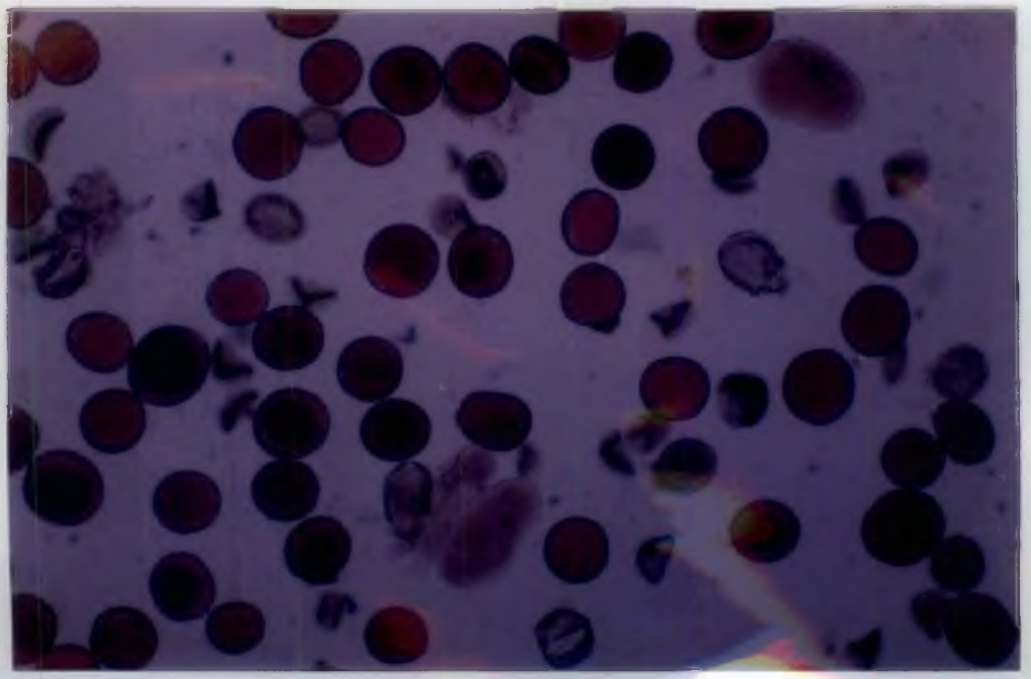


Plate 26.	Tiger Flame

Plate 27.	Accession - 1



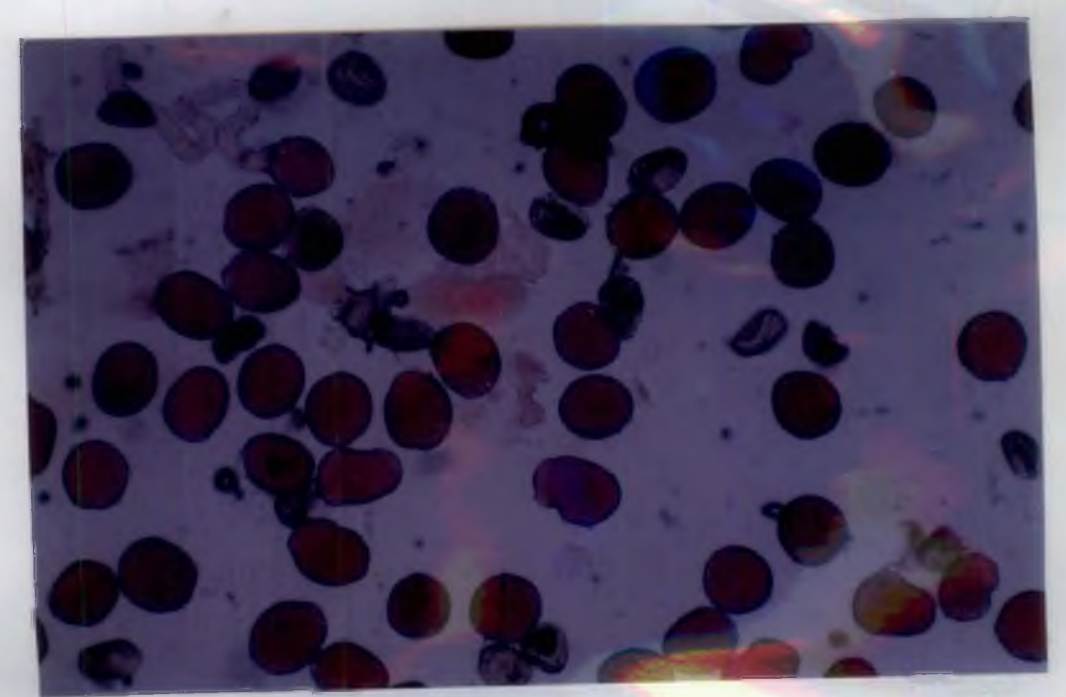
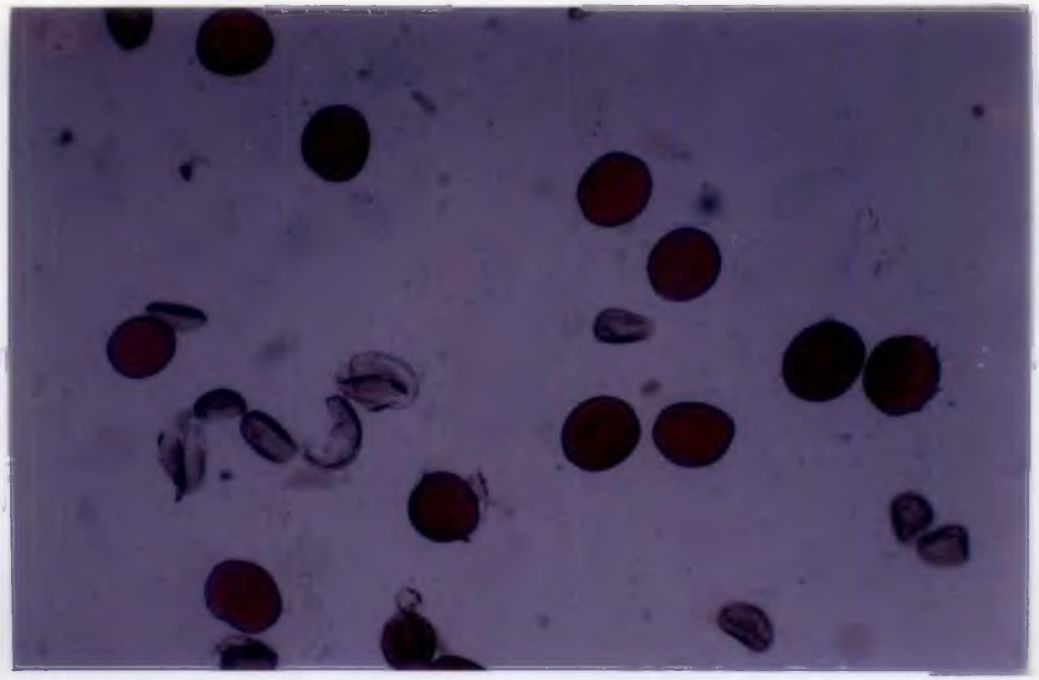


Plate 28. White Friendship

Plate 29. Pacific



Tambri had the minimum. Tiger Flame, Accession-1, Accession-2, American Beauty did not show any difference in pollen fertility. But American Beauty had resemblance to White Friendship, Mansoer Red and Echo Saunder too. Amal, Pacific, Weddiing Bouquet and Tambri were alike and grouped together.

4.3.2 Pollen diameter

The varieties showed significant differences in pollen diameter. Pacific had the maximum pollen diameter of 38.09 μ. Accession-1 had minimum pollen diameter (27.20 μ). Amal, Echo Saunder, Wedding Bouquet, Tambri and Accession-2 were similar and were grouped together. Tiger Flame and White Friendship showed resemblance in pollen diameter. White Friendship was also grouped with Amal and American Beauty. American Beauty and Accession-1 formed one group.

4.3.3 Pollen production per anther

Pollen production per anther showed significant variations among varieties. White Friendship had maximum pollen production per anther (39500) and Wedding Bouquet had the lowest (24000).

Echo Saunder, Amal and American Beauty were grouped together when Pacific, Tambri, Accession-1, Accession-2 and Tiger Flame formed another group. Wedding Bouquet and White Friendship had no similarities with any of the varieties.

4.3.4 Percentage germination of pollen

Data on pollen germination in two gladiolus varieties are given in Table 6.

(i) White Friendship

Boric acid + sucrose medium when tried at different concentration maximum pollen germination was observed in 15 per cent sucrose + 75 ppm boric acid medium and the minimum in 1 per cent sucrose + 25 ppm boric acid.

From the results it was found that as the concentration of sucrose and boric acid were when increased the germination percentage of pollen was also increased. When grouping was done based on the resemblance of the treatments in pollen germination, 1 per cent sucrose + 75 ppm boric acid, 1 per cent sucrose + 50 ppm boric acid and 5 per cent sucrose + 25 ppm boric acid were almost similar. 15 per cent sucrose and 10 per cent sucrose at 50 ppm boric acid also gave similar results. Likewise 15 per cent sucrose and 10 per cent sucrose with 25 ppm boric acid also had similarities.

(ii) Accession –1

Here also maximum pollen germination was obtained at 15 per cent sucrose + 75 ppm boric acid (94.78 %) and the minimum of 73.17 per cent in 1 per cent sucrose + 25 ppm boric acid. Here, 15 per cent sucrose at 25 ppm boric acid. Here, 15 per cent sucrose at 25 ppm boric acid, 10 per cent sucrose at 75 ppm and 50 ppm boric acid were almost similar in pollen germination. Likewise one per cent sucrose at 75 ppm and 50 ppm boric acid were alike while 5 per

Table 6. Pollen germination (%) in sucrose and boric acid medium at different concentrations in two varieties

Treatments	Pollen germination (%)	
Sucrose + Boric acid	White Friendship	Accession - 1
1% + 25 ppm	70.19 ^{H}	73.17 ^{I}
5% + 25 ppm	77.58 ^{G}	76.00 ^{H}
10% + 25 ppm	86.34 ^{E}	83.99 ^{DE}
15% + 25 ppm	88.04 ^{DE}	88.37 ^{C}
1% + 50 ppm	78.32 ^{G}	75.72 ^{HI}
5% + 50 ppm	83.04 ^{F}	79.22 ^{FG}
10% + 50 ppm	89.41 ^{CD}	86.06 ^{CD}
15% + 50 ppm	91.68 ^{BC}	91.81 ^{B}
1% + 75 ppm	79.82 ^{G}	78.13 ^{GH}
5% + 75 ppm	83.54 ^{F}	81.66 ^{EF}
10% + 75 ppm	92.86 ^{B}	87.69 ^{C}
15% + 75 ppm	97.60 ^{A}	94.78 ^{A}

Table 7. Pollen viability (%) under different storage conditions

Variety	Treatments	Pollen viability (%)					
		Week					
		0	1	2	3	4	5
White Friendship	T_1	84.50	80.59	79.15	78.17	75.74	73.71
	T_2	81.68	76.08	73.93	72.69	69.61	65.30
	T_3	83.54	77.74	77.29	76.67	75.08	74.54
	T_4	82.32	67.14	56.97	50.61	47.09	41.65
	T_5	84.62	81.12	79.12	76.82	75.95	73.85
Accession - 1	T_1	83.69	80.79	80.09	77.92	74.89	72.09
	T_2	79.54	72.31	71.29	70.23	68.05	66.06
	T_3	83.68	80.87	79.51	78.40	77.49	77.13
	T_4	76.96	64.98	56.20	51.53	43.22	39.05
	T_5	83.70	81.40	80.10	78.70	77.54	75.77

T_1 - at room temperature
T_2 - in desiccator at room temperature
T_3 - in desiccator at $4^{0}C$
T_4 - at $0^{0}C$
T_5 - at $4^{0}C$

cent sucrose + 25 ppm boric acid also resembled to them. 5 per cent sucrose at 50 and 75 ppm boric acid were alike and 5 per cent and 1 per cent sucrose at 50ppm and 75ppm boric acid respectively were similar.

4.3.5 Pollen storage

Here the varieties White Friendship and Accession-1 showed almost similar results (Table 7). In both varieties pollen storage at 0^0C showed much reduction in pollen viability after 5 weeks of pollen storage. After that much reduction in pollen viability was noticed in desiccator at room temperature. When pollen grains were stored in desiccator at 4^0C it could retain viability the most when compared to other treatments. When stored at room temperature and at 4^0C showed reduction in pollen viability between that in desiccator at room temperature and desiccator at 4^0C.

4.4 Heritability, genetic advance, genetic gain and phenotypic and genotypic coefficients of variation

Heritability, genetic advance, genetic gain and phenotypic and genotypic coefficients of variation were estimated for the 13 characters which showed significant correlation with yield (Table 8). The phenotypic and genotypic coefficients of variation of plant height were 8.40 and 8.02, respectively. Genetic gain was 15.76 per cent. Collar girth had the heritability 0.82. The genetic gain was 28.43 per cent. The PCV and GCV values were 16.76 and 15.21, respectively. Regarding the character leaf number it had the heritability 0.61and

Table 8. Range, mean, gcv, pcv heritability, genetic advance and genetic gain as percentage of mean for thirteen characters in gladiolus

Characters	Range	Mean ± SE	GCV (%)	PCV (%)	Heritability	Genetic advance	Genetic gain (%)
Days to first flowering	58.77 to 94.99	79.187 ± 0.3926	14.07	14.20	0.98	22.75	28.73
Duration of flowering (days)	4.887 to 12.44	8.997 ± 0.1326	21.53	22.27	0.93	3.86	42.90
Plant height (cm)	52.10 to 68.88	60.650 ± 0.3932	8.02	8.40	0.91	9.56	15.76
Spike length (cm)	41.89 to 64.67	52.932 ± 0.3471	13.51	13.74	0.97	14.47	27.34
Spike weight (g)	18.94 to 32.55	22.918 ± 0.1826	14.74	15.06	0.96	6.81	29.72
Number of florets per spike	6.780 to 15.00	11.569 ± 0.0775	17.59	17.78	0.98	4.15	35.87
Number of florets open at a time	1.777 to 4.223	2.851 ± 0.0810	21.39	24.06	0.79	1.12	39.28
Florets size (cm)	7.590. To 11.14	9.398 ± 0.0781	14.06	14.42	0.95	2.65	28.20
Vase life (days)	6.443 to 8.780	7.607 ± 0.0988	9.14	10.43	0.77	1.25	16.43
Spike yield per plant	1.555 to 3.110	2.340 ± 0.0720	19.22	22.61	0.72	0.79	33.76
Collar girth (cm)	5.067 to 8.500	7.036 ± 0.1280	15.21	16.76	0.82	2.00	28.43
Leaf number	5.667 to 9.443	7.678 ± 0.1815	11.45	14.66	0.61	1.41	18.36
Leaf area (cm^2)	63.96 to 141.3	94.417 ± 0.3624	22.62	22.67	1.00	43.91	46.51

genetic gain 18.36. The PCV and GCV were 14.66 and 11.45, respectively. Leaf area had the highest heritability 0.99 and PCV and GCV were 22.67 and 22.62, respectively. Leaf area also showed highest genetic gain of 46.51 per cent.

In the case of days to first flowering, heritability was 0.982 and PCV and GCVwere 14.2 and 14.07 respectively. The genetic gain was 28.73 per cent. Duration of flowering had heritability 0.93 and genetic gain, 42.90 per cent. PCV and GCV were 22.27 and 21.53, respectively. Regarding length of spike heritability was 0.97 and genetic gain was 27.34. PCV and GCV were 13.51 and 13.74, respectively. Spike weight had heritability 0.96 and the genetic gain was 29.72. PCV and GCV were 14.74 and 15.06, respectively. Heritability in the case of total number of florets per spike was 0.98. PCV and GCV were 17.78 and 17.59, respectively. Genetic gain was 35.87 per cent. Number of florets open at a time had heritability 0.79 and genetic gain, 39.28 per cent. PCV and GCV were 21.39 and 24.06, respectively. In the case of floret size heritability observed was 0.95 and PCV and GCV values were 14.06 and 14.42, respectively. The genetic gain was 28.197 per cent. Heritability of yield of spikes per plant was 0.723. PCV and GCV values were 22.61 and 19.22, respectively. The genetic gain was 33.76 per cent. Vase life had the heritability 0.77 and PCV and GCV were 10.43 and 9.14, respectively. The genetic gain was 16.43 per cent.

4.5 Correlation studies

The genotypic and phenotypic correlations of various yield components with number of flowers per spike were worked out. The results are presented in

Table 9. Genotypic correlation coefficients (rg) among different characters in gladiolus

Characters	Duration of flowering	Plant height	Spike length	Spike weight	Number of florets per spike	Number of florets open at a time	Floret size	Vase life	Spike yield per plant	Collar girth	Leaf number	Leaf area
Days to first flowering	-0.504 **	-0.230	-0.364 *	0.357 *	0.189	0.09	0.109	0.187	-0.204	0.246	-0.574 **	0.374 *
Duration of flowering		0.386 **	-0.005	-0.715 **	-0.257	-0.001	-0.68 **	-0.115	0.33 *	0.035	0.432 **	-0.614 **
Plant height			0.441 **	-0.504 **	-0.57 **	-0.24	-0.479 **	-0.135	0.781 **	-0.005	0.63 **	-0.457 **
Spike length				0.031	0.079	0.036	0.097	-0.224	0.011	-0.382 **	0.268	-0.041
Spike weight					0.547 **	-0.025	0.315 *	-0.408 **	-0.089	-0.408 **	-0.596 **	0.554 **
Number of florets per spike						0.329 *	0.249	0.002	-0.354 *	0.041	-0.402 **	0.298 *
Number of florets open at a time							0.193	0.205	-0.612 **	0.126	-0.429 **	0.37 *
Floret size								0.272	-0.711 **	0.195	-0.143	0.6 **
Vase life									-0.406 **	0.568 **	0.067	-0.286
Spike yield per plant										-0.156	0.612 **	-0.439 **
Collar girth											0.401 **	0.125
Leaf number												-0.263

* Significant at 5% level ** Significant at 1% level

Table 10. Phenotypic correlation coefficients (rp) among different characters in gladiolus

Characters	Duration of flowering	Plant height	Spike length	Spike weight	Number of florets per spike	Number of florets open at a time	Floret size	Vase life	Spike yield per plant	Collar girth	Leaf number	Leaf area
Days to first flowering	-0.494 **	-0.220	-0.353 *	0.339 *	0.192	0.083	0.105	0.151	-0.170	0.236	-0.417 **	0.372 *
Duration of flowering		0.344 *	0.002	-0.662 **	-0.246	-0.012	-0.641 **	-0.085	0.296 *	0.021	0.295 *	-0.597 **
Plant height			0.416 **	-0.466 **	-0.536 **	-0.222	-0.466 **	-0.073	0.550 **	-0.031	0.537 **	-0.435 **
Spike length				0.035	0.08	0.04	0.094	-0.17	0.035	-0.325 *	0.21	-0.046
Spike weight					0.532 **	-0.009	0.314 *	-0.314 *	-0.067	-0.367 *	-0.505 **	0.537 **
Number of florets per spike						0.281	0.235	0.005	0.297 *	0.051	0.303 *	0.295 *
Number of florets open at a time							0.19	0.188	-0.438 **	0.073	-0.315 *	0.329 *
Floret size								0.263	-0.554 **	0.165	-0.139	0.579 **
Vase life									-0.315 *	0.446 **	0.023	0.257
Spike yield per plant										-0.056	0.315 *	0.374 *
Collar girth											0.356 *	0.116
Leaf number												-0.209

* Significant at 5% level ** Significant at 1% level

Tables 9 and 10. The characters having significant correlation with number of flowers per spike were weight of spike, number of florets open at a time, spike yield per plant, leaf number, leaf area and plant height. Of these six characters number of florets open at a time, leaf area, spike weight had positive correlation. Spike weight had the highest positive correlation with number of flowers per spike (rp = 0.532, rg = 0.547). Next highest positive and significant correlation was found with number of florets open at a time in genotypic correlation (rg = 0.329) but it was leaf area in phenotypic correlation (rp = 0.275). The correlation values of the character leaf area to number of florets per spike were rp =0.295 and rg = 0.298. This was the character having least positive and significant genotypic correlation. But the least positive and significant phenotypic correlation coefficient of number of florets per spike was found with number of florets open at a time (rp=0.281, rg = 0.329).

4.5.1 Inter-correlation among different characters

Two charcters, plant height and spike weight, had largest significant correlation with number of florets per spike. Other characters namely, number of florets open at a time, spike yield per plant, leaf number and leaf area were also correlated with number of florets per spike. Among the different characters studied, six characters had significant and positive or negative correlation with number of florets per spike.

Days to first flowering had significant positive association with spike weight (rg=0.357 and rp=0.339) and leaf area (rg=0.374 and rp=0.372). Duration

of first flowering had positive and significant association with plant height (rg=0.386) spike yield per plant (rg=0.330, rp=0.296) and leaf number (rg=0.432, rp=0.295). Plant height had negative association with number of florets per spike through spike weight (rg= ¯0.504 and rp = ¯0.466), floret size (rg= ¯0.479, rp = ¯0.466) and leaf area (rg= ¯0.457, rp= ¯0.435). But plant height had high positive significant association with length of spike (rp= 0.416, rg= 0.441), spike yield per plant (rp=0.550, rg=0.781) and leaf number (rg=0.630 and rp=0.537). Length of spike had significant negative correlation with collar girth (rg= ¯0.382 rp= ¯0.325). Leaf number and spike yield per plant had significant negative correlation with number of florets per spike (rg= ¯0.402, rp= ¯0.303 and rg= ¯0.354, rp= ¯0.297 respectively).

Spike yield per plant had negative and significant correlation with number of florets open at a time (rg= ¯0.612, rp= ¯0.438). Weight of spike had negative significant correlation with vase life (rg = ¯0.408, rp = ¯0.314). Also spike yield per plant had significant negative correlation with floret size (rg = ¯0.711, rp = ¯0.554). Leaf area has positive and significant correlation with days to first flowering (rg = 0.374, rp = 0.372), spike weight (rg = 0.554, rp = 0.537), number of florets per spike (rg = 0.298, rp = 0.295) number of florets open at a time (rg = 0.370, rp = 0.329) and floret size (rg = 0.6, rp = 0.579). Leaf number had positive and significant correlation with duration of flowering (rg = 0.630, rp = 0.537), length of spike (rg = 0.268, rp=0.210), spike yield per plant (rg = 0.612 rp = 0.315) and collar girth (rg = 0.401 rp = 0.356). Likewise leaf

number had negative significant correlations with spike weight (rg = ¯0.596, rp = ¯0.505), number of of florets per spike (rg = ¯0.402, rp = ¯0.303), number of florets open at a time (rg= ¯0.429, rp = ¯0.315) and floret size (rg = ¯0.143, rp = ¯0.139). Spike yield per plant had significant negative correlations with number of florets open at a time (rg = ¯0.612, rp = ¯0.438) and floret size (rg = ¯0.711, rp = ¯0.554) and vase life (rg = ¯0.406, rp = ¯0.315). Leaf number had positive significant correlation with spike yield per plant and collar girth viz., rg = 0.612, rp = 0.315 and rg = 0.401, rp = 0.356 respectively.

4.6 Genotypic path coefficient analysis

Step down regression was performed and twelve characters which showed significant correlation with yield were selected for path coefficient analysis.

The direct and indirect effects of the component characters on yield character, number of florets per spike are furnished in Table 11.

Weight of spike had the highest positive direct effect (1.626) and followed by duration of flowering (0.913). Other characters which had positive direct effect were length of spike (0.342), number of florets open at a time (0.058) and collar girth (0.584). But days to first flowering, plant height, floret size, spike yield, leaf number and leaf area exhibited a negative direct effect (-0.072, -0.024, -0.071, -0.294, -0.034 and -0.090 respectively).

Spike weight had a high positive correlation with number of florets per spike (0.547) even though its indirect effect on yield through days to first

Table 11. Genotypic path coefficient analysis of florets per spike

Characters	Days to first flowering	Duration of flowering	Plant height	Spike length	Spike weight	Number of florets open at a time	Florets size	Vase life	Spike yield per plant	Collar girth	Leaf number	Leaf area	Correlation coefficient
Days to first flowering	**-0.072**	-0.460	0.006	-0.125	0.580	0.005	-0.008	0.073	0.060	0.143	0.019	-0.034	0.189
Duration of flowering	0.036	**0.913**	-0.009	-0.002	-1.162	0.000	0.048	-0.045	-0.097	0.021	-0.015	0.055	-0.257
Plant height	0.016	0.352	**-0.024**	0.151	-0.820	-0.014	0.034	-0.053	-0.230	-0.003	-0.021	0.041	-0.570
Spike length	0.026	-0.005	-0.011	**0.342**	0.051	0.002	-0.007	-0.087	-0.003	-0.223	-0.009	0.004	0.079
Spike weight	-0.026	-0.652	0.012	0.011	**1.626**	-0.001	-0.022	-0.159	0.026	-0.238	0.020	-0.050	0.547
Number of florets open at a time	-0.006	-0.001	0.006	0.012	-0.041	**0.058**	-0.014	0.080	0.180	0.074	0.014	-0.033	0.329
Floret size	-0.008	-0.621	0.012	0.033	0.512	0.011	**-0.071**	0.106	0.209	0.114	0.005	-0.054	0.249
Vase life	-0.013	-0.105	0.003	-0.076	-0.663	0.012	-0.019	**0.390**	0.119	0.332	-0.002	0.026	0.002
Spike yield per plant	0.015	0.301	-0.019	0.004	-0.144	-0.035	0.051	-0.158	**-0.294**	-0.091	-0.021	0.039	-0.354
Collar girth	0.018	0.032	0.000	-0.131	-0.663	0.007	-0.014	0.222	0.046	**0.584**	-0.013	-0.011	0.041
Leaf number	0.041	0.394	-0.015	0.092	-0.969	-0.025	0.01	0.026	-0.180	0.234	**-0.034**	0.024	-0.402
Leaf area	-0.027	-0.56	0.011	-0.014	0.900	0.021	-0.043	-0.111	0.129	0.073	0.009	**-0.090**	0.298

Residual = 0.2011

Diagonal values (in bold) indicate direct effects

flowering (-0.026), duration of flowering (-0.652), number of florets open at a time (-0.001), floret size (-0.022), vase life (-0.159), collar girth (-0.238) and leaf area (-0.050) were negative. Length of spike also had positive correlation (0.079) through its high and positive direct effect (0.342). Duration of flowering had negative correlation (-0.257) through negative indirect effects on plant height (-0.002), spike length (-0.002), spike weight (-1.162), vase life (-0.045), spike yield per plant (-0.097) and leaf number (-0.015). But its direct effect was high and positive (0.913). Vase life has low and positive correlation with number of florets per spike. Its direct effect was high (0.390). The indirect effect of duration of flowering through number of florets open at a time was the lowest (0.000). Also the indirect effect of collar girth was low and zero. The highest positive indirect effect on number of florets per spike was of leaf area through spike weight (0.900). The highest positive correlation of spike weight with number of florets per spike (0.547) was mainly due to its highest direct effect on number of florets per spike (1.626). Number of florets open at a time also had second highest positive correlation through its direct effect 0.058. Its indirect effects on plant height (0.006), spike length (0.012), vase life (0.080), spike yield per plant (0.180), collar girth (0.074), leaf number (0.014) were low but positive.

Floret size had high and positive correlation with number of florets per spike (0.249), but its direct effect was only –0.071. But the indirect effects of floret size except for days to flowering (-0.008), duration of flowering (-0.621) and leaf area (-0.054), through all other nine characters were positive. Spike

yield per plant had a negative correlation (-0.354), through its negative direct effect, -0.294. Leaf number also negatively correlated with a value -0.402 and it had direct effect –0.034. Though leaf area had negative direct effect (-0.090) its correlation with yield was high (0.298). The spike yield per plant has negative indirect effects through plant height (-0.019), spike weight (-0.144), vase life (-0.158), collar girth (-0.091) and leaf number (-0.021) and its indirect effects through all other characters were positiive.

Spike length had indirect positive effects through days to first flowering (0.026), spike weight (0.051), number of florets open at a time (0.002) and leaf area (0.004). All other indirect of this character were negative. Plant height had positive indirect effects through days to first flowering (0.016), duration of flowering (0.352) spike length (0.151), floret size (0.034) and leaf area (0.041). All other indirect effects of this characters were negative. Leaf area had its positive indirect effects through plant height (0.011), spike weight (0.900), number of florets open at a time (0.021), spike yield per plant (0.129), collar girth (0.073) and leaf number (0.009). All other indirect effects of this character were negative. Leaf number indirectly affects through plant height (-0.015), spike weight (-0.969), number of florets open at a time (-0.025) and spike yield per plant (-0.180). All the other indirect effect of this character were positive. Collar girth has low correlation with number of florets per spike (0.041). Its indirect effects on number of florets per spike even negative for spike length (-0.131), spike weight (-0.663), floret size (-0.014), leaf number (-0.013) and leaf area

(-0.011), all others were found to be positive. Days to flowering had negative indirect effects through duration of flowering (-0.460) spike length (-0.125), floret size (-0.008) and leaf area (-0.034). Residual for the genotypic path coefficient analysis was 0.2011

4.7 Compatibility studies in the different gladiolus varieties

Self and cross pollination were attempted in ten gladiolus varieties (Fig. 2 and Plates 30-32). In self pollination pod set was comparatively high. The number of seeds per pod and weight of seeds were also higher. In successful pollination pod set occurred and it took 25-35 days to mature (Plates 38 to 40). In Tambri and Amal when cross pollination was attempted, it failed to develop pods.

Pollen-pistil interaction was studied in Accession-1 while pollinated with Accession-2 at 6h, 12h, 24h and 48h after pollination. This cross was found to be compatible. Maximum pollen tube growth was obtained in florets which were plucked at 48h after pollination and the minimum in those florets which were plucked at 6h after pollination (Plates 33-37).

In self compatibility (Table 12) the minimum pod set was observed in Echo Saunder (63.42 %) and maximum in Accession –1 (100 %). The number of seeds per pod ranged from 51.37 in Wedding Bouquet and 77.21 in Accession-1. The weight of seeds per pod was maximum in Wedding Bouquet (1.36g) and minimum in Accession-1 (2.98 g).

	White Friendship	Tambri	Echo Saunder	American Beauty	Tiger Flame	Wedding Bouquet	Accession -1	Accession - 2	Amal	Pacific
White Friendship	S	*	*	*	*	*	*	*	*	*
Tambri	CX	SX	CX	CX	CX	CX	CX	CX	CX	CX
Echo Saunder	*	*	S	*	*	*	*	*	*	*
American Beauty	*	*	*	S	*	*	*	*	*	*
Tiger Flame	*	*	*	*	S	*	*	*	*	*
Wedding Bouquet	*	*	*	*	*	S	*	*	*	*
Accession -1	*	*	*	*	*	*	S	*	*	*
Accession - 2	*	*	*	*	*	*	*	S	*	*
Amal	CX	CX	CX	CX	CX	CX	CX	CX	SX	CX
Pacific	*	*	*	*	*	*	*	*	*	S

. - Cross compatible. S - Self compatible. CX - Cross incompatible, SX- Self incompatible

Fig. 2. Self and cross compatibility in ten gladiolus varieties

Table 12. Self compatibility

Combinations	Number of days for maturity	Percentage fruit set	Number of seeds per pod	Weight of seeds per pod	Percentage of seed germination
White Friendship	25.33	89.67	74.68	2.197	76.67
Tambri	-	-	-	-	-
Echo Saunder	33.44	63.42	69.33	2.114	64.27
American Beauty	29.89	74.29	57.29	1.791	61.33
Tiger Flame	34.00	76.93	65.77	1.994	60.38
Wedding Bouquet	36.66	69.97	51.37	1.361	62.71
Accession -1	29.33	100.00	77.21	2.979	70.01
Accession - 2	29.66	98.79	69.76	2.131	66.33
Amal	-	-	-	-	-
Pacific	30.33	87.34	71.34	2.414	78.94

- incompatible

Table 13. Cross compatibility

Combinations	Days to maturity	Pod set (per cent)	Seeds per pod	Weight of seed per pod (g)	Percentage of seed germination
1	2	3	4	5	6
White Friendship x Tambri	27.94	44.65	49.33	1.198	61.31
White Friendship x Echo Saunder	25.33	77.43	59.31	1.416	71.09
White Friendship x American Beauty	29.74	74.27	57.33	1.201	64.39
White Friendship x Tiger Flame	23.31	79.31	47.91	1.110	60.01
White Friendship x Wedding Bouquet	29.37	81.67	44.37	1.074	61.67
White Friendship x Accession -1	24.53	86.31	71.67	1.897	52.91
White Friendship x Accession -2	27.19	84.34	65.33	1.712	71.31
White Friendship x Amal	24.89	61.72	43.34	1.010	50.45
White Friendship x Pacific	26.33	71.25	61.37	1.531	74.39
Tambri x White Friendship	-	-	-	-	-
Tambri x Echo Saunder	-	-	-	-	-
Tambri x American Beauty	-	-	-	-	-
Tambri x Tiger Flame	-	-	-	-	-
Tambri x Wedding Bouquet	-	-	-	-	-
Tambri x Accession -1	-	-	-	-	-
Tambri x Accession -2	-	-	-	-	-
Tambri x Amal	-	-	-	-	-
Tambri x Pacific	-	-	-	-	-
Echo Saunder x White Friendship	32.67	66.37	60.33	1.210	54.37
Echo Saunder x Tambri	33.33	60.14	59.67	1.193	51.23
Echo Saunder x American Beauty	34.13	74.76	61.33	1.231	61.31
Echo Saunder x Tiger Flame	31.67	76.84	62.67	1.239	63.90
Echo Saunder x Wedding Bouquet	30.33	78.91	66.33	1.365	59.03
Echo Saunder x Accession -1	33.33	74.01	70.33	1.607	67.97
Echo Saunder x Accession -2	32.67	76.18	69.67	1.401	63.68
Echo Saunder x Amal	34.67	61.91	59.33	1.179	58.31
Echo Saunder x Pacific	31.13	68.38	66.33	1.365	60.16
American Beauty x White Friendship	30.03	63.13	51.71	1.301	59.61
American Beauty x Tambri	28.33	59.27	31.34	1.007	52.74
American Beauty x Echo Saunder	29.67	60.81	46.31	1.191	58.96
American Beauty x Tiger Flame	29.33	61.92	48.67	1.237	60.09
American Beauty x Wedding Bouquet	30.67	64.36	52.33	1.347	59.72
American Beauty x Accession -1	30.33	66.71	60.37	1.607	64.75
American Beauty x Accession -2	28.91	64.63	58.67	1.570	60.73
American Beauty x Amal	29.33	58.68	55.01	1.414	51.27
American Beauty x Pacific	30.03	63.37	59.33	1.591	57.12
Tiger Flame x White Friendship	34.33	55.37	37.33	0.951	54.72
Tiger Flame x Tambri	33.13	59.21	33.33	0.937	50.81
Tiger Flame x Echo Saunder	30.67	54.13	41.67	1.031	57.17
Tiger Flame x American Beauty	36.33	51.21	38.67	0.990	60.10
Tiger Flame x Wedding Bouquet	34.17	59.68	38.33	0.973	54.21
Tiger Flame x Accession -1	34.33	60.66	40.13	1.015	60.37
Tiger Flame x Accession -2	36.67	59.37	40.17	1.019	58.41
Tiger Flame x Amal	35.33	43.01	31.33	0.921	51.55
Tiger Flame x Pacific	33.67	56.18	39.67	0.998	59.71

(Contd.....)

Table 13. (contd.....)

1	2	3	4	5	6
Wedding Bouquet x White Friendship	34.33	60.78	58.33	1.210	54.34
Wedding Bouquet x Tambri	36.67	59.36	53.33	1.173	58.71
Wedding Bouquet x Echo Saunder	32.67	62.71	60.67	1.420	60.97
Wedding Bouquet x American Beauty	37.13	61.97	62.67	1.600	64.43
Wedding Bouquet x Tiger Flame	33.14	64.21	62.33	1.591	59.67
Wedding Bouquet x Accession -1	36.67	67.17	64.33	1.640	60.34
Wedding Bouquet x Accession -2	34.33	65.01	63.13	1.610	62.67
Wedding Bouquet x Amal	35.33	58.68	58.97	1.231	60.99
Wedding Bouquet x Pacific	36.97	66.44	59.31	1.310	57.12
Accession - 1 x White Friendship	29.67	67.36	61.13	1.490	75.36
Accession - 1 x Tambri	28.67	60.51	59.33	1.320	62.78
Accession - 1 x Echo Saunder	26.67	62.64	60.67	1.340	69.61
Accession - 1 x American Beauty	30.33	62.38	64.33	1.501	72.76
Accession - 1 x Tiger Flame	31.67	64.79	64.13	1.499	73.91
Accession - 1 x Wedding Bouquet	26.33	66.44	68.33	1.631	69.36
Accession - 1 x Accession -2	27.33	74.93	70.67	1.704	75.18
Accession - 1 x Amal	28.33	60.71	56.33	1.197	61.31
Accession - 1 x Pacific	28.67	68.53	66.67	1.539	77.67
Accession - 2 x White Friendship	25.33	91.78	62.37	1.97	75.37
Accession - 2 x Thambari	27.33	90.37	50.67	1.213	62.34
Accession - 2 x Echo Saunder	29.13	85.56	55.67	1.429	66.97
Accession - 2 x American Beauty	24.67	87.68	57.33	1.494	69.13
Accession - 2 x Tiger Flame	27.67	90.37	58.33	1.549	71.01
Accession - 2 x Wedding Bouquet	30.33	88.36	60.67	1.600	66.67
Accession - 2 x Accession -1	28.33	87.44	74.13	2.790	74.74
Accession - 2 x Amal	26.67	85.71	49.67	1.152	54.18
Accession - 2 x Pacific	28.67	90.37	61.73	1.722	69.68
Amal x White Friendship	-	-	-	-	-
Amal x Thambari	-	-	-	-	-
Amal x Echo Saunder	-	-	-	-	-
Amal x American Beauty	-	-	-	-	-
Amal x Tiger Flame	-	-	-	-	-
Amal x Wedding Bouquet	-	-	-	-	-
Amal x Accession -1	-	-	-	-	-
Amal x Accession -2	-	-	-	-	-
Amal x Pacific	-	-	-	-	-
Pacific x White Friendship	30.33	68.34	61.33	1.672	62.20
Pacific x Thambari	34.67	55.32	47.33	1.134	67.67
Pacific x Echo Saunder	37.31	67.67	54.67	1.43	70.01
Pacific x American Beauty	29.97	64.33	59.93	1.772	59.46
Pacific x Tiger Flame	33.13	66.33	57.67	1.671	61.24
Pacific x Wedding Bouquet	30.31	62.71	60.33	1.629	63.03
Pacific x Accession -1	29.14	74.94	66.67	1.799	69.39
Pacific x Accession -2	30.09	71.31	68.13	2.331	67.37
Pacific x Amal	36.69	51.26	38.33	1.002	60.44

- incompatible

Plate 30. Emasculation

Plate 31. Hand pollination

Plate 32.	Pollinated flower protected with butter paper cover

Pollen-pistil interaction

Plate 33.	6h after pollination

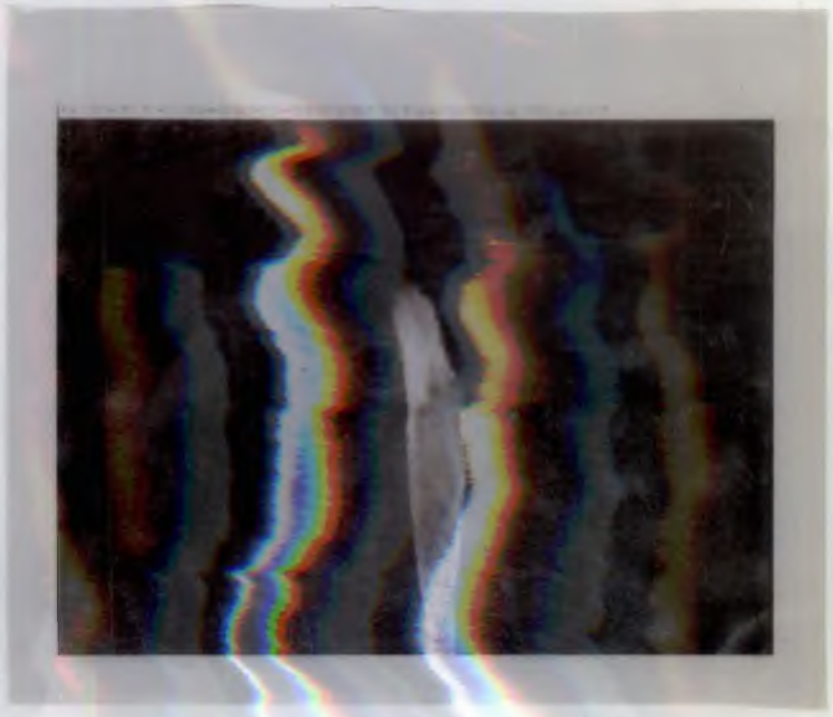


Plate 34. 12h after pollination

Plate 35. 24h after pollination

Plate 36. 48h after pollination

Plate 37. 48h after pollination

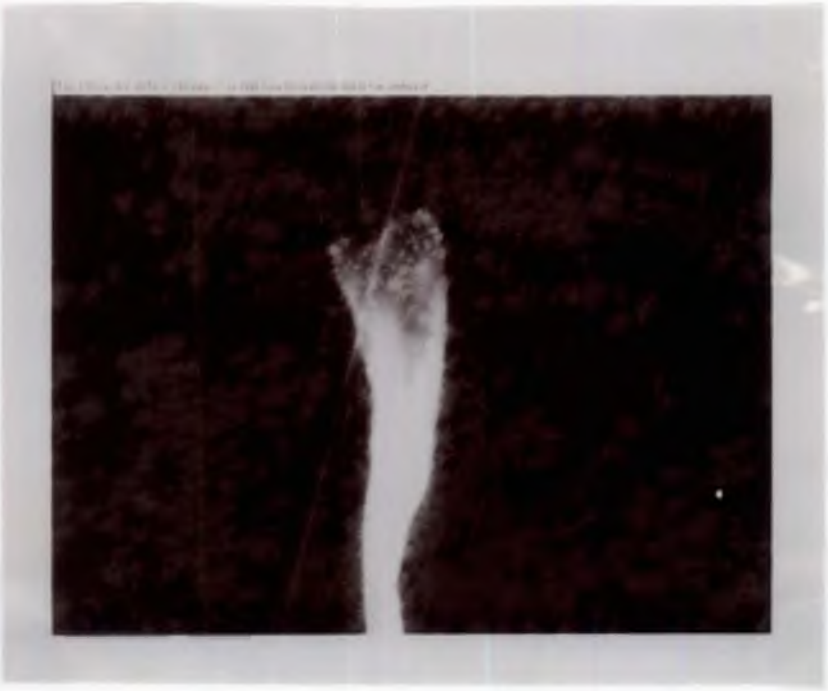


Plate 38. Pod set

Plate 39. Mature pods

Plate 40. Variability in pod size

Plate 41. Seeds

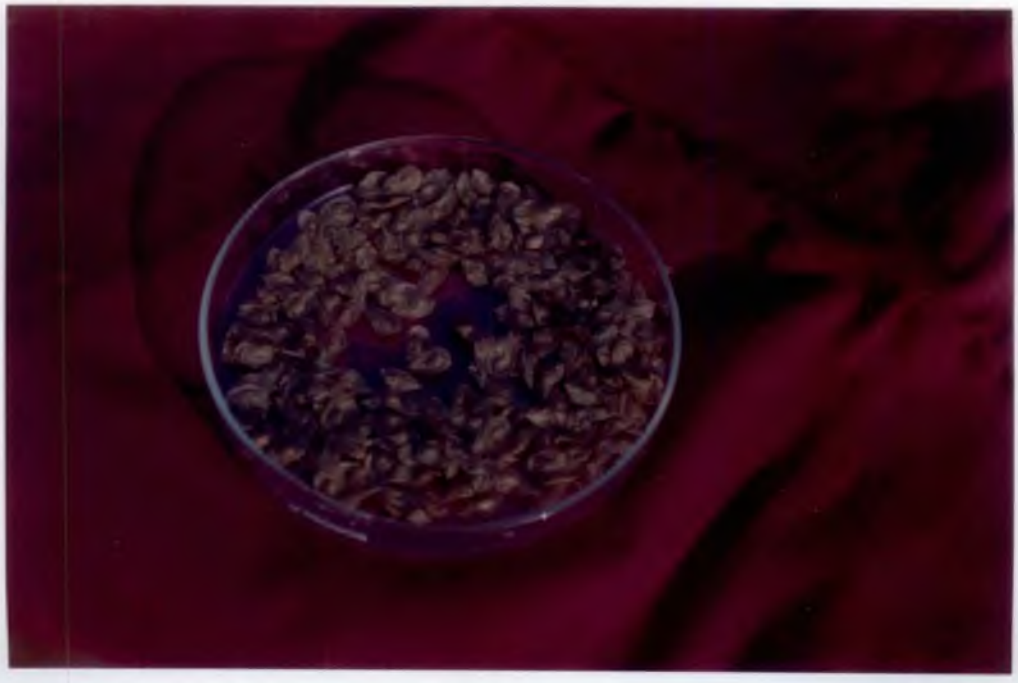


Plate 42. Seedlings

In cross compatibility (Table 13) the pod set was minimum in Tiger Flame x Amal cross (43.01 %) and maximum in Accession-2 x White Friendship (91.78 %). The number of seeds per pod ranged from 31.33 in Tiger Flame x Amal cross to 74.13 in Accession –2 x Accession-1. The weight of seeds per pod ranged from 0.92g in Tiger Flame x Amal to 2.79g in Accession-2 x Accession-1.

The mature seeds obtained were germinated (Plates 41-42). The seed germination percentage was maximum in Pacific (78.94 %) and minimum in Tiger Flame (60.38% when selfed. In crosses, maximum seed germination was in Accession-2 x White Friendship (75.37 %) and minimum in White Friendship x Amal (50.45 %).

Discussion

DISCUSSION

Gladiolus, a bulbous ornamental, has gained popularity in many parts of the world owing to its unsurpassed beauty and economic value. It is grown for both cut flower and garden display purpose. There are now a large number of varieties with different colours, types of florets and petal structure available in the world which has risen as a result of interspecific and intervarietal hybridization. The degree of interaction, of many components which are intimately associated amongst themselves and with yield character can be ascertained through precise estimation of genotypic and phenotypic correlations amongst the yield components themselves. Effectiveness of selection based on phenotypic performance can be more useful and reliable only if selection is based on heritability estimates along with genetic gain. The magnitude of variation and the estimates of heritability and genetic advance are the important parameters along which the selection is made.

For any successful hybridization programme, knowledge about the floral biology, pollen and pollination studies should form the basis. Also before going for hybridization in any crop, one should identify the compatible parents. The present study was therefore, taken up with a view to generate information on varietal characters, variability, heritability, genetic advance, correlation among characters, floral biology, pollen and pollination studies and compatibility between ten gladiolus varieties. This chapter, however, deals only with the brief discussion on the findings in the light of the work already

done as under. In this study, high expression for different characters were observed in the varieties. The varieties showing desirable expression of various characters are furnished below.

Characters	Desirable varieties
(i) Percentage corm germination	Accession-1, Agnirekha, Amal, Oscar
(ii) Plant height	Oscar, True Yellow
(iii) Collar girth	Amal, Wedding Bouquet, Echo Saunder, Tambri
(iv) Leaf number	Accession-1, Wedding Bouquet, Amal
(v) Leaf area	True Yellow, Tambri.
(vi) Days to spike emergence	White Friendship, Accession-1, Accession-2
(vii) Days to bud colour showing	Oscar, Accession-1
(viii) Day to first flowering	White Friendship, Accession-1, Accession-2
(ix) Duration of flowering	American Beauty, Morocco, Accession-1, Accession-2, Amal
(x) Spike length	Accession-1, White Friendship, American Beauty, Agnirekha
(xi) Spike weight	Mansoer Red, Tambri, Agnirekha
(xii) Number of florets per spike	Agnirekha, Oscar, Tambri
(xiii) Number of florets open at a time	Pacific, American Beauty, True Yellow
(xiv) Floret size	White Friendship, Pacific, Wedding Bouquet, Echo Saunder
(xv) Yield of spike per plant	Mansoer Red, Tambri, Accession-1, Accession-2
(xvi) Vase life	Amal, Pacific, Wedding Bouquet, Oscar
(xvii) Corm size	White Friendship, Pacific, Mansoer Red, Tiger Flame, Tambri
(xviii) Corm number	Pacific, Oscar, Tiger Flame
(xix) Corm weight	White Friendship, Pacific, Wedding Bouquet, American Beauty, Tambri, Agnirekha

(xx) Cormel Size	Wedding Bouquet, American beauty, Mansoer Red, Tiger Flame, Tambri, Accession-1
(xxi) Cormel Number	American Beauty, Morocco
(xxii) Cormel weight	Wedding Bouquet, Tambri, Tiger Flame, Pacific

5.1 Vegetative, floral and corm characters

5.1.1 Vegetative characters

5.1.1.1 Percentage of corm germination

Maximum percentage corm germination was recorded for Accession-1 (94.89). It was followed by Agnirekha, Amal, Accession-2 and Oscar (93.67, 92.83, 91.78, 91.66 per cent respectively). The lowest percentage corm germination was for True Yellow (84.32 %). Overall mean was 88.44 per cent. The findings of Varela-Nieto (1980) also registered corm germination of similar range.

5.1.1.2 Plant height

The tallest varieties found in this study were Accession-1 (68.88cm) and Accession-2 (67.89 cm). They were followed by Mansoer Red (65.22 cm) and Echo Saunder (64.78 cm). Shortest variety was True Yellow (52.10 cm). Overall mean was 60.65 cm. Mean plant height in the study by Ravidas *et al.* (1993) was also in the same range. Heritability and genetic advance for this character were 0.91 and 9.56. The PCV and GCV were the lowest for this character (8.02 and 8.40 respectively). So the influence of environment on this character was high.

5.1.1.3 Collar girth

Amal had maximum collar girth (8.50 cm) followed by Echo Saunder (8.37 cm) and Wedding Bouquet (8.33 cm). Lowest collar girth was for True Yellow (5.07 cm). The grand mean was 7.04 cm. Heritability was moderately high (0.82) and genetic advance was low (2.00). The PCV and GCV were moderately high (15.21 and 16.76 respectively). As the GCV was high, it indicated that the expression of this character is least influenced by the environment.

5.1.1.4 Leaf number

Maximum number of leaves was recorded for Accesssion-1 (9.44) followed by Wedding Bouquet (8.67) and Amal (8.51). True Yellow had lowest number of leaves (5.67). The grand mean was 7.68. Ravidas *et al.* (1993) also obtained similar results while evaluating five gladiolus varieties. It had the lowest heritability (0.61). Genetic advance was also low (1.41). So the character was highly influenced by environmental effects and selection would be ineffectve. GCV was found to be low (11.45) and PCV was moderately high (14.66) indicating the influence of environment in this character expression.

5.1.1.5 Leaf area

True Yellow had maximum leaf area (141.30cm^2) and Accession–2 had minimum leaf area (63.96cm^2). Mean leaf area was 94.42 cm^2. The heritability and genetic advance were the highest (0.99) and 43.91 respectively) for leaf

area indicating the additive gene action in the expression of this character. Hence selection will be effective in the improvement of this character. So we can go for selection for the character improvement. Also the GCV was the highest (22.62) showing the least influence of environment of this charcter expression. PCV was also found to be high. (22.67)

5.1.2 Floral characters

5.1.2.1 Days to spike emergence

Echo Saunder took maximum number of days for spike emergence. (83.41days) and Accession-1, the minimum (46.56 days). The overall mean was 60.65 days. This is in close confirmation with the findings of Lal and Singh (1978), Raghava *et al.* (1981), Negi *et al.* (1982) and Cohen and Barzilay (1991). Similar studies by Singh and Singh (1985) and Shah *et al.* (1988) showed variation between varieties in the heading time.

5.1.2.2 Days to first flowering

Echo Saunder (98.88 days) and Morocco (95.78 days) were the varieties which took maximum days for first flowering whereas Accession-1 (60.44) and White Friendship (58.77 days) were the earliest. The overall mean was 79.19 days. This is in close confirmation with the findings of Lal and Singh (1978), Raghava *etal.* (1981), Negi *et al.* (1982) and Cohen and Bazilay (1991). Singh and Singh (1985) and Shah (1988) also registered differences among varieties in days taken for first flowering.

Here the heritability (0.98) and genetic advance (22.75) were high indicating the additive gene action in the expression of this character and hence selection can be taken up for this character improvement. GCV and PCV were moderately high showing the least influence of environment on this character expression.

5.1.2.3 Duration of flowering

American Beauty (12.44 days) had maximum and True Yellow (3.33 days) had minimum duration of flowering. Overall mean was 9.00 days. In the investigations of Leinfelder and Gruber (1985) the duration of flowering was much higher. It could be due to the genetic nature of the varieties studied.

The heritability was high (0.93) but genetic advance was low (3.86) GCV (21.53) and PCV (22.27) were high. So the effect of environment on the character expression was least.

5.1.2.4 Length of spike

Accession-1 had the longest spike (64.67 cm) and Morocco had the shortest (41.89 cm). Overall mean was 52.93 cm. Studies by Wilfret (1979), Raghava *et al.* (1981) and Ravidas *et al.* (1993) revealed spike length of similar range. The findings of Lal & Singh (1978), Wilfret (1981), Negi *et al.* (1982), Misra (1983), Arora and Khanna (1985), Misra *et al.* (1987) and Wilfret (1988) revealed variation among varieties for spike length. This could be due to the genetic nature of the varieties studied.

The heritability estimate was high (0.97) and genetic gain was moderate (14.47) indicating additive gene action. Selection will be the best breeding method for improving the length of spike. This is a very important character which determines market quality and hence breeding strategies are to be formulated after careful assessment of the genetics of this character. GCV was low (13.51) showing the influence of environment in this character expression. PCV was 13.74.

5.1.2.5 Weight of the spike

Mansoer Red had the maximum spike weight (25.63 g) and American Beauty had the minimum spike weight (18.94 g). Overall mean was 22.92 g. Ravidas *et al.* (1993) also obtained spike weight in similar range

The heritability was high (0.96) with a low genetic advance (6.81). PCV (15.06) and GCV (14.74) were moderately high.

5.1.2.6 Number of florets per spike

Agnirekha had maximum number of florets per spike (15.00) while True Yellow had minimum number of florets per spike (6.68). Overall mean was 11.57. This was in agreement with the findings of Ravidas *et al.* (1993) and Wilfret (1981). Lal and Singh (1978), Misra *et al.* (1987) and Wilfret (1988) reported varietal variation for total number of florets per spike. The total number of florets per spike is a major attribute which determines the market demand and shows variation among varieties. Heritability was high (0.98) and

genetic advance was low (4.15). GCV and PCV were moderately high (17.59 and 17.78 respectively) showing that the environment had least influence on the expression of this character.

5.1.2.7 Number of florets open at a time

Pacific had maximum number of florets open at a time (4.22) and Oscar had the minimum (1.78). The grand mean was 2.85. This could be due to variation in genetic nature of varieties. Number of florets open at a time is very important in gladiolus espcially when used in floral decorations.

Heritability was moderately high (0.79) and genetic advance was also the lowest (1.12). This revealed the high influence of environment on this character expression. GCV and PCV were high (21.39 and 24.06 respectively).

5.1.2.8 Floret size

Wedding Bouquet had the maximum floret size (11.14 cm) and Amal had the minimum (7.59 cm). Overall mean was 9.39 cm. Cohen and Barzilay (1971), Wilfret (1979) and Misra *et al.* (1987) while evaluating gladiolus varieties registered mean floret sizes in the same range.

Heritability was high (0.95) and genetic advance was low (2.65). Hence hybridization can bring about improvement in floret size. GCV and PCV were moderately high (14.06 and 14.42, respectively). This revealed that the influence of environment on this character expression was low.

5.1.2.9 Yield of spike per plant

Accession-2 had maximum number of spikes per plant (3.11) and Pacific had the minimum (1.56). Overall mean was 2.34. Mukhopadhyay (1995) also recorded a spike yield of 2-3 per plant. The heritability was 0.72 which was moderate and genetic gain was the lowest (0.79). GCV and PCV were also high (19.22 and 22.61, respectively).

5.1.2.10 Vase life

Wedding Bouquet had the maximum vase life (8.78 days) and True Yellow had the minimum (6.44 days). Overall mean was 7.61 days. Works conducted by Raghava *et al.* (1981) Leinfelder and Gruber (1985) and Ravidas *et al.* (1993) recorded similar mean vase life. Heritability was moderately high (0.77) and genetic advance was very low (1.25). GCV and PCV were low (9.14 and 10.43, respectively) revealing the effect of environment on this character expression. Vase life of spikes is another important character which influences market demand and hybridization is the best breeding strategy for improving vase life.

5.1.3 Corm characters

5.1.3.1 Corm size

Pacific had maximum corm size (5.19 cm) and Echo Saunder had the lowest corm size (3.78 cm). Grand mean was 4.658 cm. According to Negi and Raghava (1986) this corm size coming under "large no.1" and agree with his

findings. Mc Kay *et al.* (1981) and Misra *et al.* (1985) also conducted eperiments with corms falling in this range.

5.1.3.2 Corm number

Pacific had maximum corm number (1.78) and True Yellow had othe minimum corm number (1.00). Overall mean was 1.26.

5.1.3.3 Corm weight

Agnirekha had maximum corm weight (31.66 g) and Amal had the lowest corm weight (16.53 g). Overall mean was 25.25. It is in close confirmation with findings of Ravidas *et al.* (1993).

5.1.3.4 Cormel size

Wedding Bouquet had maximum cormel size (1.84 cm) and it was minimum (1.28 cm) for True Yellow. Overall mean was 1.58 cm.

5.1.3.5 Cormel number

American Beauty had maximum number of cormels (8.11) and the minimum in Agnirekha (3.22). Over all mean was 5.43. This agrees with the findings of Ravidas *et al.* (1993) and contradictory to Lal and singh (1978). It could be due to environmental changes and genetic nature in the varieties used.

5.1.3.6 Cormel weight

Wedding Bouquet had the maximum cormel weight (4.65 g) and True Yellow with minimum cormel weight (2.16 g). Overall mean was 3.58 g.

Ravidas *et al.* (1993) also recorded similar cormel weight while evaluating five varieties.

5.2 Floral Biology

5.2.1 Time of full anthesis

Time of full anthsis was from 7.15 to 9 a.m. This was in agreement with findings of Roy Choudhary (1980), Ohri and Khoshoo (1981), Singh and Singh (1985) and Shah *et al.* (1988).

5.2.2 Time of anther dehiscence

Time of anther dehisence was from 9.00 a.m. to 10.30 a.m. Similar findings were reported by Misra (1975), Roy Choudhry (1980), Ohri and Khoshoo (1981), Singh and Singh (1985) and Randhawa and Mukhopadhyay (1994).

5.2.3 Time of stigma receptivity

Stigma became receptive on the day of anthesis itself. Time of stigma receptivity commencing from 9.30 a.m. (after 1.0 - 2.5 hours of anthesis) and lasted for 1 more day. Stigma became feathery by 9.30 – 10.30 a.m. and only after becoming feathery, it become receptive. Similar results were reported by Ohri and Khoshoo (1981), Singh and Singh (1985), Randhawa and Mukhopadyay (1986) and Randhawa (1995).

5.3 Pollen studies

5.3.1 Pollen fertility

White Friendship showed maximum pollen fertility (85.90 %) and Tambri had the minimum (75.56 %). Negi and Raghava (1995) reported the pollen stainability as 98 per cent .

5.3.2 Pollen diameter

Pacific had maximum pollen diameter (38.09 μ) and Accession-1 had minimum pollen diameter (27.20 μ). This is in close conformation with the findings of Mahawer (1996) where the pollen diameter ranged from 16 μ to 58 μ. In the present study, pollen diameter mean was 33.81 μ.

5.3.3 Pollen production per anther

White Friendship had maximum number of pollen per anther (39500) and Wedding Bouquet had minimum number of pollen per anther (24000). There was significant difference between the varieties in pollen production. It could be due to the genetic nature of the varieties. The overall mean was 32500.

5.3.4 Pollen germination

Two varieties, viz., White Friendship and Accession-1 were assessed for pollen germination. Using sucrose – boric acid medium in different concentrations maximum pollen germination was obtained in 15 per cent

sucrose and 75 ppm boric acid (97.6 %). Minimum pollen germination was in one per cent sucrose and 25 ppm boric acid. This result is in agreement with the findings of Choudhary (1990). The presence of boric acid would have stimulated pollen germination and tube growth according to Schumucher (1935), Munzer (1960) and Rao and Khader (1962). Increased sugar concentration also increased pollen germination

5.3.5 Pollen storage studies

Pollen viability declined in all cases with passage of time irrespective of whether it is stored at room temperature or at 0^0C. Surprisingly the loss of viability was more in case of pollen stored at 0^0C. After 5 weeks of storage of pollen grains which kept in desiccator at 4^0C showed highest viability followed by those stored at 4^0C. The pollen grain stored at room temperature was found to be more viable than those kept in desiccator at room temperature. This result is in close confirmation with that of Mahawer (1996) where the pollen grains could be stored for sixty days without much loss in viability. According to Randhawa and Mukhopadhyay (1986) gladiolus pollen remained viable for three months in desiccator at low temperature which is in agreement with the present study.

5.4 Heritability, genetic advance, genetic gain and phenotypic and genotypic coefficients of variation

5.4.1 Genetic variability

The success of any crop improvement programme depends upon the precise information available on the genetic variability and divergence of the crop. The choice of appropriate selection methods depends upon estimates of

heritability together with genetic advance (Johnson *et al.* 1955). The magnitude of variation of genotypes in relation to environmental influences is to be assessed and the available variability can be partitioned into genetic and non-genetic components. The genetic component is considered more important than variability at phenotypic level, since greater the genetic diversity, greater is the scope for selection.

There was significant difference between 15 varieties of gladiolus for all the characters studied. The existence of considerable variation indicated the scope for improving the population for these characters. Here the characters which had high genotypic and phenotypic variability were leaf area, spike yield per plant, number of florets open at a time and duration of flowering.

It was moderately high for days to first flowering, collar girth, floret size, number of florets per spike and spike weight. PCV and GCV were low for vase life, spike length, plant height and leaf number. These findings are in agreement with that of Lal *et al*, (1985) and Arora and Khanna (1986). Misra *et al.* (1987) reported high variability for the number of spikes per plant and floret size while Misra and Saini (1988) opined that leaf number had low variability. Also spike weight and days to first flowering had high variability which is in confirmation with Gowda (1989). Findings of present study was in close confirmation with Beura and Maharana (1990) where variability was high for total number of florets per plant, Soorianathasundaram and Nambisan (1991) according to which number of florets per spike and floret size had high

variability. Also the present findings are in agreement with the findings of Sobhana *et al.*, (1998) where days for flowering and floret size had high variability.

5.4.2 Heritability and genetic advance

A knowledge on heritability and genetic advance is important for effective crop improvement programmes. High heritability in broad sense indicated that large proportion of phenotypic variance was attributed to the genotypic variance and the character differences among genotypes were real and less influenced by environment. High heritability along with high genetic advance is due to additive gene action and those traits are likely to respond better to selection.

Here high heritability and genetic advance were observed for the characters like days to first flowering, spike length and leaf area which can be attributed to additive gene action on the expression of these characters.

These findings are in close confirmation with Negi *et al.* (1978, 1982) where spike length had high heritability and Lal *et al.* 1985) where spike length had high heritability and genetic advance. Arora and Khanna (1986) reported that days for flowering recorded high heritability and genetic advance. Cohat (1988) reported high heritability for flowering date and spike length which is in agreement with present findings. Also the present study confirms the findings

of Sobhana *et al.* (1998) where days for flowering had high heritability and genetic advance.

High heritability and low genetic advance were recorded in the expression of characters viz., duration of flowering, plant height, spike weight, number of florets per spike and floret size. Moderately high heritability with low genetic advance were observed for the characters like collar girth, vase life and number of florets open at a time. This is in agreement with Gowda (1989) and Sobhana *et al.* (1998)

5.5 Correlation studies

Economic characters are generaly complex in nature and influenced by many plant characters through different physiobiochemical mechanisms. A knowledge on the association of characters is essential to identify the character which could influence the economic traits.

In gladiolus, number of florets per spike which determines the market quality had positive correlation with spike weight, number of florets open at a time and leaf area. This confirms the earlier findings by Misra and Saini (1990) where spike weight had the maximum correlation coefficients (rg = 0.547 rp = 0.532). Thus number of florets per spike and thereby the market value of the spike can be increased with the improvement of any of these characters. A straight away selection from germplasm lines will be very effective for making improvement in this character.

Plant height had positive correlation with duration of flowering, spike length, spike yield per plant and leaf numbers. Lal *et al.* (1985), Gowda (1989) and Anuradha and Gowda (1994), reported similar association of plant height with spike length. Spike weight had positive association with floret size and leaf area. Pant and Lal (1992) reported similar association of spike weight with leaf size. Another important character is the vase life of the spike which had negative association with spike weight and spike yield per plant. Positive correlation with vase life was observed for collar girth. Any attempt, therefore for improving this character might result in increased vase life of the spike.

Floret size was also negatively correlated to spike yield per plant and plant height. Spike length had significant and positive correlation with plant height. Spike yield per plant was positively associated with leaf number but negatively correlated with leaf area, vase life, floret size and number of florets open at a time. So an increase in spike yield per plant makes a decline in all the desirable characters. Leaf number was negatively correlated with floret size, number of florets per spike, spike weight and days to flowering, but positively correlated to duration of flowering, plant height, spike yield per plant and collar girth. Leaf area was positively correlated with spike weight, number of florets per spike, number of florets open at a time and floret size. So it is desirable to select plants with higher leaf area.

The genotypic correlation coefficients were higher than the phenotypic correlation coefficients for most of the characters. This indicates that environment had smaller effects on these characters.

5.6 Genotypic path coefficient analysis

The direct and indirect effects of twelve characters on number of florets per spike showed that spike weight had the maximum direct effect on the number of florets per spike. It was followed by duration of flowering, collar girth, spike length and vase life. The direct selection for the characters like spike weight and duration of flowering would be beneficial for crop improvement, since these two also showed positive correlation coefficients. This confirms the earlier findings of Misra and Saini (1990), Desh Raj *et al.* (1997) and Desh Raj *et al.* (1998). Negative direct effect on the number of florets per spike was from days to first flowering, plant height, floret size, leaf area, leaf number and spike yield per plant. This is in agreement with Misra and Saini (1990). The direct effect of days to first flowering was negative eventhough its correlation with number of florets per spike was positive. It could be due to its positive indirect effects through plant height, spike weight, number of florets open at a time, vase life, spike yield per plant, collar girth, and leaf number on number of florets per spike. Even though the direct effect of duration of flowering was the second largest positive one, its correlation with number of florets per spike was negative mostly due to the negative indirect

effects on number of florets per spike through plant height, spike length, spike weight, vase life, spike yield per plant and leaf number.

The direct effect of floret size on number of florets per spike was negative although its correlation with number of florets per spike was positive. It could be due to the positive indirect effects of plant height, spike length, spike weight, number of florets open at a time, vase life, spike yield per plant, collar girth ad leaf number. In the case of leaf area, also its direct effect on number of florets per spike was negative, but its correlation with number of florets per spike was positive mostly due to its positive indirect effects on number of florets per spike through most of the characters except days to first flowering, duration of flowering, length of spike, floret size and vase life. The residual effect of 0.2011 in genotypic path coefficient analysis showing eighty per cent of the variation in the number of florets per spike was due to the twelve characters selected for the analysis.

5.7 Compatibility studies in different gladiolus varieties

In the present study ten gladiolus varieties namely, White Friendship, Tambri, Echo Saunder, American Beauty, Tiger Flame, Wedding Bouquet, Accession-1, Accession-2, Amal and Pacific were selected and crossed in all combinations. There was no pod development and seed set in Amal and Tambri. There was slight ovary bulging after pollination, later it was arrested. But in all other varieties pod development as well as seed set was observed to a desirable extent. When selfing was attempted in all these ten varieties, again in

Amal and Tambri pod development and seed set had failed. But in all other eight varieties it was successful and also the percentage pod set, number of seeds per pod and weight of seeds per pod were higher in selfing than in crossing. This confirms the earlier findings of Dhaduk *et al.* (1987).

Failure of pod development in crosses involving Amal and Tambri as maternal parents points at the unidirectional incompatibility. This in line with earlier findings in several taxa including *Nicotiana, Petunia, Lycopersicon* and *Antirrhinum* (Abdalla, 1974). Failure of seed set may be due to physical barriers, antagonism of the maternal cytoplasm to the sperm nucleus or sensitivity of the plant to the environment which could block the development or functionality of one of the ganetic, while it would not affect the other. (Lenz and Wimbler, 1959) Clarke *et al.* (1977) reported the variation in identifying stigma-pollen recognition factors could lead to incompatibility.

In self compatibility the percentage pod set ranged from 63.42 in Echo Saunder to 100 per cent in Accession-1. The number of seeds per pod ranged from 51.37 in Wedding Bouquet to 77.21 in Accession-1 and the weight of seeds per pod ranged from 1.36 to 2.98 in Accession-1. Hundred per cent pod set was also reported by Mahawer (1996). In cross compatibility the percentage pod set was from 43.01 in Tiger Flame x Amal to 91.78 per cent in Accession-2 x White Friendship. Singh (1981) observed 76.66 to 84.66 per cent pod set in gladiolus varieties George Mazure and Ratna's Butterfly. Dhaduk *et al.* (1987) reported average capsule set to be 41.25 per cent in

crosses between ten gladiolus varieties. Present study is in close confirmation with these earlier findings. The number of seeds per pod ranged from 31.33 in Tiger Flame x Amal to 74.13 in Accession-2 x Accession –1.

The findings of present study is in agreement with Singh (1981), Dhaduk *et al.* (1987) and Mahawer (1996). The number of seeds per pod varied depending upon the compatibility of a cross (Randhawa and Mukhopadhyay, 1986). The weight of seeds per pod ranged from 0.92 g in Tiger Flame x Amal to 2.79 g in Accession-2 x Accession-1.

Maximum seed germination was obtained in Pacific (78.94 %) and the lowest in Tiger Flame (60.38 %). In cross compatibility maximum germination was from 75.37 per cent in Accession-2 x White Friendship and the lowest in 50.45 per cent in White Friendship x Amal.

The time taken for pod maturity ranged from 25.33 days in White Friendship to 36.66 days in Wedding Bouquet when self pollinated. In cross compatibility studies it ranged from 23.31 days in White Friendship x Tiger Flame to 37.13 days in Wedding Bouquet x White Friendship. It is in close confirmation with Randhawa and Mukhopadhyay (1986) where it took 4-5 weeks for maturation of pods.

Summary

SUMMARY

The present investigation on 'Floral biology and compatibility in gladiolus' was conducted in the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara during the period from July 1997 to December 1998. The investigations on floral biology, pollen studies and the extent of compatibility between different varieties were done in the experimental field of AICRIP on Floriculture.

All the characters showed significant variation among themselves for all the characters studied. The vegetative characters studied were corm germination percentage, plant height, collar girth, leaf number and leaf area. Maximum corm germination was observed in Accession – 1 (94.89 %) and minimum in Pacific (71.77%). Accession – 1 was the tallest variety (68.88 cm) and True Yellow the shortest (52.10 cm). With regard to collar girth Amal registered highest value of 8.50 cm, while True Yellow had the minimum collar girth (5.07 cm). Leaf number was the highest in Accession –1 (9.44) and the lowest in True Yellow (5.67). True Yellow had the maximum leaf area of 141.30 cm^2 and Accession – 1 had the lowest leaf area (63.96 cm^2). The floral characters studied were days to spike emergence, days to first flowering, duration of flowering, length of spike, weight of spike, number of florets per spike, number of florets open at a time, floret size, yield of spike per plant and vase life. Time for spike emergence from planting ranged from 46.56 days in Accession – 1 to 83.41 days in Echo Saunder.

The variety which took maximum time for first flowering was Echo Saunder (98.88 days) and Accession – 1 took only 60.44 days for first flowering which was the lowest. The flowering period lasted from 3.33 days in True Yellow to 12.44 in American Beauty. Spike length was highest in Accession – 1 (64.67 cm) and the lowest in Morocco (41.89 cm). American Beauty had the lowest spike weight (18.94 g) whereas Mansoer Red had the highest spike weight (25.63 g). True Yellow had the lowest number of (6.68) florets per spike. Agnirekha had the maximum number of florets per spike (15.00). In Pacific maximum number of florets opened at a time (4.22) whereas Oscar registered the least number of florets opened at a time (1.78). In Accession – 2, the floret size was the lowest (7.59 cm) whereas in Wedding Bouquet it was highest (11.14 cm). Accession – 1 and Accession –2 had the maximum yield of spike per plant, viz., 3.11 whereas in Pacific it was the lowest (1.50). Vase life was maximum in Wedding Bouquet (8.78 days) whereas Tambri and True Yellow had a vase life each of only 6.44 days, which was the minimum. The corm characters studied were corm size, corm number, corm weight, cormel size, cormel number and cormel weight. Maximum corm size was for Pacific (5.19 cm) and minimum for Echo Saunder (3.78 cm). Maximum number of corms was observed in Pacific (1.78) and minimum for True Yellow (1.00). Agnirekha had maximum corm weight (31.66) and Amal had minimum (16.53 g) Wedding Bouquet produced largest cormels (1.84 cm) and True Yellow the smallest (1.28 cm). Number of cormels was highest for American Beauty (8.11)

and Agnirekha had the lowest number of cormels (3.22). Wedding Bouquet had cormels with maximum weight (4.65 g) and True Yellow had the lowest cormel weight (2.16 g).

The particular type of inflorescence characteristic of gladiolus is the spike. The individual florets are attached directly to the axis. The gladiolus florets possess floral parts in threes. The outermost three segments make up the calyx and the next whorl of three segments comprise the corolla (true petals). Sepals and petals collectively make up the perianth of the flower. The perianth surrounds three stamens and a tricarpellary pistil with a three-forked stigma. The ovary contains 75 and 150 ovals. Each flower bud is enclosed separately within its own spathe which consists of two bracts.

In gladiolus varieties studied, full anthesis occurred during the daytime. The full anthesis was observed from 7.15 a.m. and peak time was 9.00 a.m. The anther dehisced within 2-3 hours after unfurling of perianth. Anther dehisced through the two longitudinal slits on it. It was observed that the stigma became receptive only after it turned feathery. By 9.30 a.m. the stigma turned feathery and after that upto 2 days it remained receptive.

Pollen fertility, pollen diameter, pollen production per anther, pollen germination and pollen viability under different storage conditions were studied. Pollen fertility ranged from 75.56 per cent to 85.90 per cent. White Friendship had maximum pollen fertility and Tambri had the minimum. Pacific had the maximum pollen diameter of 38.09 μ. Accession – 1 had minimum pollen

diameter (27.20 μ). White Friendship had maximum pollen production per anther (39500) and Wedding Bouquet had the lowest (24000). Maximum pollen germination was observed in 15 per cent sucrose + 75 ppm boric acid medium and the minimum in 1 per cent sucrose + 25 ppm boric acid in both the varieties studied viz., White Friendship and Accession – 1.

High heritability and high genetic advance were observed in characters like days to first flowering, spike length and leaf area. This shows that most likely the heritability is due to additive gene effects and selection may be effective for these characters. PCV and GCV were high for leaf area, spike yield per plant, number of florets open at a time and duration of flowering and they were low in the case of vase life, spike length, plant height and leaf number.

The number of florets per spike which determines the market quality had positive correlation with spike weight, number of florets open at a time and leaf area. So the number of florets per spike can be increased with the improvement of any of these characters. A straight away selection from germplasm lines will be very effective for making improvement in this character. The genotypic correlation coefficients were found to be higher than the phenotypic correlation coefficients for most of the characters. This indicates that the environment had lesser effects on these characters.

The direct and indirect effects of 12 characters on number of florets per spike showed that spike weight had the maximum direct effect on number of florets per spike. It was followed by duration of flowering, collar girth, spike

length and vase life. The direct selection for the characters like spike weight and duration of flowering would be beneficial for crop improvement, since these two also showed positive correlation coefficients. Negative direct effects on number of florets per spike was from days to first flowering, plant height, floret size, leaf area, leaf number and spike yield per plant. The highest positive indirect effect on number of florets per spike was of leaf area through spike weight. The indirect effect of duration of flowering on number of florets per spike through number of florets open at a time was the lowest. Residual for the genotypic path coefficient analysis was 0.2011. It shows that eighty per cent of the variation in the number of florets per spike was due to the twelve characters selected for the path coefficient analysis.

Ten gladiolus varieties namely, White Friendship, Tambri, Echo Saunder, American Beauty, Tiger Flame, Wedding Bouquet, Accession-1, Accession-2, Amal and Pacific were selected and crossed in all possible combinations. In self pollination pod set was comparatively high. The number of seeds per pod and weight of seeds were also higher. In successful pollination pod set occurred and it took 25-35 days to mature. In Tambri and Amal when cross pollination was attempted, it failed to develop pods.

In self compatibility the minimum pod set was observed in Echo Saunder (63.42 per cent) and maximum in Accession –1 (100 per cent). The number of seeds per pod ranged from 51.37 in Wedding Bouquet and 77.21 in

Accession-1. The weight of seeds per pod was maximum in Wedding Bouquet (1.36g) and minimum in Accession-1 (2.98 g).

In cross compatibility the pod set was minimum in Tiger Flame x Amal cross (43.01 %) and maximum in Accession-2 x White Friendship (91.78 %). The number of seeds per pod ranged from 31.33 in Tiger Flame x Amal cross to 74.13 in Accession –2 x Accession-1. The weight of seeds per pod ranged from 0.92g in Tiger Flame x Amal to 2.79g in Accession-2 x Accession-1.

The seed germination percentage was maximum in Pacific (78.94 %) and minimum in Tiger Flame (60.38) when selfed. In crosses, maximum seed germination was in Accession-2 x White Friendship (75.37 %) and minimum in White Friendship x Amal (50.45 %).

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FLORAL BIOLOGY AND COMPATIBILITY IN GLADIOLUS

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ABSTRACT OF A THESIS

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ABSTRACT

The present investigation on 'Floral biology and compatibility in gladiolus was conducted in the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara during the period from July 1997 to December 1998. The investigations on floral biology, pollen studies and the extent of compatibility between different varieties were done in the experimental field of AICRP on Floriculture.

All the varieties showed significant variation among themselves for all the characters studied. Accession–1 showed maximum corm germination percentage (94.89), plant height (68.86 cm), leaf number (9.44), spike length (64.67 cm), spike yield per plant (3.11) and took minimum days for spike emergence (46.56) and first flowering (60.44 days). These desirable qualities combined in a single variety indicate its scope for using in further breeding programme. American Beauty had maximum duration of flowering (12.44 days) and highest cormel number (8.11). Agnirekha had maximum number of florets per spike (15.00) and corm weight (31.66 g). Mansoer Red had highest spike weight (25.63 g) and Wedding Bouquet had maximum floret size (11.14 cm) and cormel size (1.84). Maximum number of florets per spike was observed in Pacific. It had longest vase life (8.66 days), corm size (5.18 cm) and corm number (1.78) also. Tambri showed maximum cormel weight (4.65 g).

In all the varieties full anthesis occurred from 7.15 a.m. and peak time was 9.00 a.m. Anthers dehisced within two to three hours after unfurling of perianth. Stigma became receptive only after it turned feathery. By 9.30 a.m. on the day of anthesis stigma turned feathery and after that upto two days it remained receptive.

White Friendship had maximum pollen fertility (85.90 %) and pollen production per anther (39500) while Pacific registered highest pollen diameter (38.09 μ). Maximum pollen germination was observed in 15 per cent sucrose + 75 ppm boric acid medium for the two varieties studied viz., White Friendship and Accession–1. Pollen viability was the highest when stored in desiccator at 4°C.

High heritability and high genetic advance were observed in characters like days to first flowering, spike length and leaf area. This shows that most likely the heritability is due to additive gene effects and selection may be effective for these characters. PCV and GCV were high for leaf area, spike yield per plant, number of florets open at a time and duration of flowering and they were low in the case of vase life, spike length, plant height and leaf number.

The number of florets per spike which determines the market quality had positive correlation with spike weight, number of florets open at a time and leaf area. So the number of florets per spike can be increased with the

improvement of any of these characters. A straight away selection from germplasm lines will be very effective for making improvement in this character. The genotypic correlation coefficients were found to be higher than the phenotypic correlation coefficients for most of the characters. This indicates that the environment had lesser effects on these characters.

The direct and indirect effects of 12 characters on number of florets per spike showed that spike weight had the maximum direct effect on number of florets per spike. It was followed by duration of flowering, collar girth, spike length and vase life. The direct selection for the characters like spike weight and duration of flowering would be beneficial for crop improvement, since these two also showed positive correlation coefficients. Negative direct effects on number of florets per spike was from days to first flowering, plant height, floret size, leaf area, leaf number and spike yield per plant. The highest positive indirect effect on number of florets per spike was of leaf area through spike weight. The indirect effect of duration of flowering on number of florets per spike through number of florets open at a time was the lowest. Ten gladiolus varieties namely, White Friendship, Tambri, Echo Saunder, American Beauty, Tiger Flame, Wedding Bouquet, Accession-1, Accession-2, Amal and Pacific were selected and crossed in all possible combinations. In Amal and Tambri there was no pod development and seed set in both cross pollination and self pollination tests. In self pollination, pod set, number of seeds per pod and weight of seeds per pod were higher than that in cross pollination. Pods

took 25 to 35 days to mature. In self compatibility Accession-1 had maximum pod set (100 %) and highest number of seeds per pod (77.21). Weight of seeds per pod was highest in Wedding Bouquet (1.36 g). In cross compatibility, the pod set was maximum in Accession-2 x White Friendship (91.78 %) and the number of seeds per pod was highest in Accession-2 x Accession–1. The weight of seeds per pod was maximum in Tiger Flame x Amal (0.92 g). The seed germination percentage was maximum in Pacific (78.94 %) in self compatibility studies. In cross compatibility the seed germination percentage was highest in Accession-2 x White Friendship.

The varieties with highest number of florets per spike, vase life and early flowering were observed in this investigation. Also the compatible varieties were identified. These varieties can be exploited in further breeding programmes in gladiolus.