ENHANCEMENT OF SPIKE QUALITIES OF GLADIOLUS (*Gladiolus grandiflorus* L.)

By

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(2011-12-101)

DEPARTMENT OF POMOLOGY AND FLORICULTURE

COLLEGE OF HORTICULTURE

VELLANIKKARA, THRISSUR – 680 654

KERALA, INDIA

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THESIS

submitted in partial fulfilment of the requirement for the degree of

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Faculty of Agriculture

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Department of Pomology and Floriculture

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2015

DECLARATION

I, Simmy A.M. (2011-12-101) hereby declare that this thesis entitled **'Enhancement of spike qualities of gladiolus (*Gladiolus grandiflorus*. L)'** is a bonafide record of research work done by me during the course of research and this thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

Vellanikkara **SIMMY A.M.**

CERTIFICATE

Certified that this thesis, entitled **'Enhancement of spike qualities of gladiolus (*Gladiolus grandiflorus*. L)'** is a record of research work done independently by **Mrs. Simmy A.M.,** under my guidance and supervision and it has not previously formed the basis for the award of any degree, diploma, associateship or fellowship to her.

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We, the undersigned members of the Advisory Committee of **Mrs. Simmy A. M.**, a candidate for the degree of **Master of Science in Horticulture**, agree that this thesis entitled **'Enhancement of spike qualities of gladiolus (*Gladiolus grandiflorus*. L)'** may be submitted by **Mrs. Simmy A. M.,** in partial fulfilment of the requirement for the degree.

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Introduction

1. INTRODUCTION

Gladiolus (*Gladiolus grandiflorus* L) is one of the most attractive and popular cut flowers much acclaimed for its majestic spikes possessing attractive, elegant and delicate florets. Gladiolus belongs to the family Iridaceae with its origin in South Africa. It is said to be the 'Queen of bulbous flower crops'. It is an important cut-flower both in domestic and international market (Chanda *et al*., 2000). It stands fourth in the international cut flower trade after carnation, rose and chrysanthemum.

The name gladiolus was originally coined by Pliny the Elder from the Latin word 'gladius', which means sword, because of the shape of its leaves. The upright growth habits of plants lend itself to any manner of floral arrangements, like minimalist Japanese 'Ikebana' and it excels as a cut flower. The flowers may be frilly, ruffled or plain, solid coloured or multi coloured and they come in every shade and unimaginable colour combinations. It is also a popular decorative plant, for use in herbaceous borders, bedding and for growing in pots and bowls. This flower crop possesses a great potential for export market, especially to European countries.

Large scale production of gladiolus flowers is seen in USA, Holland, Italy, France, Poland, Bulgaria, Brazil, Australia and Israel. India, with its varied climatic conditions in different parts, offers the possibility of growing gladiolus round the year, in one or the other part of the country. In India, it is commercially cultivated in West Bengal, Himachal Pradesh, Sikkim, Karnataka, Uttar Pradesh, Tamil Nadu, Punjab and Delhi. In the eastern states like Tripura, Assam, Manipur, Meghalaya and Nagaland, this flower has established itself as a commercial proposition. There is a sizeable area under gladiolus in Jammu-Kashmir, Andhra Pradesh and Gujarat also.

In Kerala, still it is not commercially cultivated. Intense rain fall and high relative humidity during monsoon and slightly high temperature during summer hinder the commercial production of gladiolus under Kerala conditions. Traditional cultivation practices do not provide any opportunity for environmental control. Consequently the productivity of the crop is not fully realized. In this context protected cultivation has got much importance. Cultivation in polyhouses or rain shelter facilitates quality improvement and multifold productivity enhancement, which helps to compete in the global market.

In cut flower industry, the most important aspect is post harvest handling in order to maintain flower freshness and original colour of the flower for longer period after harvest. Generally, gladiolus flower spikes last for 7-8 days in tap water (Singh and Sharma, 2003; Singh *et al*., 2008). Wilting of the petals, senescence of half and full opened florets cause the early senescence of flower spikes and limit the acceptability of cut gladiolus flower spikes in the national and international trade. The qualitative and quantitative post harvest losses of gladiolus can be reduced by adopting improved technologies like harvesting at proper stage, use of floral preservatives and bud opening solution, pulsing, precooling, improved storage techniques such as low temperature storage, proper packaging methods etc.

The use of floral preservatives is the most economical and practical method for extending post harvest life of gladiolus cut spikes (Salunkhe *et al*., 1990). Pulsing is found to be of great value in promoting flower opening, prolonging life and improving floret size of gladiolus spikes. It is generally beneficial for flowers destined for long period of storage or for long distance transportation. Low temperature storage of cut flowers facilitates the adjustment of flower supply according to the market demand, enables the storing of large quantities of flowers for distant shipment and makes it possible to prolong the sale period. The quality of gladiolus spikes is also influenced by the packaging techniques and condition of the storage environment during transportation. Adding chemical preservatives to the holding solution is recommended to prolong the vase-life of the cut flowers. Sucrose has been found to be the most commonly used sugar in prolonging vase-life of cut flowers. The interactive effects of the combined application of sugars and antimicrobial agents increased vase-life up to 22%, and improved spikes quality of gladiolus cultivars (Al-Humaid, 2004). Hence the investigations to standardize the post harvest treatments to improve the spike qualities have got much importance.

Considering these points the present study was undertaken with the following objectives

1. To compare the performance of gladiolus varieties under open and rain shelter or open ventilated polyhouse conditions.

2. To standardize the post harvest treatments to improve the spike qualities of gladiolus.

Review of literature

2. REVIEW OF LITERATURE

Gladiolus is an important bulbous ornamental plant that occupies a prime position among commercial flower crops, which has demand in both domestic and international market. Development and selection of suitable genotypes is an important factor that determines successful cultivation of gladiolus under different agro-climatic conditions, as the performance of varieties with respect to various vegetative parameters like yield, quality and vase life differs greatly in different regions. Its availability in the market is mostly concentrated during the winter season. Production and supply of gladiolus flower in summer or rainy season is very limited due to adverse weather conditions. Protected cultivation facilitates quality improvement and multifold productivity enhancement in flowers which helps to compete in the global market (Attavar, 1993).

The high perishability of the gladiolus spikes renders them vulnerable to large post harvest losses. The qualitative and quantitative post harvest losses of gladiolus can be reduced by adopting improved technologies like harvesting at proper stage, use of floral preservatives and bud opening solution, pulsing, precooling, improved storage techniques such as low temperature storage, proper packaging methods etc.

A brief review on gladiolus with respect to varietal evaluation, protected cultivation, pulsing , holding, packaging and storage is presented in this chapter.

2.1. Varietal evaluation

In a study conducted in the Department of Pomology and Floriculture, College of Horticulture, five varieties of gladiolus were evaluated based on the suitability for growing under Vellanikkara conditions by Ravidas (1990). The studies were conducted during two periods, November to April and April to September. Among the varieties, American Beauty was the most superior regarding the leaf area (681 cm^2 and 412 cm^2 during the first season and second season respectively). American beauty and Friendship flowered early and produced heavy spikes. Mansoer Red and Agnirekha were the long duration varieties. Number of florets per spike was the maximum in American Beauty (15.6) during the first season and in Agnirekha (14.1), during the second season. American Beauty had the longest blooming period (14.7 days) during the first season, whereas Agnirekha was superior (9.0 days) during the second season. Mansoer Red recorded maximum vase life (9 days) during first season and Agnirekha (8.7days) during second season. She also reported that November is the best planting time to obtain quality spikes and good corm yield in gladiolus under Vellanikkara conditions.

Pant *et al*. (1998) evaluated 40 cultivars of gladiolus under hill conditions of UP. Apple Blossom (92.76 cm) Piccardy (87.44 cm) and Oscar (86.87 cm) had longest spikes and Carmine was the earliest to flower (82.33 days). Friendship had more florets per spike (19.53) followed by Oscar (17.53). Han van Mac Green had the heaviest spikes (125.13 g) followed by Oscar (122.33 g).

In a comparative study with eight gladiolus cultivars for their performance in terms of flower and corm yield characteristics under Ghataprabha conditions, Pacifica White, Summer Pearl, Summer Sunshine and Canadian Blood Red proved best with regard to spike length which fell in to the Fancy grade according to International market standards. Late flowering cultivars were best with regard to the characters spike length and number of florets per spike. Among the early flowering cultivars American Beauty proved superior with respect to number of spikes per plant (Shirmagond and Hanamashetti, 1999).

Sidhu and Arora (2000) evaluated the gladiolus varieties for summer flower production in Ludhiana and reported that variety White Prosperity produced the longest spikes (102.27 cm) and size of florets was maximum in variety Rose Supreme (8.92 cm).

Sixteen varieties of gladiolus were grown under sodic waste land (Rai *et al*. 2000). Based on different characters such as plant height, number of tillers per plant, spike length, number of florets per spike, the varieties like White

Prosperity, White Goddess, Red Beauty, Friendship,Venetie, Aldebran, First Lady were found superior in comparison to others.

Rao *et al*. (2000) developed the hybrids of gladiolus and they were evaluated for three years in IIHR, Bangalore. Among them hybrid numbered 84-6-13 (Poonam x Vinks Glory) and hybrid numbered 85-1-13 (Geliber Herald x Vinks Glory) were found to be promising. Out of these two hybrids, 85-1-13 was selected and it was named and released as Arka Suvarna for commercial cultivation.

The performance of some exotic gladiolus cultivars was compared in Lucknow by Roy and Sharga (2000). They reported that cultivars namely Jester, White Prosperity and Rose Supreme were ideal for commercial cultivation by considering various parameters like length of spike, number of florets per spike, number of florets opened at a time and vase life.

An evaluation of twenty six genotypes of gladiolus under North Bihar conditions indicated that PG-17, Moralo and Her Majesty were promising genotypes for more number of florets per spike (Neeraj *et al*., 2000).

Gupta *et al*. (2001) evaluated 11 cultivars of gladiolus. Maximum spike length was recorded in cultivar Pacific White (72.5 cm). Number of spikes per plant ranged from 1 to 2.8 (Aldeburan). The highest number of florets per spike observed in cultivar Pacific White (15.2)followed by Day Dream (14.0). The floret length ranged from 8.3 cm (Interpit Bicolor) to 11.2cm (Red Sparkle). The maximum increase in spike length was noticed in the cultivar RedSparkle (14.5%).

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

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

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

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

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

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

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

Gladiolus cultivars Dhanvantari, Anjali and Sylvia were evaluated under Delhi conditions and found that Dhanvantari produced tallest plants (130.83 cm), followed by Anjali (124 cm), whereas Sylvia was the smallest (74.33 cm) in height. Anjali produced maximum number of leaves per plant (11.33) followed by Dhanavantari (10.66) (Kishan *et al*., 2005).

The evaluation of eleven gladiolus genotypes involving ten elite hybrids and one check variety for cut flower production under transitional tract conditions of Karnataka was carried out by Rashmi (2006). Wide and significant variations for all the characters were observed among the hybrids studied. The maximum plant height was recorded in Dharwad-3 (52.47 cm) which was statistically on par with Dharwad-1, Dharwad-3 and Dharwad-7 (47.57, 45.67, 52.47 and 48.40 cm, respectively). The least plant height was recorded in hybrid Dharwad-8. The hybrid Dharwad-2 recorded maximum number of leaves per plant (5.27) which was statistically on par with AB (5.16). Among the different genotypes studied the check AB was found to be latest and the Dharwad-10 was the earliest to initiate the spikes followed by Dharwad-1. In the case of first floret to show colour and first floret to open the hybrid Dharwad-1 was the earliest and the check variety American Beauty was late.

In a comparative study on different gladiolus hybrids, maximum plant height (132.33 cm) and maximum number of leaves per plant were recorded in the hybrid Yellow Stone X Melody (Swaroop and Singh, 2007).

Singhla *et al*. (2008) reported that studies on vase life of ten gladiolus cultivars indicated that number of florets opened at one time varied significantly among cultivars. Maximum number was recorded in cultivar Chapter (7.2). Cultivar Chapter showed significantly higher per cent floret opening (89.46 %), whereas minimum per cent was observed in Asia (76.49 %). The maximum vase life was observed in cultivar Chapter (18.20 days) and minimum in cultivar Asia (8 days).

Performance of some gladiolus varieties under sub-humid conditions of Rajasthan was compared by Choudhary *et al*. (2011). The vegetative and flowering characters as well as corm and cormel characters showed significant differences amongst the studied cultivars. The minimum number of days required for corm sprouting (7.47 days) and days to slipping (59. 20) were recorded in 'Chandani'. The highest plant height (154.33 cm), spike length (96.47 cm) and flowering duration (14.93 days) were recorded in 'Sabnam'. The cultivar 'Dhanvantari' produced longest length of leaf (54.89 cm), while the maximum leaf width (3.75 cm), spike diameter (1.039 cm), floret-neck diameter (2.436 cm) and floret diameter (8.24 cm) were noted in 'TS-14'. The maximum leaf area (155.94 cm^2), rachis length (66.87 cm), florets per spike (18.47) and number of florets remaining open at time (8.67) were recorded in 'Sancerre'. The maximum number of spikes (2.73) and corms (3.20) per plant were produced in 'Punjab Dawn'.

Variability studies for yield and yield attributing traits in gladiolus (Gladiolus L.) were done in twelve genotypes of gladiolus (Kumar *et al*, 2011). The data of experiments showed that plant height varied from 57.88 to 77.53 cm, number of leaves per plant varied from 6.66 to 9.66 and leaf width varied from 2.40 to 4.21cm .

Among the varieties evaluated for the response to plant growth regulators as foliar spray and sucrose for its vase life, the maximum vase life was exhibited by Phule Ganesh (9.84 days) and minimum by Phule Tejas (8.66 days)(Neha, 2011).

Eight gladiolus varieties were compared under Vidarbha conditions by Gawali *et al* (2012). The maximum plant height was noticed with the variety Nova Lux (74.66 cm) and minimum in variety American Beauty (51.03 cm). Phule Neelrekha produced significantly the maximum leaves per plant (18.40). The variety Phule Tejas took significantly minimum period for spike emergrence (59.70 days), however the maximum days were required for the variety Pink Perfection (83.40 days). Spike length (86.91 cm) and number of florets per spike

(14.40) were found to be maximum with the variety Phule Ganesh. Variety Monte Alto recorded the maximum vase life (9.33 days) and minimum in variety Phule Tejas (6.17 days).

Kumar and Roy (2012) conducted comparative analysis of growth parameters of some promising gladiolus cultrivars for commercial cultivation. There were significant differences among the varieties under trial, with respect to plant characters. Maximum plant height was recorded in 'Yellow Stone' (72.67 cm) and the minimum in 'Oscar' (42.73 cm). The maximum number of leaves (9.23) was recorded in the 'Yellow Stone' which was statistically on par with 'Friendship Pink' and 'Tambari' (8.43 and 8.23, respectively). The least was recorded in 'Oscar' (4.89). The maximum number of days (76.33 days) for spike initiation was taken by the variety 'Aldebaran' and minimum by 'Yellow Stone (50.50 days). Maximum number of days for first floret to open was recorded by cultivar 'Aldebaran' (86.60 days) and the least (69.43 days) was recorded by 'American Beauty'.

A study was under taken to find out the suitable gladiolus varieties for cultivation in Visakhapatnam district of Andhra Pradesh (Susila, 2013). There were significant differences among the varieties with respect to vegetative and floral characters. Maximum plant height was recorded in Tilak (73.5 cm) while, Kumkum (49.1 cm) recorded minimum plant height. Sindhur recorded maximum number of leaves (9.7) per plant and were at par with Kumkum. Aarthi recorded minimum number of leaves (6.0). Early flowering was recorded in Meera (68.9 days) followed by Tilak (79.5 days). Number of days taken for flowering was longer in Aarthi (97.4 days). Tilak (67.7 cm) produced longest spike and Meera (66.7 cm) and Sindhur (65.9 cm) were at par. Aarthi (36.5 cm) produced shortest spike.

Postharvest studies were carried out on forty six cultivars of gladiolus to evaluate their performance for various attributes (Ahmed *et a*l., 2014). The analysis of post harvest attributes of gladiolus revealed a significant difference in behaviour of gladiolus cultivars. Punjab Glad 1 statistically at par with Punjab Glance, Yelllow Stone, Happy End, Big Time Supreme, Pusa Kiran took lowest number of days to opening of basal floret (1.32 days). Punjab Glad 1 statistically at par with Punjab Flame, Oscar, Pusa Kiran, Peter Pears, PG-9-2, PG-23-55 and PG-18-1 recorded maximum vase life (5.55 days), percent opening of florets (73.34%) and water absorption spike-1 (67.79 ml). On the other hand Punjab Flame recorded highest number of florets open at one time (4.20). PG-9-2 statistically at par with PG-6-16, Punjab Glance and Punjab Pink elegance recorded maximum floret diameter (8.90 cm).

2.2. Protected cultivation

Aldebaran variety of gladiolus when grown under greenhouse conditions showed early flowering compared to outdoor conditions. The greenhouse grown plants showed faster spike growth (2.34 cm/day) than that of outdoor grown plants (2.03 cm/day) (Mukherjee, 1992).

The growth and flower production of gladiolus cultivars Mayur and Melody, planted out in a plastic green house in N. India, were better than those from the same cultivars grown in the open from Nov. to May (Dadlani *et al*., 1990). Spike emergence was 13% earlier, plant height was 19% greater, spike length was 19% greater, number of florets open at a given time was 26% greater, floret size was 6% greater, life of the florets on the spike was 30% longer and corm weight was 21% greater (averaged over both cultivars) for the plants grown in the greenhouse.

Chadha *et al*. (1992) observed that gladiolus spikes were free from cold injury and of good quality, when grown under 100 micron polyethylene, whereas those grown under open were highly susceptible to cold injury.

An experiment conducted by Rama *et al*. (2000) to study the performance of gladiolus under open condition and shade nets of different intensities (50% & 75%) showed that the plants under 75 percentage shade net attained maximum height as well as spike length with more number of florets in comparison to plants grown under 50 per cent shade and open conditions.

The advantage of growing gladiolus cv. American Beauty under low-cost greenhouse (polytunnel) environments, compared to open field conditions was investigated. The greenhouse environment had better effect on the plants compared to the open field, in terms of performance for most of the characters studied (particularly for plant height, spike length, number of florets, floret size, and corm weight). Emergence was earlier in the greenhouse than the open field. Greenhouse grown plants showed 20% reduction in time taken for sprouting of corms, spike emergence and flowering (10.17 days), compared to those in the field. Corm size and weight were 20.40 and 38% higher, respectively, in the greenhouse than in the field (Sivasamy and Dadlani, 2002).

In an experiment conducted to evaluate the growth, flowering and corm production of gladiolus under naturally ventilated low cost poly house and open field condition, poly house planting resulted in 24.77 per cent increase in plant height and 22.85 per cent reduction in the time taken for flowering in comparison to open field planting. But the corm and cormel production was reduced under poly house condition by 32.75 percent and 25.16 per cent respectively. There was 18 per cent reduction in the time taken for sprouting of corms under poly house condition. Earliness in corm sprouting, spike emergence and quality flower production are beneficial to gladiolus growers as it leads to availability of flowers in the market earlier. Length of spike and size of flowers were maximum and the longevity of spikes on vase was found to increase by 16.88 per cent under polyhouse condition. (Sarkar and Maitra, 2005).

A study was conducted in Tarai condition, Pantnagar, to evaluate the effect of reduced light intensities (0,30, 50 and 75 percent shading) on vegetative, floral, corm and cormel attributes and physiological aspects in gladiolus c;u1tivars (Fop Bras, American Beauty and Subhangini) in two seasons (Saud *et al*., 2005). Varied response of gladiolus cultivars to different shade levels in winter and summer seasons were observed. In summer, shading at different levels increased the vegetative growth and flower quality in terms of spike and rachis length, number of florets/ spike and vase life of gladiolus. In summer, shading increased number of leaves per plant, but it has no significant effect on number of leaves in winter. Shading also increased chlorophyll content in both the seasons and induced earliness to flowering in summer. Shading has no significant effect on corm and cormel attributes and flower diameter in summer. However, in winter, higher shade level (75% shade) reduced vegetative growth, decreased flower quality and corm and cormel production. It also increased blindness in winter. Amongst the cultivars, Subhangini was less affected by reduced light intensity with highest flower quali.ty. The cultivar American Beauty was most sensitive to reduced light conditions. The spike length, rachis length and number of florets/spike were significantly higher in Subhangini than other cultivars. During winter, vase life was more in cv. American Beauty; whereas in summer it was higher in cv. Subhangini.

Plants grown under poly tunnel produced flower earlier (82.5 days) compared to plants grown without poly tunnel (84.6 days). Although difference of only two days in flower initiation is of no significance, but plants grown under poly tunnel performed better in respect of plant height (77.0 cm), number of leaves per plant (11.4), number of florets per spike (12.8), number of cormels per plant (8.2), weight of corm per plant (16.0 g) and weight of cormels per plant (30.6 g) than the plants grown without poly tunnel (Islam and Haque, 2011)

In a field study conducted in gladiolus (Gladiolus hybridus Hort.), fourteen promising cultivars were planted under three environments, viz, shade-house, poly house and the open condition, and tested for various characters related to earliness. Genotypes x Environment interactions were significant for days to spike emergence and days from first floret to last floret opening. Variance due to environment + (genotype x environment) and variance due to environment (linear) were highly significant for all characters (Kirtimala *et al*, 2011).

2.3. Pulsing

Sucrose in the pulsing solution was the main carbohydrate source as osmoticurn, which decreased the water potential (Halevy and Mayak, 1974) and thus improved the water uptake of the stem in gladiolus (Kofranek and Halevy, 1976).

Gladiolus spike, being a multifloret system, requires a considerable amount of respiratory substrate to ensure opening of immature florets (Singh *et al.* 2000) Singh *et al* (2001) reported that sucrose promotes opening of immature florets of gladiolus. The spikes last for only six to seven days when placed in water which is too less a postharvest life for marketing of gladiolus for distant market (Murali and Reddy, 1993).Hence, pulsing of spikes with sucrose or use of vase solutions containing sucrose have been found to increase vase life of spikes (Halevy and Mayak 1981, Nowak and Rudnicki 1990, Singh *et al*., 2000, 2001).

According to Arora *et al*. (2001) pulsing treatment with 20 percent sucrose significantly improved the vase life of cut gladiolus spikes. The use of biocides, viz., aluminium sulphate, citric acid, $CoCl_2$ and 8-HQC has also been earlier reported useful for gladiolus (Roychowdhury and Sarkar, 1995). Post harvest pulsing treatments of cut tuberose spikes revealed that pulsing solution treatment of 20 % S + 250 ppm 8-HQS significantly improved vase life and flower opening of cut tuberose spikes (Reid *et al*., 2001).

Spikes of gladiolus cv. Eighth Wonder of 80 cm length where lowest bud had just started showing colour were harvested and pulsed in solutions of silver thiosulfate at 0, 100, 200, 400, 800, 1000 and 1200 mg silver thiosulfate/litre for 8 and 16 h at room temperature (25°C maximum and 20°C minimum) and 80% relative humidity. Just after pulsing, the spikes were placed in distilled water. . Pulsing of gladiolus for 8 h with 600 mg silver thiosulfate/litre improved the vase life (15 days) and floret opening (93%). (Barman *et al*., 2004).

The double pulse treatment comprising of 8-HQ (300 ppm) for a duration of one hour followed by sucrose (20%) for more duration of 12 hours (double pulsing), significantly enhanced water uptake and percent gain in fresh weight as compared to the control and single pulsed spikes (Alka and Kumar, 2005).

Studies were conducted on the effect of pre-storage pulsing of gladiolus spikes with sucrose (20 percent)+$Al_2(SO_4)_3.16H_2O$ (400 ppm), and it was observed that the treatment significantly improved post-storage vase life of the spikes, per cent opening of florets, floret size and number of florets opening at one time and also decreased per cent loss of weight of spikes in storage (Grover *et al*., 2005).

Srivastava *et al*. (2005) carried out an experiment to study the effect of pulsing solution, packaging material and storage duration on the post-harvest life of gladiolus cv. Nova Lux. Among all the pulsing treatments, sucrose [20%] + $Al_2(SO_4)_3$[200 ppm] was found better for most of the floral traits; whereas among all packaging and storage treatments, spikes wrapped in brown paper and stored for 72hours at 4°C was found suitable for enhancing the longevity of cut spikes.

Pulsing of gladiolus spikes with 20 percent sucrose along with Aluminium sulphate 400 ppm and GA_3 200 ppm, resulted in greater vase life (7.88 days) ,floret size (10.18 cm), floret longevity (4.28 days), percent increase in fresh weight 12.69 and percent opening of florets (86.91) over other treatments. The pulsed gladiolus spikes, wet stored under refrigerated conditions, showed decline in vase life, floret longevity, floret size, percent floret opening and percent increase in fresh weight.(Namitha and Kumar, 2006).

Investigations were conducted by Singh *et al*.(2009) to study the effects of pre-storage sucrose pulse treatment on flower quality of modified atmosphere low temperature (MALT)-stored gladiolus cv. ‘Peter Pears’. The pre-storage pulse treatment with 8-HQ (300 ppm) for 1 hour and sucrose (200 ppm) for 12 hours proved to be highly promising in augmenting the flower quality of the MALT-stored gladioli. This treatment significantly increased the water uptake by the gladioli spikes, improved bud opening and enhanced number of open florets per spike.

The studies on the effect of pulsing of gladiolus spikes of cultivar White Prosperity, with 10% sucrose in combination with 150 ppm of 8-HQS (8-Hydroxyquinoline Sulphate) or 100 ppm Ag NO_3 (Silver Nitrate) before storage resulted in greater floret opening and size than those not pulsed. Pulsing of spikes with 10% sucrose in combination with 2 mM Silver Thiosulphate (STS) resulted in maximum floret longevity and vase life. A sucrose treatment alone was not effective; however, these three treatments with sucrose were found to be at par and recommended prior to storage of Gladiolus spikes for long duration (Bhat *et al*., 2012).

Babaji *et al*. (2014) conducted experiments to study the effects of different levels of sugar from 0% to 20% in pulsing treatments on post harvest quality of gladiolus cv. American Beauty. The treatment 20% sugar results in a greater number of opened flowers (11.33 florets) and longer vase life (15.83 days) compared to control (5.17 florets and 9.83 days respectively). For long-distance transportation, an even earlier harvest stage can be recommended, if it is combined with sugar pulsing (20 % for 20hrs), to ensure proper opening of the flowers at their destination market.

2.4. Holding

The effect of silver nitrate in enhancing the vase life of cut gladiolus spikes could be attributed to its role as a bactericide (Halevy and Mayak, 1981). It also reduces vascular plugging at the cut end of spikes (Choi and Roh, 1980; Deswal and Patel, 1983).

Wang and Gu (1985) reported that gladiolus spikes held in vase solution containing 5% sucrose + AgNO3 (50ppm) + 8-HQC (300 ppm) + acidifier had highest fully opened florets as compared to other treatments and control. Silver thiosulphate (STS) was reported as most effective bactericide and an inhibitor to ethylene production and action by Nowak and Rudnicki (1990). The increase in floret opening percentage and water balance due to STS treatment was found by Gendy (2000) on gladiolus cut flower spikes.

Vase solution containing 4% sucrose significantly improved the vase life of gladiolus spikes (Singh *et al*., 2001). Silver thiosulphate inhibited ethylene action and reduced lipoxygenase activity as well as served as an antibacterial component when used in vase solutions and resulted in increased florets longevity and vase life of gladiolus (Sashikala *et al*, 2001).

American Beauty spikes recorded lowest weight loss per spike (0.63g/day) with maximum water uptake (14ml/day) and longest vase life (11.3 day) in a solution having sucrose 4ppm and Silver nitrate 100 ppm (Singh and Singh, 2001).

In an investigation carried out by Singh and Sharma (2003) to study the effect of sucrose in combination with metal salts on the postharvest life of pulsed (20% sucrose for 24 hours) gladiolus spikes cv. White Prosperity it was found that combination of sucrose and metal salts increased the vase life of cut gladiolus spikes from 8.5 days in control to 11.0 days in sucrose (5%) + silver nitrate 200 mg/L combinations.

Spikes of gladiolus cv. Eighth Wonder were pulsed in solutions of 600 mg silver thiosulfate/litre for 8 hours. Further, holding of spikes in silver nitrate at 800 mg/litre delayed spike bending (7.20 days), improved floret opening (87%) and vase life (13 days) (Barman *et al*., 2004).

Holding solution of sucrose 4 percent + Aluminium sulphate 300 ppm + sodium hypochloride 25 ppm having pH 4.0 is recommended for extending the vase life of gladiolus spike cv. Sancerre (9.50 days) (Gaurav *et al*., 2006)

In an experiment conducted for enhancing the post harvest life and quality of cut spikes of gladiolus cultivar Jacksonville Gold, a combination of sucrose 4 percent and Aluminium sulphate 400 ppm was found to be more effective in improving vase life (8.72 days) ,floret size (9.60 cm), floret longevity (4.28 days), days to opening of basal floret (3.56 days), number of florets open at one time (7.54), percent opening of florets (86.91) and water uptake (63.73 ml)(Namitha and Kumar, 2006)

An experiment was conducted to investigate the effect of different vase solutions for better keeping quality of cut spikes of gladiolus cv. White Prosperity (Kumar *et al*., 2006). Maximum vase life (8.10 days), floret size (8.76), floret longevity (4.40 days), number of florets open at a time (6.50), per cent opening of florets(82.80) and solution absorption per spike (66.34 ml) was recorded when a vase solution of sucrose 4 percent + Silver nitrate 50 ppm was used.

The vase solution treatment of GA3 (50ppm) with sucrose (5%) delayed the petal senescence and increased the longevity of the cut spikes and exhibited improved flower quality with bright petal colour. (Singh, 2006).

Singh *et al*. (2008) reported that vase solution containing GA3 (50 mg/L), followed by BA (50 mg/L) with sucrose (50 g/L) significantly enhanced the vase life of gladiolus flowers compared to control (distilled water).

Six holding solutions, viz tap water (control), sucrose (4%), sucrose (4%) + 8-HQC (250 ppm), sucrose (4%) + acetyl salicylic acid (Aspirin) (200 ppm), sucrose (4%) + $Al2(SO_4)_3$ (200 ppm) and sucrose (4%)+ ZnSO4 (0.1%) were used to prolong the post-harvest life of Pusa Jyotsana gladiolus by Kumar *et al*. (2009). He reported that holding solution of sucrose (4%) + 8-HQC (250 ppm), significantly improved the diameter of first (10.14 cm) and third (9.50 cm) floret, whereas, the longevity of first florets (4.43 days), effective useful life (10.14 days) and vase life (13.14 days) were recorded in sucrose (4%) + 8-HQC (250 ppm). Number of fully opened florets was found maximum (4.57 and 5.00, respectively) with sucrose (4%) + 8-HQC (250 ppm) on fifth and seventh day in vase.

The effect of floral preservatives on vase life of gladiolus cv. White Prosperity was studied by Kumar *et al*. (2010). They have reported that the treatment of 4% sucrose + 250 ppm 8 – hydroxyl quinoline citrate tended to increase the days to basal floret opening (4.72 days), floral size (12.76 and 14.58 cm) of fifth and second floret, respectively, length of spike (9.84 cm), vase life (10.07 days) and vase solution uptake (31.30 ml). Longevity of first five florets was registered to be the highest in the spikes treated with 4% sucrose + 300 ppm $Al_2(SO_4)_3$. The minimum values for these traits were recorded in untreated control.

Experiments were carried out by Tiwari *et al* (2010) to investigate the effect of vase solution made of different chemicals on vase-life and quality of cut flowers of gladiolus and China aster cultivars. Out of the four vase solution, the treatment with Tween-20 (0.02%) was observed to be the best followed by $AgNO_3$ (200 ppm), citric acid(200 ppm) and sucrose (5%), resulting in the longest vase-life and maximum weight gain at third day and total solution uptake. Correlation studies revealed that floret diameter had a strong positive correlation with loss in weight of vase solution up to ninth day, total weight loss of vase solution, floret opening per cent and vase-life in various cultivars of both crops.

The effect of $AgNO_3$ and sucrose on the vase life of cut gladiolus spikes of cultivar Yellow Stone was studied by Kumar and Awasthi (2012). Among all the treatments, $AgNO_3$ 25ppm, AgNO3 50ppm + sucrose (4 %) and sucrose (2%) significantly influenced the vase life, water uptake, flower diameter, rachis length, floret length and florets opened as compared to control (distilled water). The maximum (92.30) percentage of fully opened florets per spike were recorded in AgNO3 50ppm + sucrose (4 %).However, the minimum (80.56) percentage of fully opened floret was recorded in control (distilled water).The vase life was 14.66 days in AgNO3 50ppm + sucrose (4 %) and 9.33 days in control.

In order to enhance the vase life of gladiolus, Saeed *et al* (2014) subjected the cut spikes to different levels of gibberellic acid (GA_3), viz., 0, 25, 50, 100 and 200 mg L^{-1} in vase solution. The GA_3 treatment significantly influenced the vase quality attributes and antioxidants capacity of gladiolus cut flowers. Gibberellic acid at 25 mg L^{-1} caused the longest time taken to open the floret and increased the floret opening, vase life duration and fresh weight. The highest antioxidative activities of superoxide dismutase and free radicals scavenging were also recorded with GA_3 at 25 mg L^{-1}. The highest peroxidase, catalase activity and the lowest membrane leakage were recorded with GA_3 at 50 mg L^{-1}. They concluded that GA_3 applied at lower concentrations (25 mg L^{-1}) renders greater beneficial effects on vase life quality, membrane stability and antioxidant activities in gladiolus cut spike, and further higher application rates cause no improvement in the flower longevity.

2.5. Packaging and storage

Waters (1966) conducted an experiment to study the influence of storage temperatures and atmospheres, length of storage, and packaging methods on subsequent vase-life of gladiolus flowers. Satisfactory keeping quality was obtained when spikes were stored at 35°C to 40°C for 6 to 8days, 40°C to 50°C for 4 to 6 days, or 50° to80° for 2 to 4 days. Packaging method exerted a major effect upon flower quality. Spike turgor, appearance, and opening ability of flowers covered with moisture proof wrapping or stored in boxes lined with wrapping were superior to those in paper containers.

Wet refrigerated storage which implies storage in water or preservative solution is the most practiced method for day to day handling of cut flowers (Goszczynska and Rudnicki, 1988). Song *et al*., (1992) studied the effect of cold storage periods of 1 or 2 weeks at 8°C, on gladiolus cut flowers, reported that increasing storage period markedly reduced vase life. Dry storage of flowers causes deterioration in the flower quality (Van Doorn and Hont, 1994). Arora *et al*. (2001) reported that florets of gladiolus lose the ability to open with advancement in the duration of storage.

Storage at 4°C proved better in improving the quality and longevity of flowers, which might be due to slower metabolic activity at 4°C (Palanikumar and Bhattacharjee, 2001). The key to successful modified storage of fresh flowers is to use packaging films of suitable permeability so as to ensure and establish the optimal Equilibrium Modified Atmosphere (EMA) at low temperature (Day, 2001).

The technique of appropriate packaging along with cold storage can contribute in maintaining flower quality through modified atmosphere storage (Zeltser *et al.*, 2001). According to him the polypropylene and plastic coated paper packaging films might possess low air diffusion rate across the film compared to other films. Initially, continued metabolic activities, especially respiration and transpiration of the flowers, might have led to the evolution of beneficial equilibrium of modified atmosphere (EMA) with high CO_2 and low O_2 and high relative humidity within the package. This further might have caused closure of stomata and minimized the respirational loss of carbohydrates as well as transpirational loss of water from the cut spikes.

Beura and Singh (2003) also reported significant effect of storage temperature and wrapping material on postharvest life of gladious. The cut spikes of gladiolus cv. Her Majesty were wrapped in polyethylene, cellophane, butter paper or newspaper, and were packed in boxes. The box was stored at 4°C or 10°C or in ambient condition for 2, 4 and 6 days. The postharvest life of cut spikes of gladiolus was highest with packing in cellophane and butter paper and storage at 4°C for 2 days; in cellophane or butter paper for 4 days and in butter paper for 6 days.

The spikes of three Gladiolus cultivars (Jacksonville Gold, Suchitra and Praha), dry-stored in polyethylene sleeves under refrigerated conditions, showed decline in vase life and percent opening of florets and increase in percent weight loss (Singh *et al.*, 2003). They also reported that the cultivars differed in their response to storage. According to them, wrapping the gladiolus spikes of cv Sancerre in cellophane paper and holding for 24 hours at room temperature (20-25^0 C) for long distance transport have been beneficial compared to other wrappers.

The enhanced bud opening in cut flowers is associated with high cell turgidity (Torre *et al*., 1999) and regulation of optimum metabolic activities with high petal sugar status (Singh *et al*., 2005). Similar effects of improved bud opening with modified atmosphere packaging have been reported by Meir, *et al*. (1995); Grover *et al*. (2005).

Spikes of gladiolus cv. White Prosperity pulsed with sucrose (20 per cent) + $Al_2(SO_4)_3$. $16H_2O$ (400 ppm) were stored in poly propyelene packages in a cool chamber (4±0.5°C temperature and 90–95% RH), for 15 days. Then spikes were put in cylindrical vases of glass containing distilled water and kept in an air-conditioned laboratory at 23±2°C temperature, 60–70% RH and 16 h illumination (1000 lux) provided by 40 W white fluorescent tubes. The spikes showed post storage vaselife of more than 6 days. There is therefore, considerable scope for refrigerated transportation of gladiolus spikes in PP packages(Grover *et al*, 2005)

Studies were conducted on the relative efficacy of different polymeric film sleeves on the dry MA storage of gladiolus spikes.The spikes stored in 200 guage polypropylene sleeves showed higher number of florets opening at a time and percent opening of florets Polypropylene film sleeves which maintained higher levels of CO_2 and lower levels of oxygen inside the packages, proved suitable for storage of gladiolus spikes under refrigerated conditions. Among different packaging films like cellophane, polypropylene, plastic coated brown paper, news paper, butter paper and brown paper, the polypropylene packaging proved to be good in enhancing the keeping quality of gladiolus cut spikes Polypropylene packed spikes under refrigerated storage at 6-10^0 C, retained best flower quality and vase life. The polypropylene packed cut spikes recorded slight loss in per cent fresh weight and dry weight and appeared fully turgid after dry storage at low temperature while unpacked cut spikes recorded higher loss in fresh weight and dry weight and appeared flaccid upon unpacked spike just after the low temperature storage. The polypropylene packed cut spikes recorded maximum water uptake, percent flower opening, number of opened florets at a time as compared to unpacked spikes. (Singh *et al*., 2006)

The effect of different packaging films and cold storage durations (5,10 and 15 days) at 6^{o} C to 10°C temperature on flower quality of gladiolus cut spikes cv. Peater Pears was investigated by Singh *et al*. (2007). They reported that among different packaging films (cellophane, polypropylene, newspaper, butter paper, brown paper and plastic coated brown paper), polypropylene and plastic coated paper packaging proved promising in augmenting the keeping quality of cut spikes. The keeping quality of unpackaged cold stored cut spikes was highly deteriorated and decreased with increase in storage duration. According to them polypropylene or plastic coated paper packaged cut spikes recorded maximum water uptake with improved per cent bud opening per spike and maximum number of open florets at a time per spike as compared to the other packaging films and unpackaged stored cut spikes. Cold storage of spikes for 10 days with polypropylene packaging maintained good keeping quality with improved floret opening, floret size and tepal colour. Polypropylene packaging has also been reported to retain higher level of sugars in gladiolus tepals.

Polypropylene (60 µ) is found to be an effective packaging film for the modified atmosphere (MA) storage at low temperature (6-10^{0}C) for gladiolus spikes up to 10 days (Alka *et al*., 2007).

Prestorage pulse treatment o f 8-HQ (300 ppm) for one hour and sucrose (20%) for 12 hours, followed by 60 micron polypropylene MAP with dry refrigerated storage and post storage vase solution of 8-HQ (300 ppm) with sucrose (5%) is best for improving the flower quality and extending vase life as compared to fresh cut spikes of gladiolus cv Peter Pears (Singh *et al*.,2009).

Munsi *et al* (2011) conducted experiments to study the effect of storage conditions and packaging supplemented with different solutions (wet packing) on vase life of gladiolus cv. Sylvia. Spikes were cut (under water) to a length of 70 cm. After cutting, 10 ml of solutions containing sucrose (3% and 4%) were poured in plastic pouches and flower ends wrapped with cotton were inserted in the pouches. Packaging materials (Polyethylene-PE, Polypropylene-PP and

Newspaper-NP) were used for wrapping 10 spikes at a time and packed in corrugated fibre board boxes (with vent) for 24, 48 and 72 hours at room conditions as well as under 10°C. Spikes kept within the boxes without packing served as control for three different durations. After completion of the storage period, spikes were placed in vases containing filtered tap water. The percent floret display and vase life were higher in flowers wet packed with sucrose 4%, wrapped in polyethylene, up to 48 hours storage, even at ambient condition. However, for low temperature (10°C) storage, sucrose at 3% was more effective when wrapped with polyethylene. .

Materials and Methods

3. MATERIALS AND METHODS

Studies were conducted during the year 2012-2013, at the Department of Pomology & Floriculture, College of Horticulture,Vellanikkara, to compare the performance of gladiolus varieties under open and rain shelter conditions and to standardize the post harvest treatments to improve the spike qualities. The details of the materials used and methods adopted are presented in this chapter.

3.1. Season

The experiment was conducted in two seasons, from May 2012 to October 2012 (first season) and from November 2012 to April 2013 (second season). The weather data for the period under study are given in Appendix.

3.2. Performance evaluation

The crop was grown as per KAU recommendation and observed for growth, flowering and post harvest characters.

3.2.1. Treatments

3.2.1.1. Varieties

The following varieties were used for the study.

i) Oscar

ii) Summer Sunshine

iii) White prosperity

3.2.1.2**.** Growing conditions

i) Rain shelter (open ventillated poly house) (G1)

ii) Open field (G2)

Open ventilated poly

Inside view of poly house

Open field

Plate 1. General view of the experimental plot

Oscar

Summer Sunshine

White Prosperity

Plate 2. Gladiolus varieties

3.2.1.3. Planting time

i) May 2012 (First season/S1)

ii) November 2012 (Second season/ S2)

3.2.2. Lay out of the experiment

The crop was raised both in open area and rain shelter. The selected area for experiment was ploughed; stubbles removed, levelled and raised beds of size 1.5 m x 0.8 m were prepared. The experiment was laid out in Randomised Block Design with four replications.

3.2.3 Planting material

Pest and disease free corms of uniform size were selected. The corms were cleaned by removing the dried scales present on them. Then they were dipped in Bavistin (0.2%) solution for 30 minutes as preventive measure for wilt disease. These corms were planted at a spacing of 20 cm x 30 cm in each bed at a depth of 5-6 cm. Light irrigation was given immediately after planting.

3.2.4. Care and management

3.2.4.1. Manures and fertilizers

Well decomposed farm yard manure at the rate of 25 t ha^{-1} was applied and mixed well with the soil at the time of land preparation. Recommended dose of 100:60:60 kg NPK per ha was applied in the form of Urea, Single Super Phosphate and Muriate of Potash respectively. At the time of planting half the dose of N, full doses of P_2O_5 and K_2O were applied. The crop was top dressed with remaining half dose of N at 45 days after planting.

3.2.4.2. Cultural operations

The beds were irrigated daily. The experimental site was kept free of weeds by periodic hand weeding. Earthing up was done along with fertilizer application. Staking of the plants was done at the time of spike emergence. Irrigation was with held, two weeks prior to lifting of the corms.

3.2.4.3. Plant protection

Timely and suitable plant protection measures were taken up to protect the plants from pest and diseases incidence. Soil drenching with Bavistin 0.2% was done periodically as preventive measure for Fusarium wilt disease.

3.2.4.4. Harvesting

The spikes were harvested when first floret starts showing colour and used for recording post harvest observations. The corms and cormels were lifted from the ground, when the foliage turned to yellow colour. These harvested corms and cormels were used for recording different post harvest yield parameters. They were then dried and stored.

3.3. Post harvest treatment studies

Gladiolus spikes were harvested when the first floret shows colour and were subjected to the following post harvest treatments.

3.3.1. Pulsing

Harvested spikes were kept under the pulsing solutions for three hours. Pulsed spikes were then placed in vase (with distilled water) and vase characters were recorded.

Design	CRD
No. of treatments	7
No. of replications	3

3.3.1.1. Treatments

T_1 Sucrose 10% + 8 HQC 100 ppm

T_2 Sucrose 10% + 8 HQC 200 ppm

T_3 Sucrose 20% + 8 HQC 100 ppm

T_4 Sucrose 20% + 8 HQC 200 ppm

T_5 Sucrose 10%

T_6 Sucrose 20%

T_7 Control

Best pulsing treatment was selected from the study.

3.3.2. Holding solution

The spikes after treating with the best pulsing solution, were put into various holding solutions and the vase characters were recorded.

Design CRD

No. of treatments 8

No. of replications 3

3.3.2.1. Treatments

T_1 Sucrose 5% + $AgNO_3$ 25 ppm

T_2 Sucrose 5% + $AgNO_3$ 50 ppm

T_3 Sucrose 5% + BA 50 ppm

T_4 Sucrose 5% + BA 100 ppm

T_5 Sucrose 5% + GA 50 ppm

T_6 Sucrose 5% + GA 100 ppm

T_7 Sucrose 5%

T_8 Control

Among the different holding solutions the best one was selected.

3.3.3. Storage

The harvested spikes were subjected to the best pulsing treatment and then kept in three storage conditions , viz., at low temperatures ($10^0C \pm 2^0C$) and at ambient condition ($30^0C \pm 2^0C$), for a period of 24 hours and the vase life was recorded by keeping it in the best holding solution.

Design : CRD

Replication : 5

Treatments : 3

3.3.3.1. Treatments

T_1 12^0C

T_2 8^0C

T_3 Control (Ambient condition)

3.3.4. Packaging

Harvested spikes were treated with the best pulsing solution and packed in cartons of 75×30×10 cm^3 size with any one of the following lining material and were placed in the best storage condition.

Design CRD

No. of treatments 5

No. of replications 4

3.3.4.1. Lining materials

T_1 Brown paper

T_2 News paper

T_3 Polypropylene sheet

T_4 Polythene sheet

T_5 Control

After 24 hours, the spikes were transferred to the best holding solution and the vase life was recorded.

3.5. Observations

3.5.1. Plant characters

The observations on growth parameters were recorded at fortnightly intervals

3.5.1.1. Plant height

The height of the plant was measured from the collar region to the tip of the youngest leaf at fortnightly intervals and expressed in centimeters.

3.5.1.2. Number of leaves

The number of leaves on each plant was counted and recorded.

3.5.1.3. Length and breadth of leaves

Length and breadth of each leaf were measured and expressed in centimeters.

3.5.1.4. Total leaf area

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

The sum of the leaf area of all the leaves of a plant was taken as the total leaf area, which was expressed in cm^2.

3.5.1.5. Duration from planting to spike emergence

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

3.5.1.6. Duration from spike emergence to opening of floret (days)

The number of days taken from the appearance of flower spike to the opening of the lower most floret was recorded.

3.5.1.7. Time taken for flowering

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

3.5.1.8. Blooming period

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 blooming period

3.5.1.9. Total duration

The total duration of the crop was recorded as the number of days taken from planting to the end of flowering period.

3.5.1.10. Pest and disease incidence

Incidence of pests and diseases were observed and recorded.

3.5.2. Spike characters

3.5.2.1. Length of the spike

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

3.5.2.2. Diameter of the spike

The diameter of the spike below the first floret was measured and expressed in centimeter.

3.5.2.3. Length of the rachis

The rachis length was measured from the base of the first floret to the last floret of the spike and expressed in centimeter.

3.5.2.4. Number of florets/spike produced

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

3.5.2.5. Size of the florets

The width of the second floret was measured and expressed in centimeter.

3.5.2.6. Number of florets opened at a time

The number of florets opened, when the first floret started wilting were counted and recorded.

3.5.3. Post harvest studies

3.5.3.1. Vase characters: For performance evaluation and post harvest treatment studies the following vase characters were observed

3.5.3.1.1. Fresh weight of the spike

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

3.5.3.1.2. Percentage of fully opened florets

The number of fully opened florets was counted and expressed as a percentage of the total florets in the spike.

3.5.3.1.3. Percentage of partially opened florets

The number of partially opened florets was counted and expressed as a percentage of the total florets in the spike.

3.5.3.1.4. Percentage of unopened florets

The number of unopened opened florets was counted and expressed as a percentage of the total florets in the spike.

3.5.3.1.5. Longevity of individual florets

The time taken from opening to drying of each fully opened floret was recorded as the life of individual floret in days

3.5.3.1.6. Number of florets opened at a time

The number of florets opened, when the first floret started wilting were counted and recorded.

3.5.3.1.7. Nature of bending

The days taken for the bending of the spike in the vase was recorded. The position of breakage was also recorded as the number of florets below the point of break.

3.5.3.1.8. Water uptake

The spikes were harvested and held in vases with measured quantity of distilled water. The quantity of water left after the spike was discarded at the end of its vase life was measured. The difference gave the water uptake, expressed in ml.

3.5.3.1.9. Vase life

The number of days taken from opening of first floret to wilting of last floret, when the spike was put in the vase solution was counted and recorded.

3.5.3.2 Corm and cormel yield

3.5.3.2.1. Weight of the corm

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

3.5.3.2.2. Size of the corm

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

3.5.3.2.3. Number of cormels per plant

The cormels collected from each plant were counted and recorded.

3.5.3.2.4. Weight of cormels

The cormels were cleaned and weighed, the weight was expressed in grams.

3.6. Weather parameters

Temperature and relative humidity of both rain shelter and open field are recorded at 8.00am and 2.30 pm daily and monthly mean was calculated. Light intensity was recorded at 12.00 a.m. daily and monthly mean was calculated. The data on rain fall (monthly mean) was collected from Department of Agriculture meteorology, College of Horticulture, Vellanikkara.

3.7. Tabulation and statistical analysis

Observations under each experiment were tabulated and analyzed statistically. MSTAT package was used for analysis of plant characters, spike characters, vase characters, corm and cormel yield in a randomized block design (RBD). The post harvest treatments were tested using DMRT.

Results

4. RESULTS

Studies were conducted during the year 2012-2013, at the Department of Pomology & Floriculture, College of Horticulture, Vellanikkara, to compare the performance of gladiolus varieties under open and rain shelter conditions and to standardize the post harvest treatments to improve the spike qualities. The results of the studies are presented in this chapter under the following captions

1. Plant characters

2. Spike characters

3. Vase characters

4. Corm and cormel yield

5. Postharvest treatments

   i. Pulsing

   ii. Holding

   iii. Storage

   iv. Packing

4.1. Plant characters

The observations related to different plant characters in rain shelter and open field are analysed and presented in Table 1a to Table 10 b

4.1.1. Plant height

Data pertaining to the fortnightly variation in height during first season are presented in Table 1(a) and that of second season are presented in Table 1(b).

Fortnightly variation in height was significant from two weeks after planting, under both growing conditions during both the seasons for all the varieties.

Table 1a. Effect of growing conditions on plant height (cm) in gladiolus varieties during first season

Varieties	Weeks after planting							
	2		4		6		8	
	G1	G2	G1	G2	G1	G2	G1	G2
Oscar	8.05	7.47	23.87	22.26	35.51	32.96	51.06	43.91
Summer Sunshine	10.26	8.86	28.93	18.77	44.06	38.37	63.59	52.58
White Prosperity	9.05	8.85	24.86	17.46	35.20	34.61	54.98	46.03
CD (0.05)	0.41		1.85		1.63		1.67	

Table 1b. Effect of growing conditions on plant height (cm) in gladiolus varieties during second season

Varieties	Weeks after planting							
	2		4		6		8	
	G1	G2	G1	G2	G1	G2	G1	G2
Oscar	9.48	8.75	27.63	24.51	38.71	36.03	56.76	47.92
Summer Sunshine	12.15	8.74	34.68	25.17	56.22	42.04	71.47	53.19
White Prosperity	9.24	9.58	25.55	25.10	40.38	40.26	64.06	51.03
CD (0.05)	0.69		2.58		2.45		4.74	

Table1c. Effect of season on plant characters in gladiolus varieties grown in rain shelter

Varieties	Plant height (cm)		No: of leaves		Leaf area (cm^2)	
	S_1	S_2	S_1	S_2	S_1	S_2
Oscar	51.06	56.76	8.48	8.53	713.61	777.78
Summer Sunshine	63.59	71.47	8.03	8.93	878.66	925.89
White Prosperity	54.98	64.06	8.45	8.55	870.07	903.00
CD	2.16		0.24		25.03	

First season

Summer Sunshine (10.26 cm) recorded the maximum plant height at two weeks after planting in rain shelter, followed by White prosperity (9.05 cm). The lowest height was recorded by Oscar (8.05). In the open field, Summer Sunshine and White prosperity were performing on par at two weeks after planting with a height of 8.86 cm and 8.85 cm respectively. Oscar (7.47 cm) exhibited the minimum height.

At four weeks after planting also, Summer Sunshine (28.93 cm), registered the highest plant height in rain shelter followed by White prosperity (24.86 cm) which was on par with Oscar (23.87 cm). In the open field, the maximum height was observed in Oscar (22.26) followed by Summer Sunshine (18.77 cm) which was on par with White prosperity (17.46 cm).

In rain shelter, the highest plant height of 44.06 cm was recorded in Summer Sunshine, at six weeks after planting, which was followed by Oscar (35.51cm) and White prosperity (35.20 cm) which were statistically on par. The maximum plant height was noticed in Summer Sunshine (38.37 cm), in open field also, at six weeks after planting. It was followed by White Prosperity (34.61cm) and Oscar (32.96 cm).

The maximum plant height of 63.59 cm was observed in Summer Sunshine, in rain shelter, at eight weeks after planting, which was followed by White prosperity (54.98 cm) and Oscar (51.06 cm). The same trend was noticed in open field also.

In general significant effect of rain shelter was noticed on the height of the plant for all the varieties. The varieties varied significantly among themselves in plant height at all stages of growth. Among the varieties, Summer Sunshine maintained a better plant height both in rain shelter and open field, starting from two weeks after planting itself, stretched towards eight weeks after planting.

Second season

The plant height was found to be maximum in rain shelter, for all the three varieties under consideration, during second season also (Table 1b). Summer sunshine recorded the maximum plant height of 12.15 cm in rain shelter at two weeks after planting, followed by Oscar (9.48 cm) which was on par with White prosperity (9.24 cm). In the open field, White prosperity (9.58 cm) registered the highest plant height, at two weeks after planting, followed by Oscar (8.75 cm) which was on par with Summer Sunshine (8.74 cm).

At four weeks after planting Summer Sunshine (34.68 cm) showed the maximum height in rain shelter, followed by Oscar (27.63 cm) which was on par with White prosperity (25.55 cm). In open field also, Summer Sunshine (25.17cm) had the highest height which was on par with White prosperity (25.10 cm) and Oscar (24.51 cm).

Summer Sunshine (56.22 cm) had better plant height at six weeks after planting, followed by White prosperity (40.38 cm) and the minimum height was observed in Oscar (38.71 cm). The same trend was noticed in open field also.

In rain shelter, at eight weeks after planting, the maximum height was observed in Summer Sunshine (71.47cm), followed by White prosperity (64.06 cm) and Oscar (56.76 cm). The same trend was noticed in open field also.

In general, growing condition had significant influence on plant height for all the three varieties under consideration. The plants show better plant height in rain shelter than in open field from two weeks after planting itself up to eight weeks after planting. Among the varieties under consideration, Summer Sunshine maintained a better plant height, both in rain shelter and open field starting from two weeks after planting itself (12.15 cm), stretched towards eight weeks after planting (71.47 cm).

4.1.1.1. Effect of season on plant height

Season had significant influence on plant height of all the varieties both in rain shelter and open field (Table 1c & Table 1d and Fig 1 & Fig 3). In rain shelter Oscar (56.76 cm), Summer Sunshine (71.47 cm) and White prosperity (64.06 cm) had maximum plant height during second season (Table 1c). In open field also Oscar (47.92 cm), Summer Sunshine (53.19 cm) and White prosperity (51.03 cm) had maximum leaf area during second season (Table 1d).

Table1d. Effect of season on plant characters in gladiolus varieties grown in open field

Varieties	Plant height (cm)		No: of leaves		Leaf area (cm^2)	
	S_1	S_2	S_1	S_2	S_1	S_2
Oscar	43.91	47.92	7.88	8.45	551.39	678.96
Summer Sunshine	52.58	53.19	7.48	7.83	633.39	718.78
White Prosperity	46.03	51.03	7.75	7.98	569.47	885.53
CD	3.81		NS		6.85	

Table 2a.Effect of growing conditions on number of leaves in gladiolus varieties during first season

Varieties	Weeks after planting							
	2		4		6		8	
	G1	G2	G1	G2	G1	G2	G1	G2
Oscar	2.03	1.95	3.95	3.98	6.23	6.25	8.48	7.88
Summer Sunshine	1.90	2.00	3.88	3.85	5.95	5.65	8.03	7.48
White Prosperity	2.53	2.00	4.43	3.83	6.35	5.68	8.45	7.75
CD (0.05)	0.1		0.17		0.24		NS	

Table 2b. Effect of growing conditions on number of leaves in gladiolus varieties during second season

Varieties	Weeks after planting							
	2		4		6		8	
	G1	G2	G1	G2	G1	G2	G1	G2
Oscar	2.00	2.08	4.00	3.95	6.00	5.85	8.53	8.45
Summer Sunshine	2.00	2.00	4.00	4.00	6.93	5.85	8.93	7.83
White Prosperity	2.00	2.08	4.00	4.00	5.83	5.98	8.55	7.98
CD (0.05)	NS		NS		0.15		0.24	

4.1.2. Number of leaves

First season

In the case of number of leaves, the varieties varied significantly from two weeks after planting onwards, during the first season (Table 2a). Two weeks after planting, under rain shelter condition, White Prosperity recorded the maximum number of leaves (2.53) followed by Oscar (2.03) which was on par with Summer Sunshine (1.09). In the open field the number of leaves recorded by Oscar (1.95), Summer Sunshine (2.00) and White prosperity (2.00) were on par.

At four weeks after planting, under rain shelter condition, maximum number of leaves were observed in White prosperity (4.43) followed by Oscar (3.98) and Summer Sunshine (3.88). In the open field the number of leaves recorded by Oscar (3.98), Summer Sunshine (3.85) and White prosperity (3.83) were on par.

White prosperity (6.35) produced the maximum number of leaves, under rain shelter condition at six weeks after planting which was on par with Oscar (6.23). Summer sunshine (5.95) recorded the least number of leaves. But under open field condition maximum number of leaves was observed in Oscar (6.25). Summer Sunshine (5.65) and White prosperity (5.68) were on par.

It can be concluded that growing condition exerted significant influence on number of leaves from two weeks after planting up to six weeks after planting. But at eight weeks after planting for all the three varieties, growing conditions had no significant influence on number of leaves.

Second season

During the second season, growing conditions had no significant effect on the number of leaves of the three varieties, at two weeks after planting and four weeks after planting (Table 2b). But at six weeks after planting and eight weeks after planting growing conditions had significant effect on the number of leaves of all the varieties. Summer Sunshine (6.93) recorded the maximum number of leaves, followed by Oscar (6.00), under rain shelter condition. Minimum number of leaves was recorded in White Prosperity (5.83). In the open field, the number of leaves observed on Oscar (5.85), Summer Sunshine (5.85) and White prosperity (5.98) were on par.

Summer sunshine (8.93) recorded the maximum number of leaves under rain shelter condition at eight weeks after planting. Oscar (8.53) and White prosperity (8.55) were on par. In the open field Oscar (8.45) exhibited maximum leaves. White Prosperity (7.98) and Summer Sunshine (7.83) were on par.

4.1.2.1. Effect of season on number of leaves

Season had significant influence on number of leaves of all the varieties in rain shelter (Table 1c). In rain shelter Oscar (8.53), Summer Sunshine (8.93) and White prosperity (8.55) had maximum leaves during second season. But in open field, number of leaves was not significantly influenced by season (Table 1d)

4.1.3. Length of the leaf

First season

Leaf length was significantly influenced by growing conditions. Varieties exhibited significant variation in leaf length in rain shelter than in open field. (Table 3a).

In rain shelter, at two weeks after planting, Summer Sunshine (34.48 cm) showed better leaf length than White prosperity (30.01 cm). Oscar (27.88 cm) recorded the lowest leaf length. But in the open field Oscar (26.28 cm) showed the highest leaf length, followed by Summer Sunshine (25.70 cm) and White prosperity (19.23 cm).

The leaf length was maximum in Summer Sunshine (41.44 cm and 28.25 cm respectively), both in rain shelter and open field at four weeks after planting.

At six weeks after planting, the leaf length was maximum in Summer Sunshine (57.05cm) in rain shelter, which was followed by White prosperity (50.46 cm) and Oscar (49.98 cm). In the open field, the highest leaf length was

Table 3a. Effect of growing conditions on length of leaves (cm) in gladiolus varieties during first season.

Varieties	Weeks after planting							
	2		4		6		8	
	G1	G2	G1	G2	G1	G2	G1	G2
Oscar	27.88	26.28	29.89	26.62	49.98	42.51	53.65	45.87
Summer Sunshine	34.48	25.70	41.44	28.25	57.05	48.04	57.40	51.03
White Prosperity	30.01	19.23	34.56	26.99	50.46	38.89	56.20	46.89
CD (0.05)	1.01		1.04		1.14		0.44	

Table 3b. Effect of growing conditions on length of leaves (cm) in gladiolus varieties during second season.

Varieties	Weeks after planting							
	2		4		6		8	
	G1	G2	G1	G2	G1	G2	G1	G2
Oscar	31.21	23.82	32.61	26.74	52.30	43.78	54.18	53.98
Summer Sunshine	37.10	30.06	44.44	32.60	54.67	51.84	59.29	53.44
White Prosperity	31.90	25.50	39.89	32.98	52.94	54.16	57.64	57.29
CD (0.05)	NS		1.27		0.85		1.32	

Table 4a. Effect of growing conditions on breadth of leaves (cm) in gladiolus varieties during first season.

Varieties	Weeks after planting							
	2		4		6		8	
	G1	G2	G1	G2	G1	G2	G1	G2
Oscar	2.03	1.95	3.95	3.98	6.23	6.25	8.48	7.88
Summer Sunshine	1.90	2.00	3.88	3.85	5.95	5.65	8.03	7.48
White Prosperity	2.53	2.00	4.43	3.83	6.35	5.68	8.45	7.75
CD (0.05)	0.1		0.17		0.24		NS	

observed in Summer Sunshine (48.04 cm), followed by Oscar (42.51 cm) and White prosperity (38.89 cm).

Summer Sunshine (57.40 cm) had better leaf length in rain shelter at eight weeks after planting also, followed by White prosperity (56.20 cm) and Oscar (53.65 cm). In the open field, also the same trend was noticed.

Second season

The growing condition had significant influence on leaf length of all the varieties (Table 3b).

At two weeks after planting, even though growing condition had no significant influence on leaf length, Summer Sunshine recorded maximum leaf length in rain shelter (37.10 cm) as well as in open field (30.06 cm).

In rain shelter, Summer Sunshine (44.44 cm) had highest leaf length, at four weeks after planting, followed by White prosperity (39.89 cm). The leaf length was minimum in Oscar (32.61 cm). In open field, White prosperity (32.98 cm) showed maximum leaf length which was statistically on par with Summer Sunshine (32.60cm). Least was recorded in Oscar (26.74 cm).

Maximum leaf length was noticed in Summer Sunshine (54.67 cm) in rain shelter at six weeks after planting, followed by White prosperity (52.94 cm) which was statistically on par with Oscar (52.30 cm). In open field, White prosperity (54.16 cm) showed maximum leaf length, followed by Summer Sunshine (51.84 cm). The minimum was observed in Oscar (43.78 cm).

At eight weeks after planting also Summer Sunshine (59.29 cm) had maximum leaf length in rain shelter followed by White prosperity (57.64 cm). The lowest was recorded in Oscar (54.18 cm). In open field White prosperity (57.29 cm) recorded maximum leaf length followed by Oscar (53.98 cm) which was statistically on par with Summer Sunshine (53.44 cm).

4.1.4. Breadth of the leaf

First season

Growing condition had significant influence on leaf breadth of all the varieties (Table 4a). At two weeks after planting, Summer Sunshine recorded the maximum leaf breadth both in rain shelter (1.99 cm) and open field (1.78 cm). The lowest leaf breadth was noticed in White prosperity (1.79 cm) in rain shelter and in Oscar (1.35 cm) in open field.

Summer Sunshine (2.26 cm) exhibited maximum leaf breadth in rain shelter at four weeks after planting. Oscar (1.93 cm) and White prosperity (1.93 cm) were statistically on par. In open field also Summer Sunshine (1.91 cm) recorded the maximum leaf breadth. Least was recorded in Oscar (1.52 cm).

At six weeks after planting, Summer Sunshine recorded the maximum leaf breadth both in rain shelter (2.64 cm) and open field (2.02 cm).The lowest was recorded in Oscar in rain shelter. In open field, Oscar (1.86 cm) and White prosperity (1.84 cm) were statistically on par.

The highest leaf breadth was noticed in Summer Sunshine both in rain shelter (2.70 cm) and open field (2.02 cm), at eight weeks after planting. In open field, the lowest was recorded in Oscar both in rain shelter (2.23 cm) and open field (1.88 cm).

Second season

Leaf breadth was significantly influenced by growing condition in all the varieties (Table 4b)

Summer sunshine (2.12 cm) recorded the maximum leaf breadth in rain shelter at two weeks after planting, followed by White prosperity (2.03 cm). The lowest was recorded by Oscar (1.86 cm). The same trend was noticed in open field. At four weeks after planting, in rain shelter, leaf breadth was maximum in Summer sunshine (2.30 cm) which was statistically on par with White prosperity

Table 4b. Effect of growing conditions on breadth of leaves (cm) in gladiolus varieties during second season.

Varieties	Weeks after planting							
	2		4		6		8	
	G1	G2	G1	G2	G1	G2	G1	G2
Oscar	1.86	1.51	2.00	1.66	2.33	1.94	2.39	2.08
Summer Sunshine	2.12	1.80	2.30	1.99	2.58	2.19	2.70	2.23
White Prosperity	2.03	1.77	2.24	2.00	2.48	2.22	2.67	2.67
CD (0.05)	0.67		0.61		0.05		0.04	

Table 5a. Effect of growing conditions on leaf area (cm^2) in gladiolus varieties during first season.

Varieties	Weeks after planting							
	2		4		6		8	
	G1	G2	G1	G2	G1	G2	G1	G2
Oscar	92.96	71.82	180.97	149.41	495.99	385.71	713.61	551.39
Summer Sunshine	111.86	84.07	291.75	174.85	654.53	447.90	878.66	633.39
White Prosperity	94.26	61.68	215.99	157.61	538.05	357.31	870.07	569.47
CD (0.05)	3.09		13.67		9.07		14.56	

Table 5b. Effect of growing conditions on leaf area (cm^2) in gladiolus varieties during second season.

Varieties	Weeks after planting							
	2		4		6		8	
	G1	G2	G1	G2	G1	G2	G1	G2
Oscar	100.11	72.07	216.66	163.20	555.48	406.16	777.78	678.96
Summer Sunshine	126.26	93.75	307.01	217.92	711.17	509.35	925.89	718.78
White Prosperity	107.03	84.57	281.25	220.34	681.29	538.97	903.00	885.53
CD (0.05)	3.79		9.19		19.16		21.28	

(2.24 cm) and Oscar (2.00 cm). In open field, the highest leaf breadth was noticed in White prosperity (2.00 cm) which was statistically on par with Summer Sunshine (1.99 cm) and Oscar (1.66 cm).

Summer sunshine (2.58 cm) showed the maximum leaf breadth in rain shelter at six weeks after planting, followed by White prosperity (2.48 cm). The lowest was recorded by Oscar (2.33 cm). In open field, the maximum leaf breadth was noticed in White prosperity (2.22 cm) which was statistically on par with Summer Sunshine (2.19 cm).The lowest was observed in Oscar (1.94 cm).

The maximum leaf breadth of 2.70 cm was recorded in Summer Sunshine in rain shelter, at eight weeks after planting which was statistically on par with White prosperity (2.67 cm). The minimum was recorded in Oscar (2.39 cm). In open field, White prosperity (2.67 cm) had the highest leaf breadth followed by Summer Sunshine (2.23 cm). Least was recorded in Oscar (2.08 cm).

4.1.5. Leaf area

Data related to the observations on leaf area, of the three gladiolus varieties under rain shelter and open field, starting from second week after planting up to eight weeks after planting, are depicted in Table. 5a for the first season and in Table. 5b for the second season.

First season

The observations recorded for the first season revealed significant influence of growing conditions, on the leaf area of all the three varieties under consideration, starting from two weeks after planting itself (Table 5a). The varieties varied significantly among themselves, in their leaf area, from two weeks after planting itself, under both the growing conditions.

The maximum leaf area of 111.86 cm^2 was recorded in Summer Sunshine, under rain shelter condition, at two weeks after planting. The leaf area of Oscar (92.96 cm^2) and White prosperity (94.26 cm^2) were on par. In the open field also,

Fig 1. Effect of season on plant height (cm) in gladiolus varieties grown in rain shelter

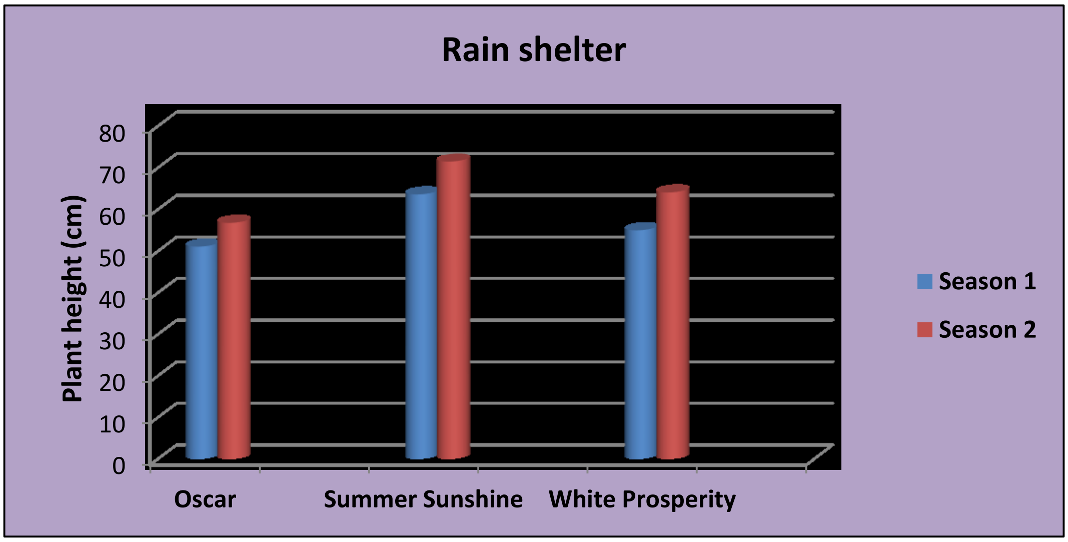
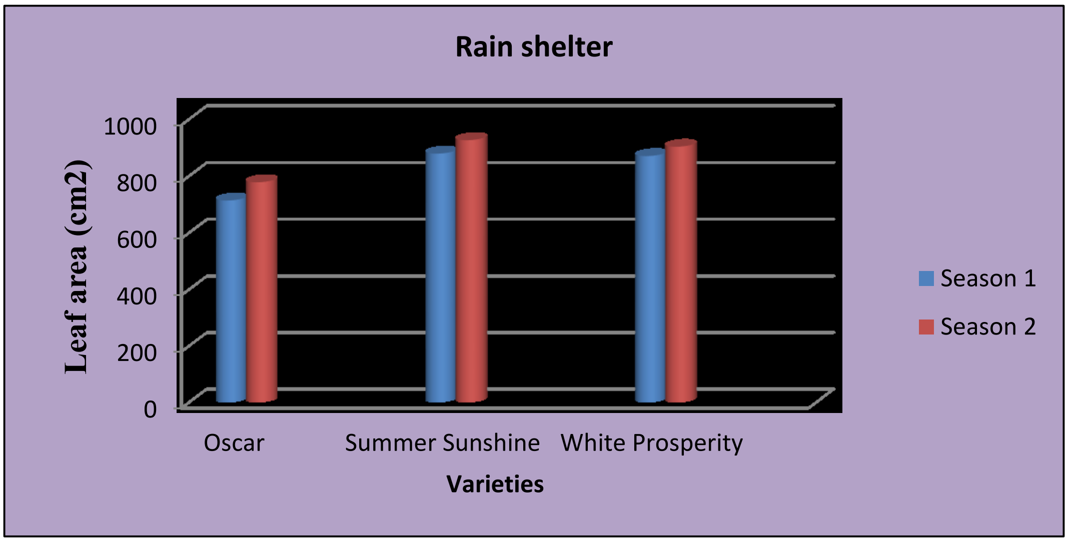


Fig 2. Effect of season on leaf area (cm^2) in gladiolus varieties grown in rain shelter



Summer Sunshine (84.07 cm^2) showed maximum leaf area, followed by Oscar (71.82 cm^2) and White prosperity (61.68 cm^2).

Summer Sunshine was found to have maximum leaf area of (291.75 cm^2) under rain shelter, followed by White prosperity (215.99 cm^2) at four weeks after planting. Oscar (180.97 cm^2) registered the minimum leaf area. Summer Sunshine (174.85 cm^2) recorded the maximum leaf area under open field condition also, at four weeks after planting. The leaf area of Oscar (149.41cm^2) and White prosperity (157.61 cm^2) were statistically on par.

Summer sunshine (654.53 cm^2) recorded the maximum leaf area at six weeks after planting, under rain shelter, followed by White prosperity (538.05cm^2) and Oscar (495.99 cm^2). In the open field also Summer Sunshine (447.90 cm^2) recorded the maximum leaf area, followed by Oscar (385.71cm^2) and White prosperity (357.31cm^2).

At eight weeks after planting, Summer Sunshine (878.66 cm^2) exhibited the maximum leaf area under rainshelter, which was on par with White prosperity (870.07 cm^2). The minimum leaf area of 713.61 cm^2 was noticed in Oscar. Summer Sunshine (633.39cm^2) recorded the maximum leaf area under open field condition also, at eight weeks after planting, which was followed by White prosperity (569.47 cm^2) and Oscar (551.39 cm^2).

Second season

During the second season, the varieties showed significant variation in leaf area under both growing conditions (Table 5b).

In rain shelter, at two weeks after planting, the highest leaf area of 126.26 cm^2 was observed in Summer Sunshine which was followed by White prosperity (107.03 cm^2) and Oscar (100.11 cm^2). Summer sunshine (93.75 cm^2) recorded the maximum leaf area at two weeks after planting, under open field, followed by White prosperity (84.57cm^2) and Oscar (72.07 cm^2).

Fig 3. Effect of season on plant height (cm) in gladiolus varieties grown in open field

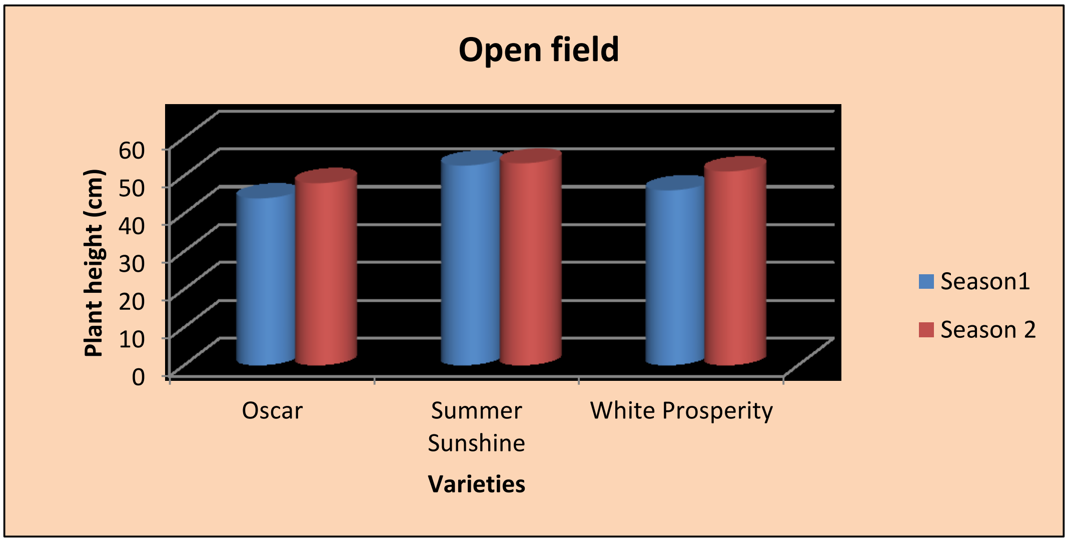
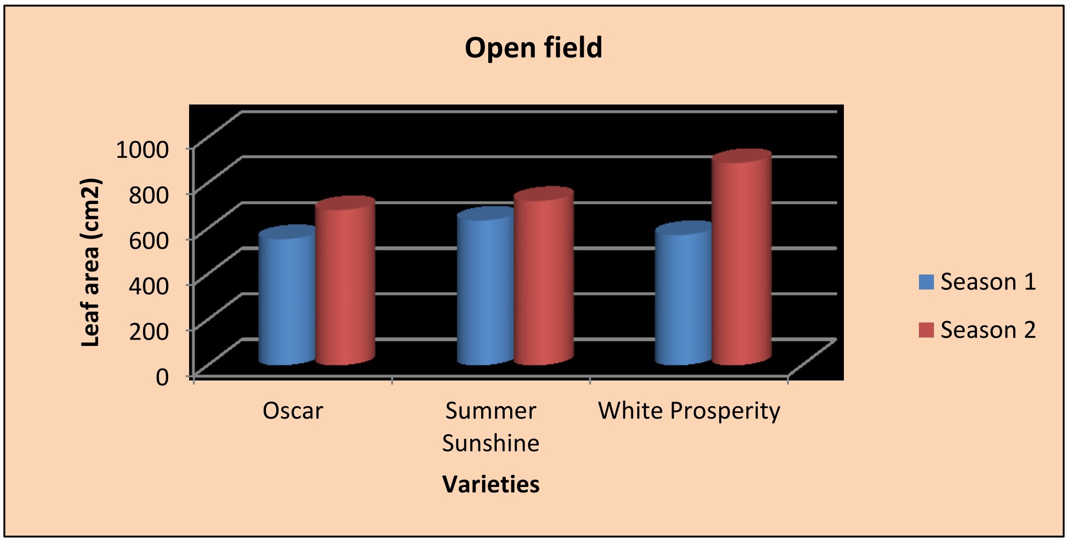


Fig 4. Effect of season on leaf area (cm^2) in gladiolus varieties grown in open field



The maximum leaf area was noted in Summer sunshine (307.01 cm^2) at four weeks after planting in rain shelter which was followed by White prosperity (281.25 cm^2) and Oscar (216.66 cm^2). In open field highest leaf area is noted in White prosperity (220.34 cm^2) which was on par with Summer Sunshine (217.92 cm^2). The lowest leaf area was noted in Oscar (163.20 cm^2).

Summer sunshine (711.17 cm^2) had the maximum leaf area at six weeks after planting, under rain shelter, followed by White prosperity (681.29 cm^2) and Oscar (555.48 cm^2).White prosperity (538.97cm^2) was showing highest value in open field , followed by Summer Sunshine(509.35 cm^2) and Oscar (406.16 cm^2).

The highest leaf area of 925.89 cm^2 was observed in Summer Sunshine which was followed by White prosperity (903.00 cm^2) and Oscar (777.78 cm^2), in rain shelter at eight weeks after planting. In open field, White prosperity (885.53cm^2) recorded the highest leaf area followed by Summer Sunshine (718.78 cm^2) and Oscar (678.96 cm^2).

In general highest leaf area was recorded in rain shelter, for all the three varieties, during both seasons.

4.1.5.1. Effect of season on leaf area

Season had significant influence on leaf area of all the varieties both in rain shelter and open field (Table 1c & Table 1d, Fig2 & Fig 4). In rain shelter Oscar (777.78 cm^2), Summer Sunshine (925.89 cm^2) and White prosperity (903.00 cm^2) had maximum leaf area during second season. In open field also Oscar (678.96 cm^2), Summer Sunshine (718.78 cm^2) and White prosperity (885.53 cm^2) had maximum leaf area during second season.

4.1.6. Number of days taken from planting to spike emergence

First season

There was significant difference among varieties with respect to the number of days taken from planting to spike emergence, both in rain shelter and open field, during the first season (Table 6a). The maximum number of days for

Fig 5. Effect of growing conditions on planting to spike emergence (days) in gladiolus varieties during first season

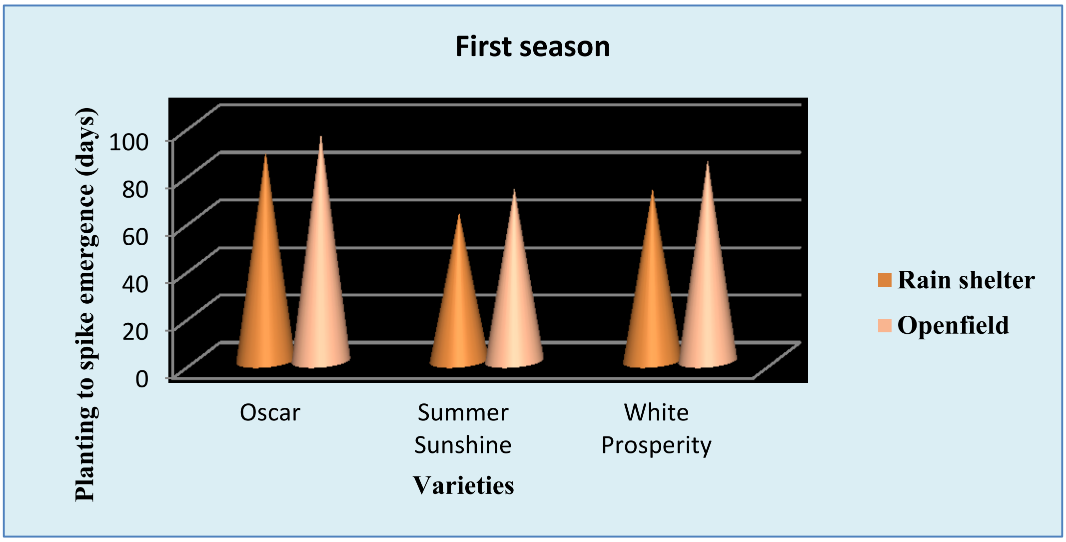


Fig 6. Effect of growing conditions on total duration (days) in gladiolus varieties during first season

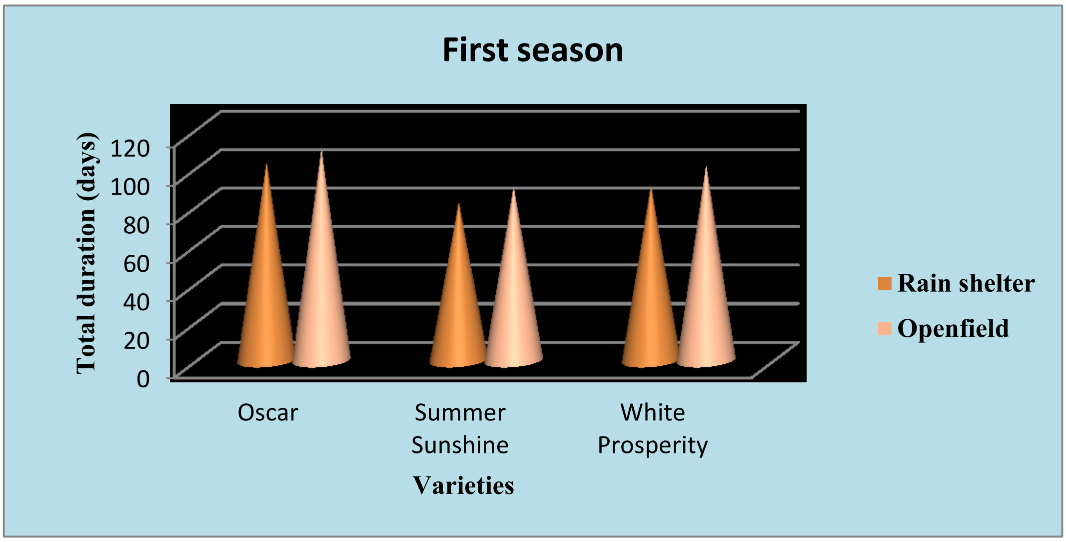


Table 6a. Effect of growing conditions on flowering in gladiolus varieties during first season.

Varieties	Planting to spike emergence (days)		Spike emergence to opening (days)		Time taken for flowering (days)		Blooming period (days)		Total duration(days)	
	G1	G2	G1	G2	G1	G2	G1	G2	G1	G2
Oscar	87.35	94.73	7.28	5.83	94.63	100.55	9.03	6.90	103.65	107.45
Summer Sunshine	61.90	72.03	8.08	8.70	69.98	80.73	11.68	8.95	81.65	89.68
White Prosperity	72.05	84.00	8.53	9.30	80.58	93.30	9.68	7.45	90.25	100.75
CD(0.05)	0.44		0.44		0.70		0.30		0.85	

Table 6b. Effect of growing conditions on flowering in gladiolus varieties during second season.

Varieties	Planting to spike emergence (days)		Spike emergence to opening (days)		Time taken for flowering (days)		Blooming period (days)		Total duration(days)	
	G1	G2	G1	G2	G1	G2	G1	G2	G1	G2
Oscar	73.25	78.68	6.60	7.68	79.85	86.35	10.08	9.05	89.93	95.40
Summer Sunshine	56.22	64.05	6.73	9.23	62.95	73.28	13.03	9.93	75.98	83.20
White Prosperity	62.08	70.40	7.68	10.10	69.75	80.50	12.05	8.70	81.80	89.20
CD(0.05)	0.72		0.28		0.82		0.24		0.92	

Fig 7. Effect of growing conditions on planting to spike emergence (days) in gladiolus varieties during second season

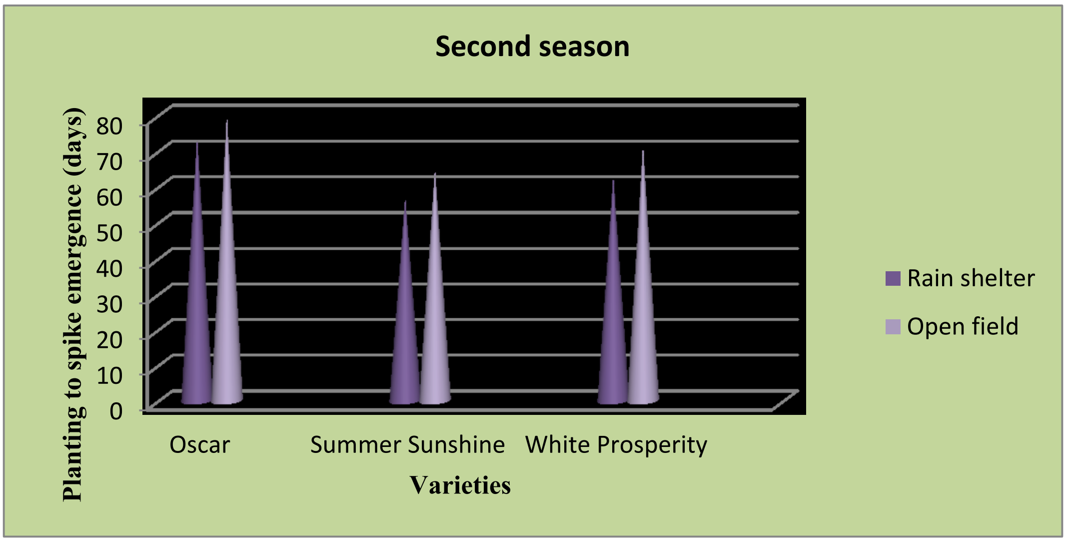
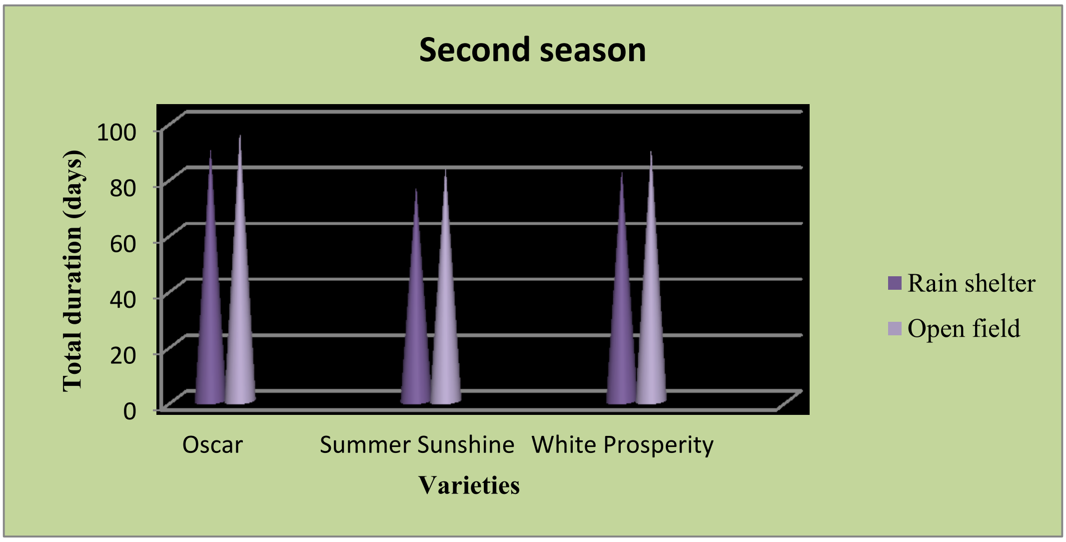


Fig 8. Effect of growing conditions on total duration (days) in gladiolus varieties during second season



spike emergence was taken by Oscar, both in rain shelter (87.35 days) and open field (94.73 days).The lowest number of days for spike emergence was taken by Summer Sunshine, both in rain shelter (61.90 days) and open field (72.03 days).

Second season

During second season also, there were significant difference among varieties with respect to the number of days taken from planting to spike emergence, both in rain shelter and open field (Table 6b).

Summer Sunshine took lowest number of days to spike emergence, both in rain shelter (56.22 days) and open field (64.05 days). The maximum number of days to spike emergence was recorded in Oscar both in rain shelter (73.25 days) and open field (78.68 days).

It was revealed that growing condition had significant influence on number of days taken from planting to spike emergence during two seasons (Fig. 5 and Fig.7). The spike emergence was earlier in rain shelter than in open field for all the varieties.

4.1.7. Number of days taken from spike emergence to opening

First season

Growing condition had significant influence on number of days taken from spike emergence to opening (Table 6a).

Among the varieties, White Prosperity took maximum number of days from spike emergence to opening, both in rain shelter (8.53 days) and open field (9.30 days). Oscar needed the lowest number of days from spike emergence to opening, both in rain shelter (5.83 days) and open field (7.28 days).

It was observed that all the varieties took lesser number of days from spike emergence to opening in rain shelter than in open field.

Second season

The number of days taken from spike emergence to opening was significantly influenced by growing condition (Table 6b).

Among the varieties, White Prosperity took maximum number of days from spike emergence to opening, both in rain shelter (7.68 days) and open field (10.10 days). Oscar needed the lowest number of days from spike emergence to opening, both in rain shelter (6.60 days) and open field (7.68 days).

4.1.8. Time taken for flowering

First season

The response of varieties with respect to time taken for flowering was significantly influenced by growing conditions (Table 6a).

Oscar took more time for flowering than other varieties, both in rain shelter (94.63 days) and open field (100.55 days). Summer Sunshine recorded the minimum time for flowering than other varieties, both in rain shelter (69.98 days) and open field (80.73 days).

It was observed that time taken for flowering was lowest in rain shelter for all the varieties.

Second season

Time taken for flowering was significantly influenced by growing condition (Table 6b).

Oscar exhibited the maximum time taken for flowering both in rain shelter (79.85 days) and open field (86.35 days). Least was recorded in Summer Sunshine both in rain shelter (62.95 days) and open field (73.28 days).

Table 6c. Effect of season on flowering in gladiolus varieties grown in rain shelter

Varieties	Planting to spike emergence (days)		Spike emergence to opening (days)		Blooming period (days)		Total duration (days)	
	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2
Oscar	87.35	73.25	7.28	6.60	9.03	10.08	103.65	89.93
Summer Sunshine	61.90	56.22	8.08	6.73	11.68	13.03	81.65	75.98
White Prosperity	72.05	62.08	8.53	7.68	9.68	12.05	90.25	81.80
CD (0.05)	0.58		0.40		0.32		0.89	

Table 6d. Effect of season on flowering in gladiolus varieties grown in open field

Varieties	Planting to spike emergence (days)		Spike emergence to opening (days)		Blooming period (days)		Total duration (days)	
	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2
Oscar	94.73	78.68	5.83	7.68	6.90	9.05	107.45	95.40
Summer Sunshine	72.03	64.05	8.70	9.23	8.95	9.93	89.68	83.20
White Prosperity	84.00	70.40	9.30	10.10	7.45	8.70	100.75	89.20
CD (0.05)	0.47		0.32		0.27		0.72	

Fig 9. Effect of season on blooming period (days) in gladiolus varieties grown in rain shelter

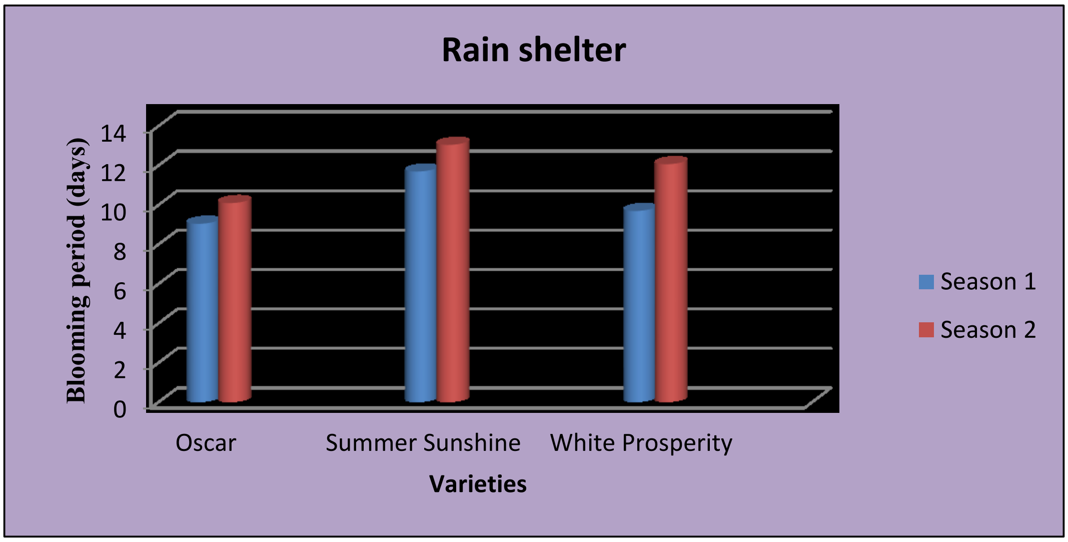
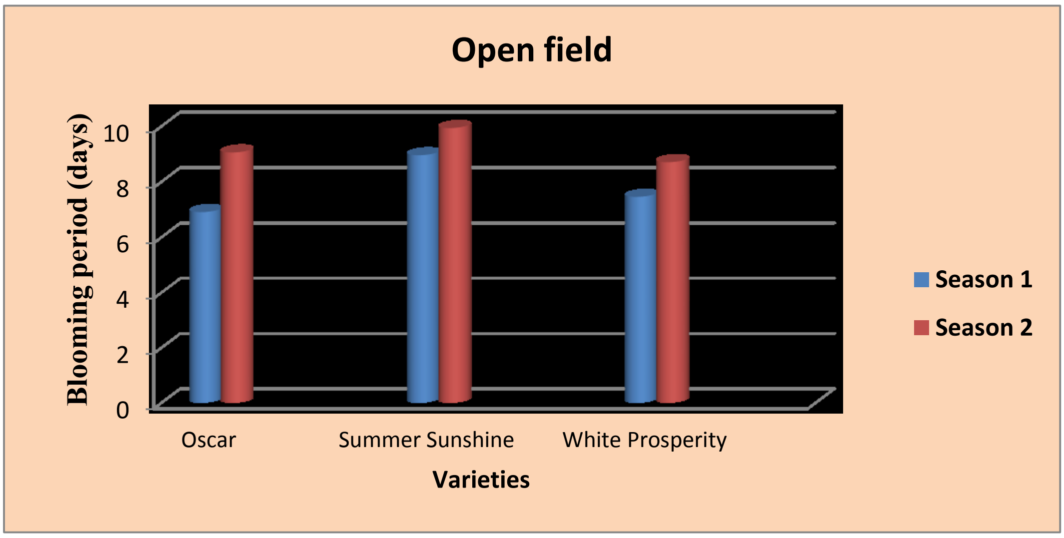


Fig 10. Effect of season on blooming period (days) in gladiolus varieties grown in open field



4.1.9. Bloooming period

First season

There was significant influence of growing condition on blooming period of gladiolus varieties (Table 6a)

Summer Sunshine recorded the maximum blooming period both in rain shelter (11.68 days) and open field (8.95 days). Blooming period observed was lowest in Oscar, both in rain shelter (9.03 days) and open field (6.90 days).

It can be concluded that blooming period was more in rain shelter than in open field for all the varieties.

Second season

Blooming period of gladiolus varieties were significantly influenced by growing condition (Table 6b).

The maximum blooming period was recorded in Summer Sunshine, both in rain shelter (13.03 days) and open field (9.93 days). Blooming period observed was lowest in Oscar in rain shelter (10.08 days). In open field White prosperity recorded the minimum blooming period (8.70 days).

In general, the blooming period was more in rain shelter than in open field for all the varieties.

4.1.10. Total duration

First season

Total duration of all the varieties was significantly influenced by growing condition (Table 6a).

Oscar recorded the highest total duration, both in rain shelter (103.65 days) and open field (107.45 days). The lowest total duration was observed in Summer Sunshine, both in rain shelter (81.65 days) and open field (89.68 days).

It was revealed that total duration was lower in rain shelter than in open field, for all the varieties ((Fig 6).

Second season

Growing conditions had significant influence in total duration of all the varieties (Table 6b).

Oscar recorded the highest total duration, both in rain shelter (89.93 days) and open field (95.40 days). Summer Sunshine exhibited the lowest total duration, both in rain shelter (75.98 days) and open field (83.20 days).

In general, the total duration was lower in rain shelter than in open field, for all the varieties (Fig 8).

4.1.11 Effect of season on flowering of gladiolus varieties

In rain shelter, Oscar (73.25 days), Summer Sunshine (56.22 days) and White Prosperity (62.08 days) recorded the shortest duration for spike emergence during second season (Table 6c). In open field also, Oscar (78.68 days), Summer Sunshine (64.05 days) and White Prosperity (70.40 days) recorded the shortest duration during second season (Table 6d).

Oscar (6.60 days), Summer Sunshine (6.73days) and White Prosperity (7.68 days) recorded the shortest duration for spike emergence to flowering during second season under rainshelter conditions (Table 6c). In open field also, Oscar (7.68 days), Summer Sunshine (9.23 days) and White Prosperity (10.10 days) recorded the shortest duration during second season (Table 6d).

In rain shelter, Oscar (10.08 days), Summer Sunshine (13.03 days) and White Prosperity (12.05 days) recorded the longest blooming period during second season (Table 6c and Fig 9). In open field also, Oscar (9.05 days), Summer Sunshine (9.93 days) and White Prosperity (8.70 days) recorded the longest blooming period during second season (Table 6d and Fig 10)

Oscar in open field

Oscar in poly house

Summer Sunshine in open field

Summer Sunshine in poly house

White Prosperity in open field

White Prosperity in poly house

Plate 3.Gladiolus spikes from two growing conditions

Fig 11. Effect of growing conditions on spike length (cm) in gladiolus varieties during first season

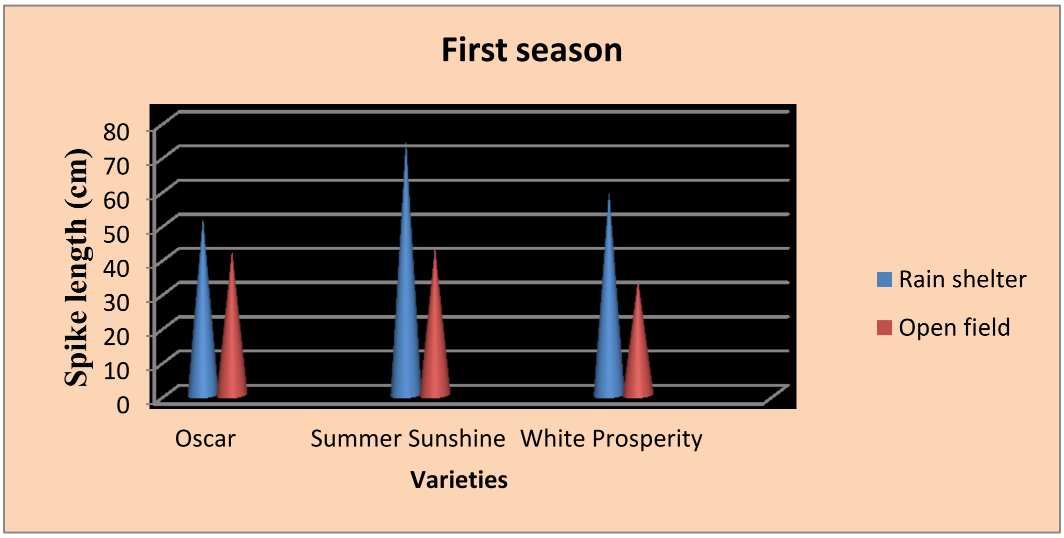


Fig 12. Effect of growing conditions on spike length (cm) in gladiolus varieties during second season

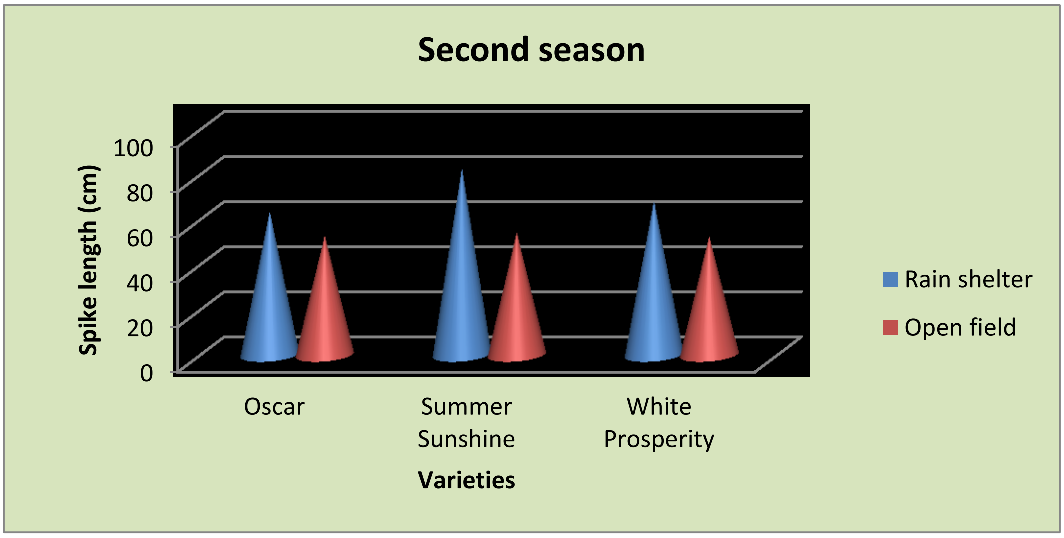


Table 7a. Effect of growing conditions on spike characters in gladiolus varieties during first season

Varieties	Length of spike (cm)		Diameter of spike (cm)		Length of rachis (cm)		Number of florets/spike		Size of the florets (cm)		No: of florets opened at a time	
	R	O	R	O	R	O	R	O	R	O	R	O
Oscar	51.02	41.63	0.90	0.69	33.51	25.73	10.35	9.78	9.47	8.86	3.93	3.40
Summer Sunshine	73.54	42.46	0.89	0.72	44.42	20.47	11.38	8.98	8.79	6.57	6.33	5.13
White Prosperity	59.05	33.13	1.02	0.88	37.39	20.19	9.23	8.03	7.53	6.40	4.20	4.18
CD(0.05)	2.07		0.04		2.14		0.48		0.32		0.28	

Table 7b. Effect of growing conditions on spike characters in gladiolus varieties during second season

Varieties	Length of spike (cm)		Diameter of spike (cm)		Length of rachis (cm)		Number of florets/spike		Size of the florets (cm)		No: of florets opened at a time	
	R	O	R	O	R	O	R	O	R	O	R	O
Oscar	62.91	52.26	1.34	1.28	42.66	38.65	12.00	10.25	10.31	9.11	4.30	3.43
Summer Sunshine	82.07	53.77	1.22	1.05	51.09	42.74	13.80	10.35	9.90	8.64	6.25	6.45
White Prosperity	67.66	51.94	1.02	0.97	44.90	36.89	11.57	9.60	9.15	8.17	5.55	4.38
CD(0.05)	1.41**		0.03**		2.47**		0.42**		0.17*		0.30*	

Fig 13. Effect of growing conditions on number of florets per spike in gladiolus varieties during first season

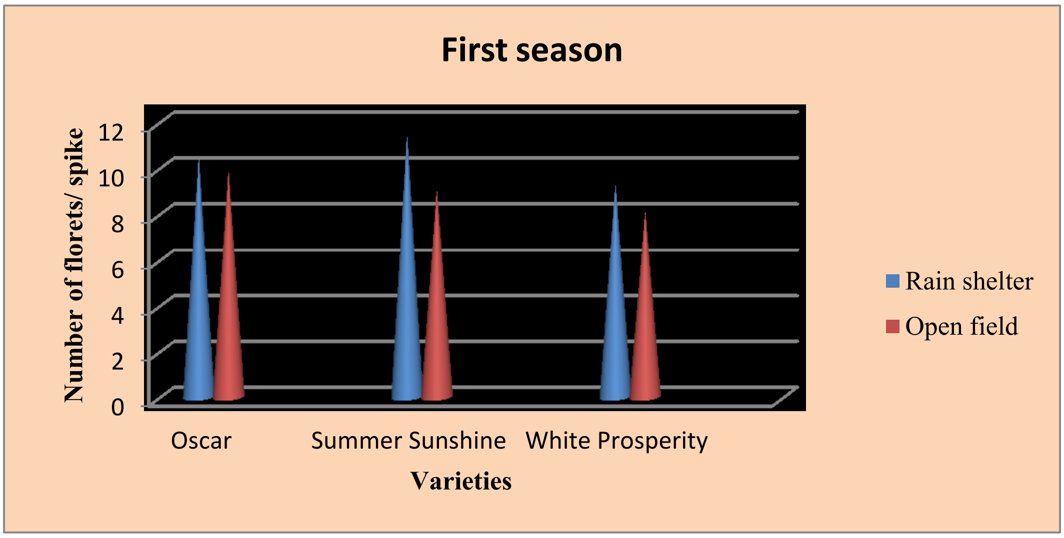
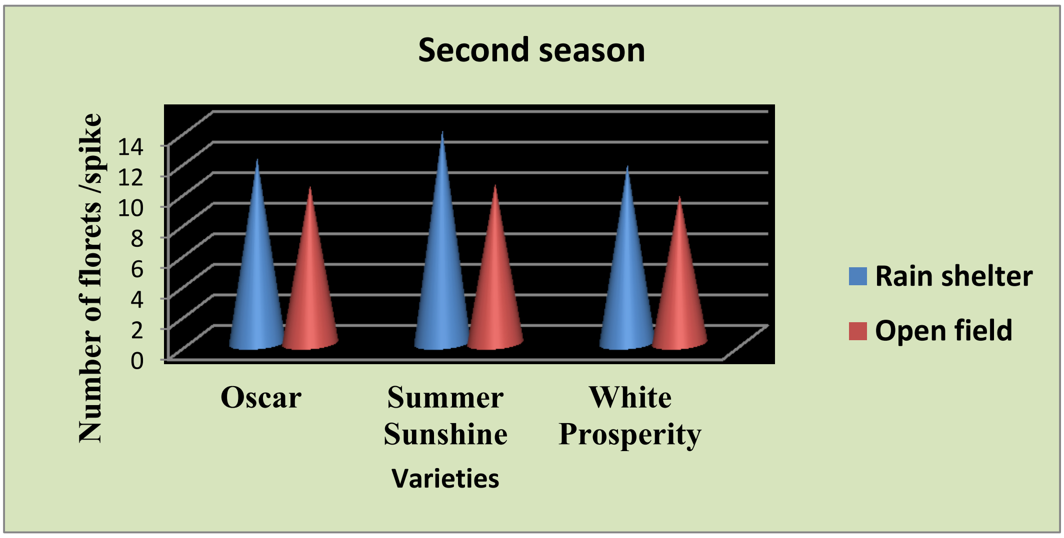


Fig 14. Effect of growing conditions on number of florets per spike in gladiolus varieties during second season



In rain shelter, the total duration for Oscar (89.93 days), Summer Sunshine (75.98 days) and White Prosperity (81.80 days) recorded was shorter during second season (Table 6c). In open field also, Oscar (95.40 days), Summer Sunshine (83.20 days) and White Prosperity (89.20 days) recorded the shortest total duration during second season (Table 6d)

4.1.12. Pest and disease incidence

The plants were free from insect pest attack during the entire period of study. But a few plants were destroyed by Fusarium wilt caused by the fungus *Fusarum oxysporium*, var. gladioli.

Symptoms: A gradual yellowing of the tips of the oldest leaves was first noticed. The yellowing of the leaves at first was confined to one side of the leaf, but eventually the entire leaf was affected. Browning and wilting of the entire plant followed. At the base of the plant (near the corm), blackening of the root bases, extending into the corm was seen. When the corm was cut in half, there was a brown discoloration of the corm.

Control: Soil drenching was done with *Pseudomonas fluorescens* at the rate of 10g/litre water at fortnightly intervals and further spread of disease was controlled.

4.2. Spike characters

Data pertaining to spike characters during the first season are presented in Table 7a and that of second season in Table 7b. The results revealed that growing condition has significant influence on the spike characters of gladiolus in both seasons.

4.2.1. Length of the spike

First season

During the first season, there were significant difference among varieties with respect to spike length, both under rain shelter and open field (Table 7a and

Fig 11).In rain shelter, the spike length was significantly higher in Summer Sunshine (73.54 cm), which was followed by White prosperity (59.05 cm). Oscar (51.02 cm) recorded the minimum spike length.

In open field, Summer Sunshine (42.46 cm) recorded better spike length which was statistically on par with Oscar (41.63 cm). The lowest spike length was recorded in White prosperity (33.13 cm).

Second season

During the second season also, there were significant difference among varieties with respect to spike length, both under rain shelter and open field (Table 7b and Fig 12).

In rain shelter, the spike length was maximum in Summer Sunshine (82.07cm), which was followed by White prosperity (67.66 cm). Oscar (62.91cm) showed the lowest spike length.

In open field, Summer Sunshine (53.77cm) had significantly higher spike length, followed by Oscar (52.26 cm) which was statistically on par with White prosperity (51.94 cm).

4.2.2. Diameter of the spike

First season

During the first season, the growing condition had significant influence on diameter of spike for all the varieties (Table 7a).

In rain shelter, the diameter of spike was maximum in White prosperity (1.02 cm), followed by Oscar (0.90 cm) which was statistically on par with Summer Sunshine (0.89 cm).

White prosperity (0.88 cm) showed highest spike diameter in open field followed by Summer Sunshine (0.72 cm) which was statistically on par with Oscar (0.69 cm).

Table 7c. Effect of season on spike characters in gladiolus varieties grown in rain shelter

Varieties	Length of spike (cm)		Diameter of spike (cm)		Length of rachis (cm)		Number of florets/spike		Size of the florets (cm)		No: of florets opened at a time	
	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2
Oscar	51.02	62.91	0.90	1.34	33.51	42.66	10.35	12.00	9.47	10.31	3.93	4.30
Summer Sunshine	73.54	82.07	0.89	1.22	44.42	51.09	11.38	13.80	8.79	9.90	6.33	6.25
White Prosperity	59.05	67.66	1.02	1.02	37.39	44.90	9.23	11.57	7.53	9.15	4.20	5.55
CD(0.05)	2.15		0.03		NS		0.49		0.28		0.36	

Table 7d. Effect of season on spike characters in gladiolus varieties grown in open field

Varieties	Length of spike (cm)		Diameter of spike (cm)		Length of rachis (cm)		Number of florets/spike		Size of the florets (cm)		No: of florets opened at a time	
	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2
Oscar	41.63	52.26	0.69	1.28	25.73	38.65	9.78	10.25	8.86	9.11	3.40	3.43
Summer Sunshine	42.46	53.77	0.72	1.05	20.47	42.74	8.98	10.35	6.57	8.64	5.13	6.45
White Prosperity	33.13	51.94	0.88	0.97	20.19	36.89	8.03	9.60	6.40	8.17	4.18	4.38
CD(0.05)	1.19		0.04		2.65		0.36		0.17		0.31	

Second season

During the second season also, the growing condition had significant influence on diameter of spike for all the varieties (Table 7b).

Oscar (1.34 cm) had the highest spike diameter in rain shelter, followed by Summer Sunshine (1.22 cm). White Prosperity (1.02 cm) showed the minimum spike diameter. The same trend was noticed in open field also.

It is revealed that the varieties varied significantly among themselves in spike diameter, both under rain shelter and open field. Among the varieties, White Prosperity (first season) and Oscar (second season) had better spike diameter compared to other varieties, both under rain shelter and open field.

4.2.3. Length of rachis

First season

Length of rachis was significantly higher in rain shelter for all the three varieties (Table 7a).

The maximum rachis length was noticed in Summer Sunshine (44.42 cm) in rain shelter, followed by White prosperity (37.39 cm). Least was observed in Oscar (33.51 cm). In open field Oscar (25.73 cm) had higher rachis length than other varieties. Summer Sunshine (20.47 cm) was statistically on par with White prosperity (20.19 cm).

Second season

All the three varieties had better rachis length in rain shelter (Table 7b).

Summer Sunshine (51.09 cm) had maximum rachis length in rain shelter, followed by White prosperity (44.90 cm) was statistically on par with Oscar (42.66 cm). In open field also Summer Sunshine (42.74 cm) recorded higher rachis length than other varieties. Oscar (38.65 cm) was statistically on par with White prosperity (36.89 cm).

The results explain that rachis length is significantly influenced by growing condition during both seasons.

4.2.4. Number of florets per spike

First season

In rain shelter, Summer Sunshine (11.38) had more number of florets per spike followed by Oscar (10.35) (Table 7a). The minimum number of florets per spike was noticed in White prosperity (9.23). In the open field, the maximum number of florets per spike was observed in Oscar (9.78), followed by Summer Sunshine (8.98). The lowest number of florets per spike was recorded in White Prosperity (8.03).

Second season

The highest number of florets per spike was noticed in Summer Sunshine (13.80) in rain shelter, followed by Oscar (12.00) which was on par with White prosperity (11.57) (Table 7b).

In the open field, the maximum number of florets per spike was observed in Summer Sunshine (10.35) which was on par with Oscar (10.25). The least number of florets per spike was recorded in White Prosperity (9.60).

It was revealed that all the varieties recorded better number of florets per spike in rain shelter in both seasons (Fig 13 and Fig 14). Among the varieties, Summer Sunshine had more number of florets per spike in rain shelter than in open field in both seasons.

4.2.5. Size of the florets

First season

Florets with maximum size are observed in Oscar (9.47 cm) in rain shelter, followed by Summer Sunshine (8.79 cm) (Table 7a). White prosperity (7.53 cm) had the least floret size. In the open field also Oscar (8.86 cm) recorded maximum floret size. Summer Sunshine (6.57 cm) and White Prosperity (6.40 cm) were statistically on par with respect to floret size.

Second season

Maximum floret size was found in Oscar, in rain shelter (10.31 cm) as well as in open field (9.11 cm) (Table 7b). The lowest floret size was observed in White prosperity, both in rain shelter (9.15cm) and open field (8.17 cm).

Growing condition significantly influenced floret size during both seasons. In general, all the varieties had large sized florets in rain shelter compared to open field during both seasons. The varieties varied significantly among themselves in floret size under rain shelter as well as open field. Among the varieties, Oscar showed larger florets both in rain shelter and open field.

4.2.6. Number of florets opened at a time

First season

During first season, there were significant differences among varieties with respect to number of florets opened at a time both in rain shelter and open field (Table 7a). The number of florets opened at a time was significantly higher in Summer Sunshine, both in rain shelter (6.33) and open field (5.13). The lowest number of florets opened at a time was reported in Oscar, both in rain shelter (3.93) and open field (3.40).

Second season

There were significant differences among varieties with respect to number of florets opened at a time both in rain shelter and open field during second season also (Table 7b). The number of florets opened at a time was significantly higher in Summer Sunshine, both in rain shelter (6.25) and open field (6.45). The lowest number of florets opened at a time was reported in Oscar, both in rain shelter (4.30) and open field (3.43).

In general, rain shelter had significant influence on number of florets opened at a time, in all the varieties, in two seasons.

4.2.7. Effect of season on spike characters of gladiolus varieties

Season significantly influenced the spike characters of gladiolus varieties (Table7c and Table 7d). In rain shelter all the varieties had better spike characters during second season. But in rain shelter season had no significant influence on rachis length. In open field all the varieties had better spike characters during second season.

4.3. Vase characters

Results of studies on vase characters are presented in (Table 8a) for the first season and that of second season in (Table 8b)

4.3.1. Fresh weight of the spike

First season

The growing condition exerted significant influence on fresh weight of spike for all the varieties (Table 8a and Fig 15). There were significant differences among varieties with respect to fresh weight of spike both in rain shelter and open field. Summer Sunshine had the heaviest spikes both in rain shelter (46.13 g) and open field (36.80 g). Oscar recorded the minimum spike fresh weight both in rain shelter (23.90 g) and open field (19.00 g).

Second season

During the second season also, the varieties showed significant variation in spike fresh weight under both growing conditions (Table 8b and Fig 16). The maximum spike fresh weight was observed in Summer Sunshine both in rain shelter (55.67 g) and open field (44.27 g) and the minimum in Oscar both in rain shelter (34.97 g) and open field (25.17 g).

Fig 15. Effect of growing conditions on fresh weight of spike (g) in gladiolus varieties during first season

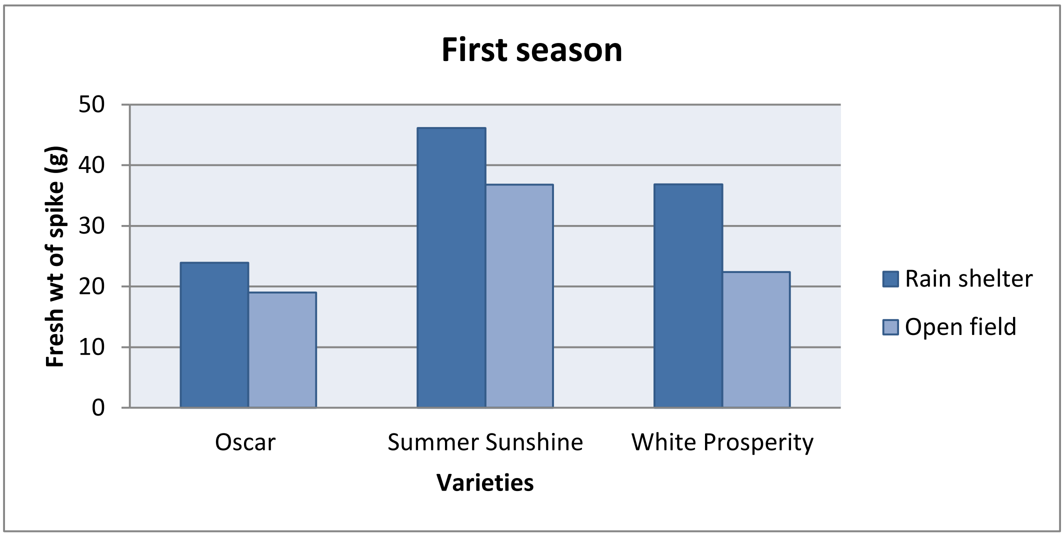


Fig 16. Effect of growing conditions on fresh weight of spike (g) in gladiolus varieties during second season

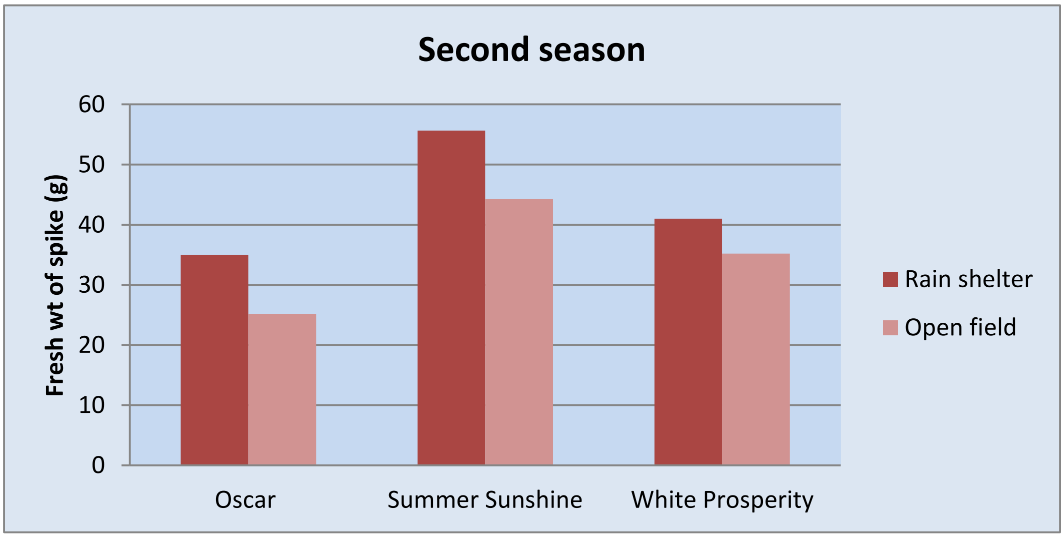


Table 8a. Effect of growing conditions on vase characters in gladiolus varieties during first season

Variety	Fresh wt of spike (g)		Percentage of fully opened florets		Percentage of partially opened florets		Percentage of unopened florets		Longevity of individual florets (days)		Number of florets opened at a time		Nature of bending: From which day in vase		Nature of bending: From which floret		Water uptake (ml)		Vase life (days)	
	G1	G2	G1	G2	G1	G2	G1	G2	G1	G2	G1	G2	G1	G2	G1	G2	G1	G2	G1	G2
Oscar	23.90	19.00	27.27	20.00	18.18	20.00	54.55	60.00	1.67	1	2	2	4	4	4	4	31.23	22.03	5.00	3.67
Summer Sunshine	46.13	36.80	41.67	22.22	16.67	11.11	41.67	66.66	3.2	2.5	3	2	6	4	6	4	35.93	28.77	6.67	4.00
White prosperity	36.83	22.40	33.33	25.00	22.22	12.50	44.44	62.50	1.33	1	3	2	3	3	4	2	24.00	12.40	3.33	2.00
CD(0.05)	2.068		0.20		0.01		NS		NS		NS		NS		NS		3.326		0.80	

Fig 17. Effect of growing conditions on vase life (days) in gladiolus varieties during first season

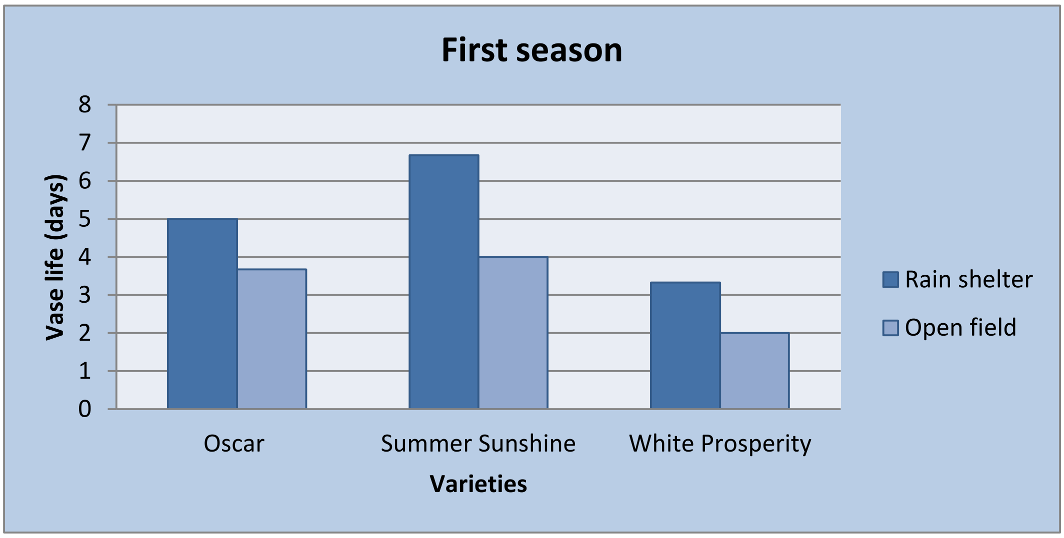


Fig 18. Effect of growing conditions on vase life (days) in gladiolus varieties during second season

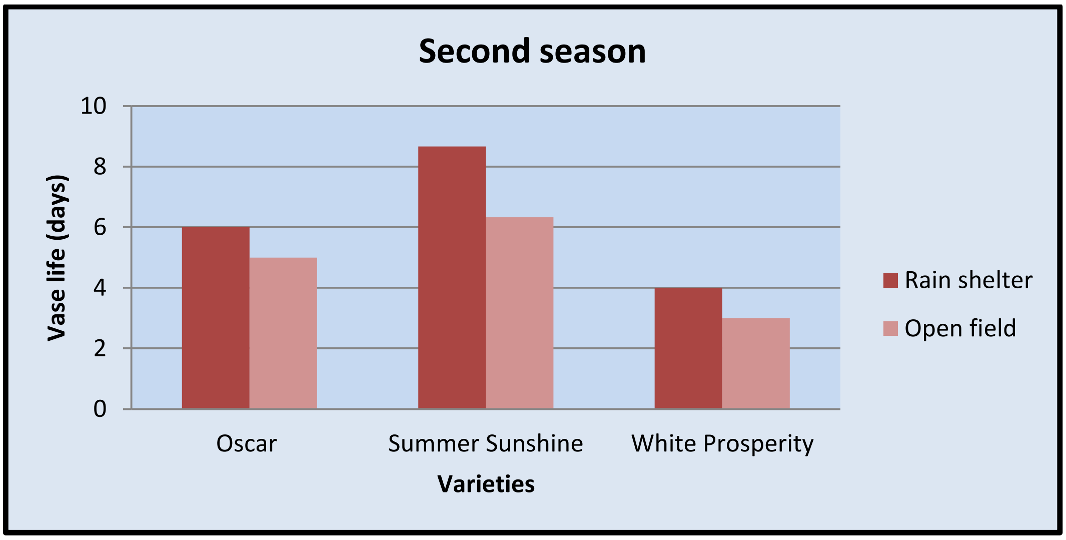


Table 8b. Effect of growing conditions on vase characters in gladiolus varieties during second season

Variety	Fresh wt of spike (g)		Percentage of fully opened florets		Percentage of partially opened florets		Percentage of unopened florets		Longevity of individual florets (days)		Number of florets opened at a time		Nature of bending: From which day in vase		Nature of bending: From which floret		Water uptake (ml)		Vase life (days)	
	G1	G2	G1	G2	G1	G2	G1	G2	G1	G2	G1	G2	G1	G2	G1	G2	G1	G2	G1	G2
Oscar	34.97	25.17	33.33	30.00	25.00	20.00	41.67	50.00	2.00	1.67	2.00	2.00	5.00	5.00	6.00	5.00	35.87	21.20	6.00	5.00
Summer Sunshine	55.67	44.27	42.86	36.36	21.43	18.18	35.71	45.45	3.67	3.25	4.00	3.00	7.00	5.00	7.00	6.00	41.43	33.07	8.67	6.33
White prosperity	41.03	35.20	41.67	30.00	25.00	20.00	33.33	50.00	2.20	2.00	4.00	2.00	5.00	5.00	6.00	5.00	31.23	25.70	4.00	3.00
CD (0.05)	2.974		NS		NS		0.028		0.002		0.801		NS		NS		2.803		0.67	

4.3.2. Percentage of fully opened florets

First season

Significant influence of growing condition was noticed on percentage of fully opened florets in vase for all the varieties during the first season (Table 8a). Varieties varied significantly among themselves also, with respect to percentage of fully opened florets in vase. Summer Sunshine (41.67 %) recorded the highest percentage of fully opened florets in rainshelter . But in openfield the maximum was recorded by White Prosperity (25.00 %). The lowest percentage of fully opened florets in vase was found in Oscar, both in rain shelter (27.27 %) and open field (20.00%).

Second season

The influence of growing condition on the percentage of fully opened florets in vase was insignificant for all the varieties during the second season (Table 8b).

4.3.3. Percentage of partially opened florets

First season

Percentage of partially opened florets in vase was significantly influenced by growing condition for all the varieties during first season (Table 8a). In rainshelter maximum percentage of partially opened florets was exhibited by White prosperity (22.22%) and minimum by Summer Sunshine (16.67%). But in open field, highest percentage of partially opened florets was recorded in Oscar (20.00%) and the lowest in Summer Sunshine (11.11%).

Second Season

There was no significant influence of growing condition on the percentage of partially opened florets in vase for all the varieties during second season (Table 8b) .

4.3.4. Percentage of unopened florets

First season

Growing conditions had no significant influence on the percentage of unopened florets for all the varieties during the first season (Table 8a) .

Second season

During second season the influence of growing condition on percentage of unopened florets in vase was highly significant for all the varieties (Table 8b). In rain shelter the percentage of unopened florets was recorded maximum in Oscar (41.67%) and minimum in White prosperity (33.33%). In open field, Oscar (50.00%) and White prosperity (50.00%) were on par and the minimum was observed in Summer Sunshine (45.45%).

4.3.5. Longevity of individual florets

First season

Longevity of individual florets was not significantly influenced by growing condition for all the varieties, during the first season (Table 8a) .

Second season

The growing condition exerted significant influence on longevity of individual florets for all the varieties during second season (Table 8b). Summer Sunshine had the maximum longevity of individual florets, both in rain shelter (3.67 days) and open field (3.25 days) and the minimum was observed in Oscar, both in rain shelter (2.00days) and open field (1.67 days).

4.3.6. Number of florets opened at a time

First season

There was no significant influence of growing condition on number of florets opened at a time in vase during first season for all the varieties (Table 8a).

Second season

Number of florets opened at a time in vase was significantly influenced by growing condition for all the varieties, during the second season (Table 8b). In rain shelter the maximum was recorded by Summer Sunshine (4.00) and White prosperity (4.00) and minimum by Oscar (2.00). In open field Summer Sunshine (3.00) exhibited the highest number of florets opened at a time in vase, followed by Oscar (2.00) and White Prosperity (2.00).

4.3.7. Nature of bending

The influence of growing condition on the nature of bending was insignificant for all the varieties during both the seasons (Table 8a and 8b).

4.3.8. Water uptake

First season

Water uptake was significantly influenced by growing condition for all the varieties during the first season (Table 8a). Summer sunshine had the highest water uptake both in rain shelter (35.93 ml) and open field (28.77 ml) and the lowest by Oscar (24.00 ml and 12.40 ml respectively).

Second season

During second season also growing condition had significant influence on varieties with respect to water uptake (Table 8b). Summer Sunshine recorded the maximum water uptake both in rain shelter (41.43 ml) and open field (33.07 ml). The minimum was recorded by White Prosperity (31.23 ml) in rain shelter and by Oscar (21.20 ml) in open field.

4.3.9 Vase life

First season

Growing condition had significant influence on vase life of all the varieties during the first season (Table 8a). Summer Sunshine recorded the highest vase life

Fig 19. Effect of season on longevity of individual florets (days) in gladiolus varieties grown in rain shelter

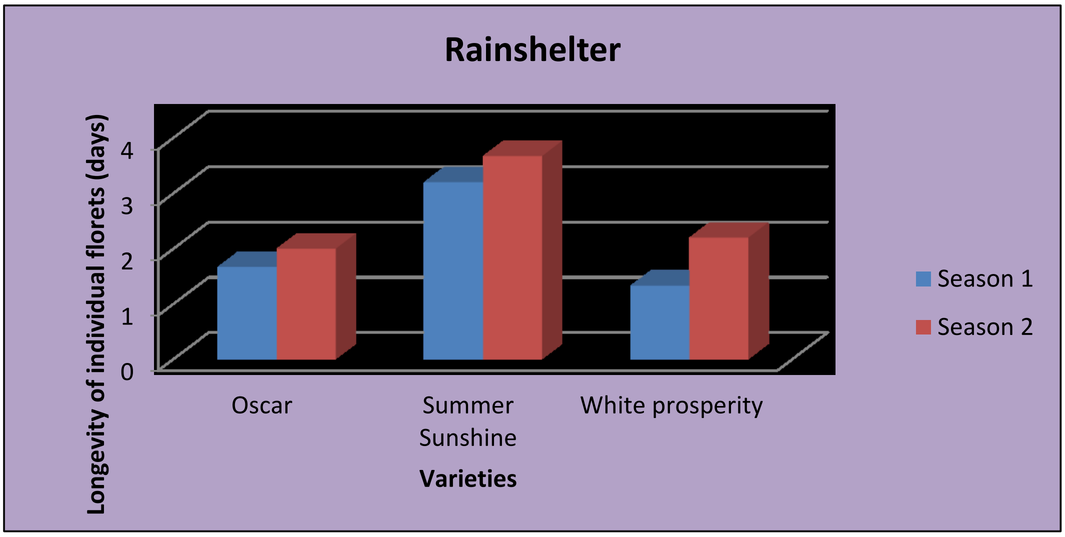


Fig 20. Effect of season on longevity of individual florets (days) in gladiolus varieties grown in open field

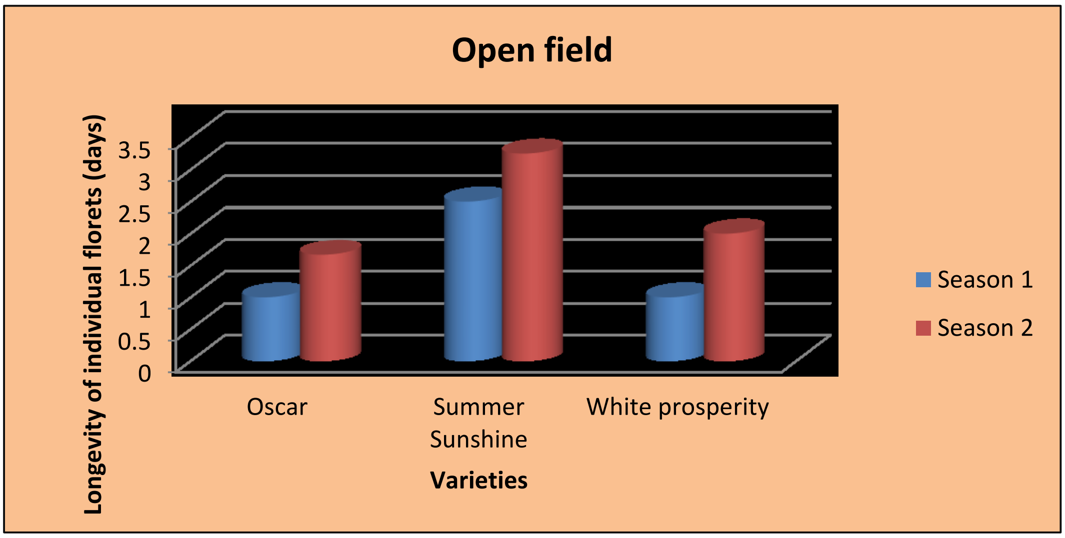


Table 8c. Effect of seasons on vase characters in gladiolus varieties grown in rain shelter

Variety	Fresh wt of spike (g)		Percentage of fully opened florets		Longevity of individual florets (days)		Number of florets opened at a time		Vase life (days)	
	S1	S2	S1	S2	S1	S1	S1	S2	S1	S2
Oscar	23.90	34.97	27.27	33.33	5.00	5.00	2.00	2.00	3.67	4.33
Summer Sunshine	46.13	55.67	41.67	42.86	6.33	6.33	3.00	4.00	4.00	6.33
White prosperity	36.83	41.03	33.33	41.67	3.33	3.33	3.00	4.00	2.00	4.33
CD(0.05)	2.93		NS		0.003		NS		0.64	

Table 8d. Effect of seasons on vase characters in gladiolus varieties grown in open field

Variety	Fresh wt of spike (g)		Percentage of fully opened florets		Longevity of individual florets (days)		Number of florets opened at a time		Vase life (days)	
	S1	S2	S1	S2	S1	S1	S1	S2	S1	S2
Oscar	19.00	25.17	20.00	30.00	1.00	1.67	2	2	5.00	6.00
Summer Sunshine	36.80	44.27	22.22	36.36	2.50	3.25	2	3	6.33	8.00
White prosperity	22.40	35.20	25.00	30.00	1.00	2.00	2	2	3.33	6.00
CD(0.05)	1.42		0.005		0.002		NS		0.87	

Oscar

White Prosperity

Summer Sunshine

Plate 4. Corms of three gladiolus varieties

(6.67 days) in rain shelter and the lowest (3.33 days) was recorded by White Prosperity. In open field also Summer Sunshine recorded maximum vase life (4.00 days) which was statistically on par with Oscar (3.67 days). White Prosperity recorded the minimum vase life (2.00 days).

Second season

During second season also growing condition had significant influence on varieties with respect to vase life (Table 8b). Summer Sunshine recorded the maximum vase life both in rain shelter (8.67 days) and open field (6.33 days). The minimum was recorded by White Prosperity both in rain shelter (4.00 days) and open field (3.00 days).

It can be concluded that vase life exhibited was better in rain shelter than in open field for all the varieties during both seasons (Fig 20 and Fig 21).

4.3.10. Effect of season on vase characters of gladiolus varieties

Season significantly influenced some of the vase characters of gladiolus varieties (Table 8c and Table 8d). In rain shelter all the varieties had better fresh weight, longevity of individual florets and vase life, during second season. But in rain shelter, season had no significant influence on percentage of fully opened florets and number of florets opened at a time. In open field all the varieties had better fresh weight, percentage of fully opened florets, longevity of individual florets (Fig 18 and Fig 19) and vase life, during second season. But season had no significant influence on number of florets opened at a time in open field grown plants.

4.4. Corm and cormel yield

Data related to corm and cormel yield during first season are presented in (Table 9a) and that of second season in (Table 9b)

4.4.1. Weight of corms

First season

The growing condition had significant influence on weight of corms (Table 9a). The weight of corms was maximum in Summer Sunshine both in rain shelter (108.11 g) and open field (70.50 g). The lowest was observed in White prosperity, both in rain shelter (42.79 g) and open field (22.41g).

Second season

The growing condition had significant influence on weight of corms (Table 9b). The weight of corms was maximum in Summer Sunshine both in rain shelter (147.33 g) and open field (84.76 g). The lowest was observed in White prosperity (57.22 g), in rain shelter. In open field Oscar (35.74 g) and White Prosperity (35.04 g) were stastically on par.

In general the weight of corms was more in rain shelter for all the varieties, in both seasons.

4.4.2. Size of corms

First season

Size of the corms was significantly influenced by growing condition (Table 9a). The highest corm size was recorded in Summer Sunshine both in rain shelter (7.24 cm) and open field (5.74 cm). White prosperity showed the lowest values, in rain shelter and open field (5.15 cm and 4.02 cm respectively).

Second season

Size of the corms was significantly influenced by growing condition (Table 9b). The highest corm size was recorded in Summer Sunshine both in rain shelter (8.10cm) and open field (6.04cm). In the second season also White prosperity showed the lowest corm size, in rain shelter (5.30 cm) and open field (4.29 cm).

Table 9a. Effect of growing conditions on the corm and cormel yield of gladiolus varieties during first season

Varieties	Weight of corms (g)		Size of corms (cm)		Number of cormels		Weight of cormels (g)	
	S1	S2	S1	S2	S1	S2	S1	S2
Oscar	59.57	30.80	5.95	4.99	14.75	9.23	19.23	10.01
Summer Sunshine	108.11	70.50	7.24	5.74	5.75	17.75	8.41	13.37
White Prosperity	42.79	22.41	5.15	4.02	4.88	1.93	2.49	0.30
CD(0.05)	2.45		0.16		1.82		1.60	

Table 9b. Effect of growing conditions on the corm and cormel yield of gladiolus varieties during second season

Varieties	Weight of corms (g)		Size of corms (cm)		Number of cormels		Weight of cormels (g)	
	S1	S2	S1	S2	S1	S2	S1	S2
Oscar	75.59	35.74	6.02	4.88	21.63	7.65	20.78	9.46
Summer Sunshine	147.33	84.76	8.10	6.04	6.93	17.49	8.72	13.60
White Prosperity	57.22	35.04	5.30	4.29	8.05	4.65	4.23	0.61
CD(0.05)	5.95		0.22		1.37		0.88	

Fig 21. Effect of growing conditions on corm size (cm) in gladiolus varieties during first season

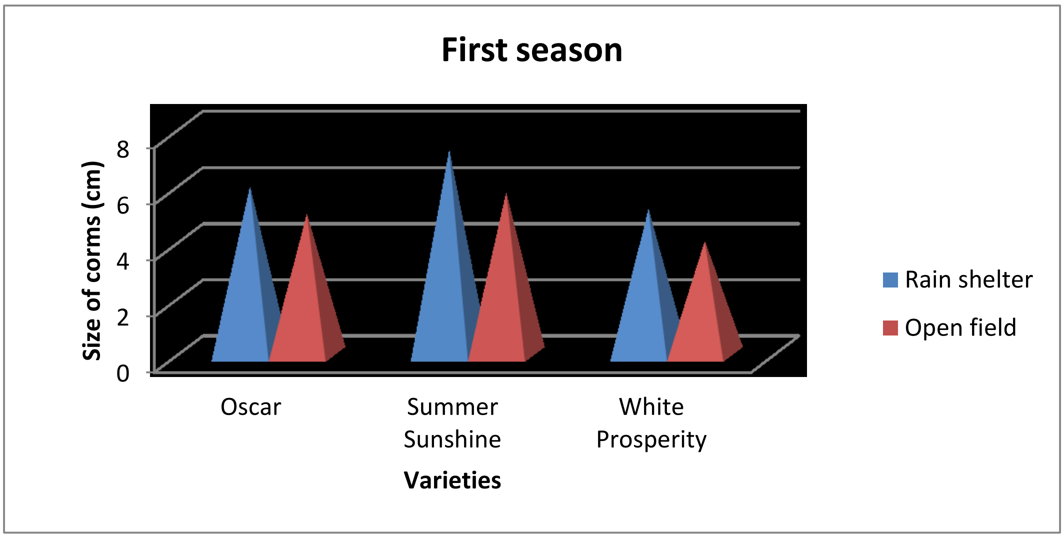
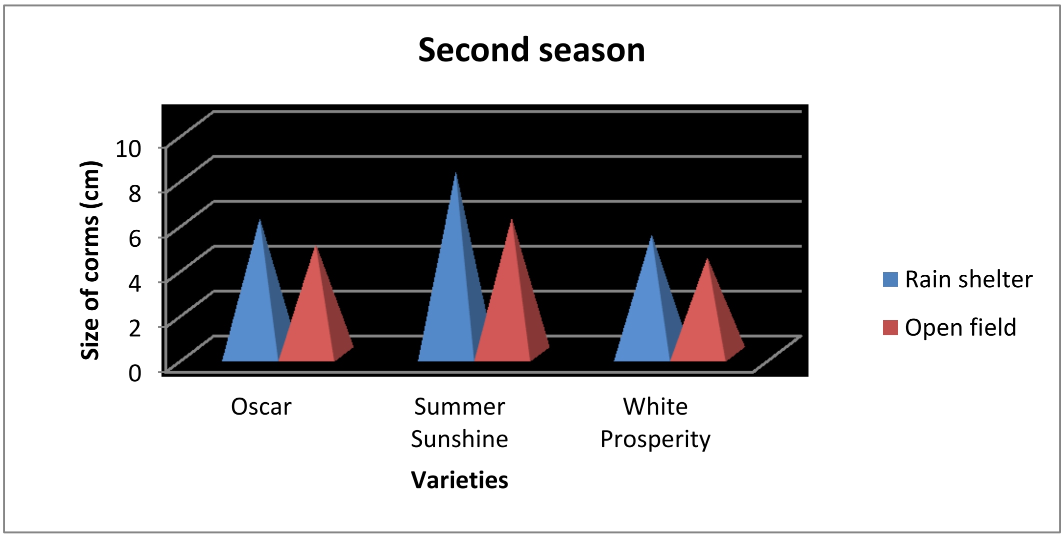


Fig 22. Effect of growing conditions on corm size (cm) in gladiolus varieties during second season



It can be concluded that size of the corms was maximum in rain shelter for all the varieties (Fig 21 and Fig 22).

4.4.3. Number of cormels per plant

First season

Number of cormels per plant was significantly influenced by growing condition (Table 9a). The maximum number of cormels was recorded by Oscar in rain shelter (14.75) and by Summer Sunshine (17.75) in open field . White prosperity showed the minimum number of cormels, both in rain shelter (4.88) and open field (1.93).

Second season

Number of cormels per plant was significantly influenced by growing condition (Table 9b). Maximum number of cormels was produced by Oscar in rain shelter (21.63) and by Summer Sunshine (17.49) in open field . White prosperity showed the minimum number of cormels, both in rain shelter (8.05) and open field (4.65).

Results revealed that Oscar and White Prosperity produced maximum number of cormels in rain shelter condition. But Summer Sunshine recorded more cormels in open field during both seasons.

4.4.4. Weight of cormels

First season

The growing condition significantly influenced weight of cormels of all the varieties (Table 9a).The highest weight of cormels was recorded by Oscar in rain shelter (19.23g) and by Summer Sunshine (13.37 g) in open field . White prosperity showed the minimum number of cormels, both in rain shelter (2.49 g) and open field (0.30 g).

Table 9c. Effect of seasons on the corm and cormel yield of gladiolus varieties grown in rain shelter

Varieties	Weight of corms (g)		Size of corms (cm)		Number of cormels		Weight of cormels (g)	
	S1	S2	S1	S2	S1	S2	S1	S2
Oscar	59.57	75.59	5.95	6.02	14.75	21.63	19.23	20.78
Summer Sunshine	108.11	147.33	7.24	8.10	5.75	6.93	8.41	8.72
White Prosperity	42.79	57.22	5.15	5.30	4.88	8.05	2.49	4.23
CD(0.05)	4.62		0.15		1.39		NS	

Table 9d. Effect of seasons on the corm and cormel yield of gladiolus varieties grown in open field

Varieties	Weight of corms (g)		Size of corms (cm)		Number of cormels		Weight of cormels (g)	
	S1	S2	S1	S2	S1	S2	S1	S2
Oscar	30.80	35.74	4.99	4.88	9.23	7.65	10.01	9.46
Summer Sunshine	70.50	84.76	5.74	6.04	17.75	17.49	13.37	13.60
White Prosperity	22.41	35.04	4.02	4.29	1.93	4.65	0.30	0.61
CD(0.05)	4.31		0.22		1.28		NS	

Second season

The growing condition significantly influenced weight of cormels of all the varieties (Table 9b).The highest weight of cormels was recorded by Oscar in rain shelter (20.78 g) and by Summer Sunshine (13.60 g) in open field . White prosperity showed the minimum weight of cormels, both in rain shelter (4.23 g) and open field (0.61 g).

Present study showed that in both seasons, maximum cormel yield was obtained in rain shelter for Oscar and White Prosperity. Summer Sunshine recorded significantly higher weight of cormel in open field during both seasons.

4.4.5. Effect of season on corm and cormel of gladiolus varieties

Season significantly influenced corm and cormel yield of gladiolus varieties (Table 9c and Table 9d). All the varieties had better corm weight, corm size and number of cormels during second season under both growing conditions. But season had no significant influence on weight of cormels of all the varieties grown under both conditions.

4.5. Post-harvest treatment studies

Investigations were carried out to standardize the post harvest treatments to improve the spike qualities of gladiolus. Studies were done on effect of different pulsing solutions, holding solutions, storage temperature and packing materials. The data pertaining to the studies are presented in Table 10a to Table 13c.

4.5.1. Pulsing

The results of investigations on pulsing treatments are presented in Table 10a to Table 10c.

Table 10a. Effect of pulsing treatments on the vase characters in gladiolus cv. Oscar

Treatments	Percentage of fully opened florets	Percentage of partially opened florets ++	Percentage of unopened florets	Longevity of individual florets (days)+	Number of florets opened at a time	Nature of bending		Water uptake (ml)	Vase life (days)
						From which day in vase +	From which floret +		
Sucrose 10% + 8- HQC 100 ppm	36.36^{b}	18.18	45.45^{b}	1.75	2.00^{b}	5.00	4.00	27.67^{cd}	5.00^{b}
Sucrose 10% + 8- HQC 200 ppm	39.39^{b}	18.18	42.42^{b}	1.75	2.33^{b}	5.00	4.00	31.37^{b}	5.67^{a}
Sucrose 20% + 8- HQC 100 ppm	36.36^{b}	18.18	45.45^{b}	1.75	2.00^{b}	5.00	4.00	27.93^{c}	5.00^{b}
Sucrose 20% + 8- HQC 200 ppm	45.45^{a}	18.18	36.36^{c}	1.8	3.00^{a}	6.00	4.00	36.07^{a}	6.00^{a}
Sucrose 10%	27.27^{c}	18.18	54.55^{a}	1.67	2.00^{b}	4.00	4.00	26.03^{d}	5.00^{b}
Sucrose 20%	27.27^{c}	18.18	54.55^{a}	1.67	2.00^{b}	4.00	4.00	28.97^{c}	5.00^{b}
Control	27.27^{c}	18.18	54.55^{a}	1.67	2.00^{b}	4.00	4.00	24.00^{e}	5.00^{b}

Treatment means having similar alphabets in superscript do not differ significantly

\+ Not statistically different ++ No statistical analysis done

Fig 23. Effect of pulsing treatments on fully opened florets (%) in gladiolus cv. Oscar

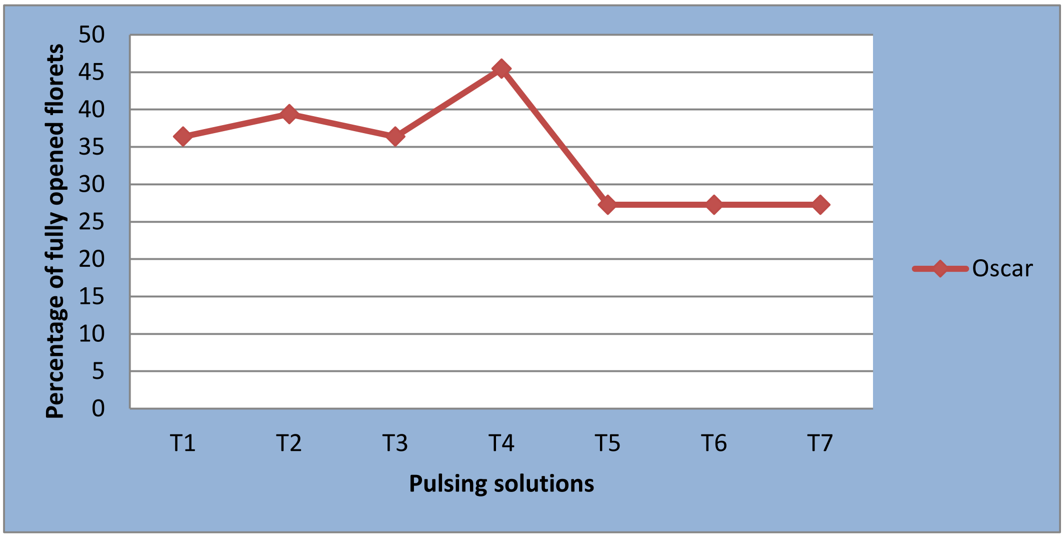
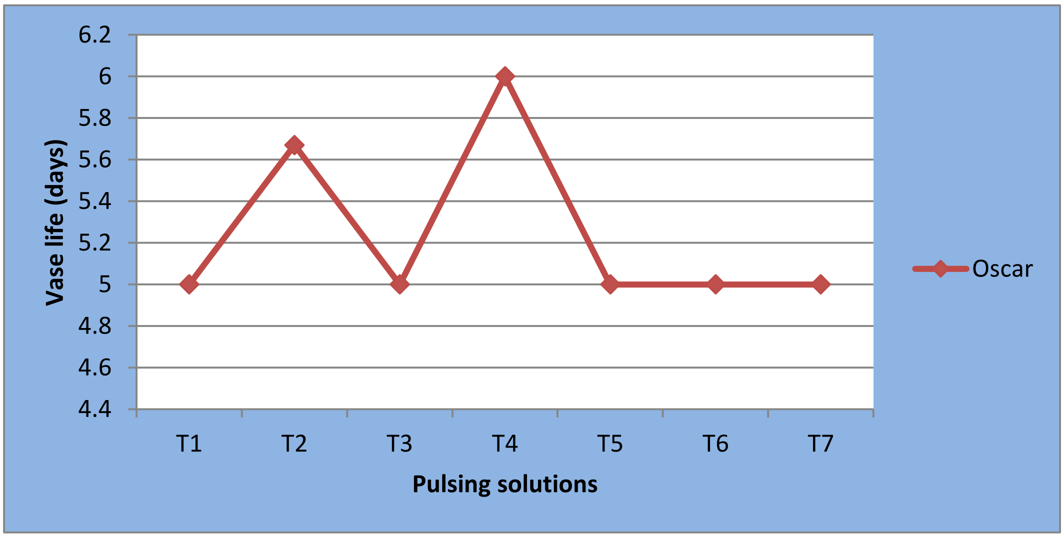


Fig 24. Effect of pulsing treatments on vase life (days) in gladiolus cv. Oscar



T_1 - Sucrose 10% + 8- HQC 100 ppm, **T_2** - Sucrose 10% + 8- HQC 200 ppm

T_3 - Sucrose 20% + 8- HQC 100 ppm, **T_4** - Sucrose 20% + 8- HQC 200 ppm

T_5 - Sucrose 10%, **T_6** - Sucrose 20%, **T_7** - Control

4.5.1.1. Percentage of fully opened florets

4.5.1.1.1 Oscar

Pulsing treatments exerted significant influence on percentage of fully opened florets in this variety (Table 10a and Fig 23). T_4 (Sucrose 20% + 8- HQC 200 ppm) recorded the maximum percentage of fully opened florets (45.45%). The minimum percentage (27.27%) was recorded by T_5 (Sucrose 10%), T_6 (Sucrose 20%) and T_7 (Control).

4.5.1.1.2. Summer Sunshine

The influence of pulsing treatments was not significant on percentage of fully opened florets in this variety (Table 10b).

4.5.1.1.3. White prosperity

Percentage of fully opened florets in this variety was not significantly influenced by pulsing treatments (Table 10c).

4.5.1.2. Percentage of partially opened florets

4.5.1.2.1 Oscar

Pulsing treatments had no influence on percentage of partially opened florets in this variety (Table 10a).

4.5.1.2.2. Summer Sunshine

The influence of pulsing treatments was not significant on percentage of partially opened florets in this variety (Table 10b).

4.5.1.2.3. White prosperity

Percentage of partially opened florets in this variety was not significantly influenced by pulsing treatments (Table 10c).

4.5.1.3. Percentage of unopened florets

4.5.1.3.1 Oscar

Pulsing treatments significantly influenced the percentage of unopened florets in this variety (Table 10a). T_5 (Sucrose 10%), T_6 (Sucrose 20%) and T_7 (Control) recorded the maximum percentage (54.55%) of unopened florets. The minimum percentage (36.36%) was recorded by T_4 (Sucrose 20% + 8- HQC 200 ppm).

4.5.1.3.2. Summer Sunshine

Percentage of unopened florets in this variety was not significantly influenced by pulsing treatments (Table 10b).

4.5.1.3.3. White prosperity

The influence of pulsing treatments was not significant on percentage of unopened florets in this variety (Table 10c).

4.5.1.4. Longevity of individual florets

4.5.1.4.1 Oscar

Longevity of individual florets in this variety was not significantly influenced by pulsing treatments (Table 10a).

4.5.1.4.2. Summer Sunshine

Pulsing treatments significantly influenced the longevity of individual florets in this variety (Table 10b and Fig 25). The maximum longevity of individual florets (3.83 days) was recorded by T_4 (Sucrose 20% + 8- HQC 200 ppm). T_5 (Sucrose 10%), T_6 (Sucrose 20%) and T_7 (Control) recorded the minimum longevity of individual florets (3.20 days).

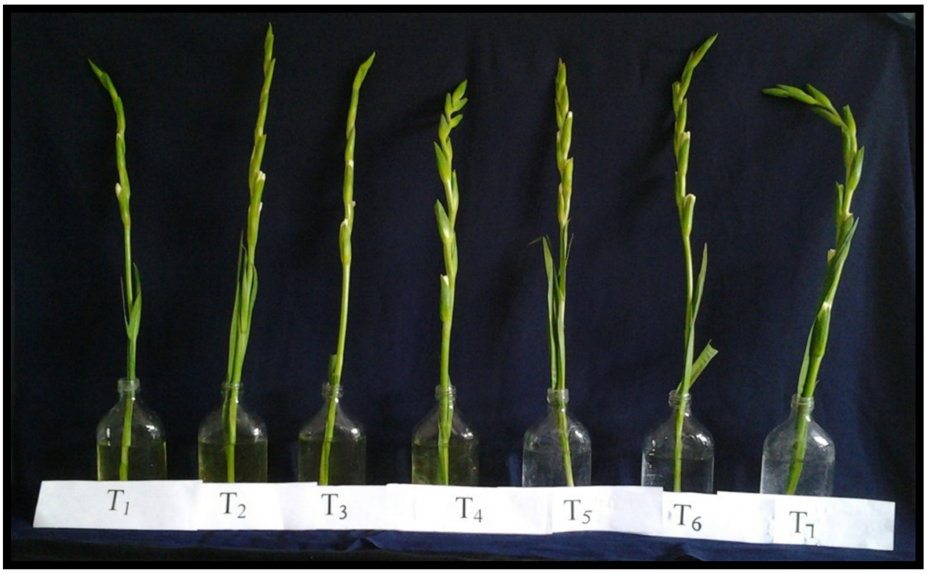


Plate 5. Spikes of gladiolus cv. White Prosperity kept in pulsing solutions

Table 10b. Effect of pulsing treatments on the vase characters in gladiolus cv. Summer Sunshine

Treatments	Percentage of fully opened florets +	Percentage of partially opened florets +	Percentage of unopened florets +	Longevity of individual florets (days)	Number of florets opened at a time	Nature of bending		Water uptake (ml)	Vase life (days)
						From which day in vase +	From which floret +		
Sucrose 10% + 8- HQC 100 ppm	50	16.67	33.33	3.3[c]	3.00[b]	6.00	7.00	43.17[b]	7.00[b]
Sucrose 10% + 8- HQC 200 ppm	50	25.00	25.00	3.56[b]	3.67[a]	7.00	7.00	43.8[b]	7.33[b]
Sucrose 20% + 8- HQC 100 ppm	50	16.67	33.33	3.3[c]	3.00[b]	6.00	7.00	43.5[b]	7.00[b]
Sucrose 20% + 8- HQC 200 ppm	50	25.00	25.00	3.83[a]	4.00[a]	7.00	7.00	47.00[a]	8.00[a]
Sucrose 10%	41.67	16.67	41.67	3.2[d]	3.00[b]	6.00	6.00	38.17[c]	7.00[b]
Sucrose 20%	41.67	16.67	41.67	3.2[d]	3.00[b]	6.00	6.00	34.77[d]	7.00[b]
Control	41.67	16.67	41.67	3.2[d]	3.00[b]	6.00	6.00	31.23[e]	6.00[c]

Treatment means having similar alphabets in superscript, do not differ significantly

\+ Not statistically different

Fig 25. Effect of pulsing treatments on longevity of individual florets (days) in gladiolus cv. Summer Sunshine

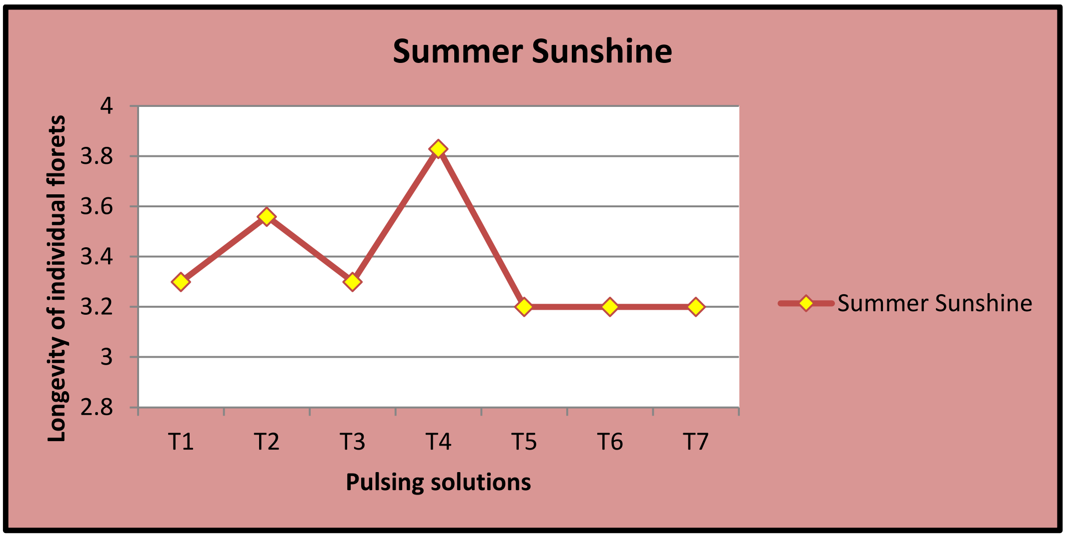
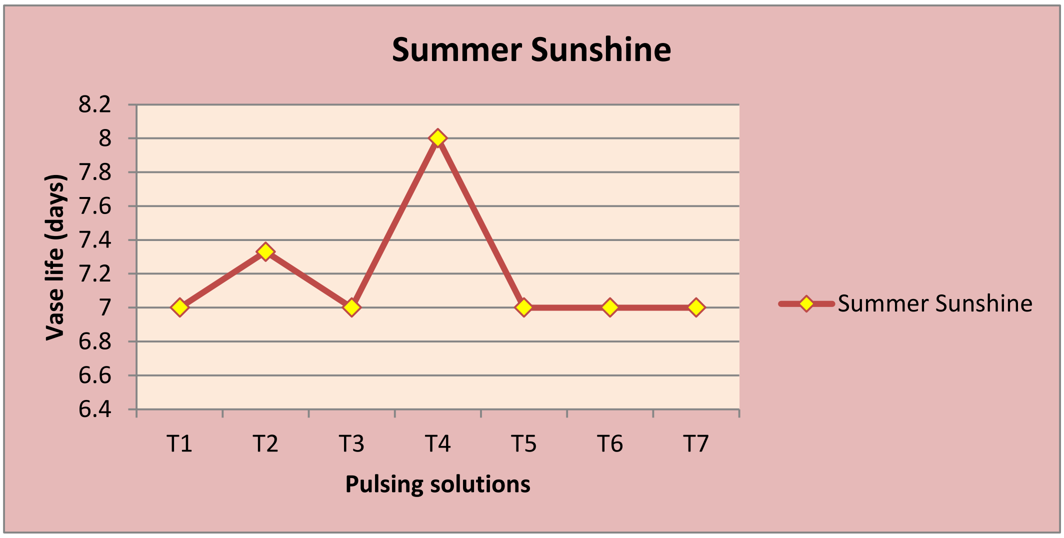


Fig 26. Effect of pulsing treatments on vase life (days) in gladiolus cv. Summer Sunshine



T_1 **-** Sucrose 10% + 8- HQC 100 ppm, **T_2** - Sucrose 10% + 8- HQC 200 ppm

T_3 - Sucrose 20% + 8- HQC 100 ppm, **T_4** - Sucrose 20% + 8- HQC 200 ppm

T_5 - Sucrose 10%, **T_6** - Sucrose 20%, **T_7** - Control

4.5.1.4.3. White prosperity

The influence of pulsing treatments was not significant on longevity of individual florets in this variety (Table 10c).

4.5.1.5. Number of florets opened at a time

4.5.1.5.1 Oscar

Pulsing treatments significantly influenced the number of florets opened at a time in this variety (Table 10a). The maximum number of florets opened at a time (3.00) was observed in T_4 (Sucrose 20% + 8- HQC 200 ppm). T_1 (Sucrose 10% + 8- HQC 100 ppm), T_3(Sucrose 20% + 8- HQC 100ppm), T_5 (Sucrose 10%), T_6 (Sucrose 20%) and T_7 (Control) recorded the minimum number of florets opened at a time (2.00).

4.5.1.5.2. Summer Sunshine

Number of florets opened at a time in this variety was significantly influenced by pulsing treatments (Table 10b). The number of florets opened at a time (4.00) was highest in T_4 (Sucrose 20% + 8- HQC 200 ppm) which was statistically on par with T_2 (Sucrose 10% + 8- HQC 200 ppm). T_1 (Sucrose 10% + 8- HQC 100 ppm), T_3(Sucrose 20% + 8- HQC 100ppm),T_5 (Sucrose 10%), T_6 (Sucrose 20%) and T_7 (Control) recorded the minimum number of florets opened at a time (3.00).

4.5.1.5.3. White prosperity

The influence of pulsing treatments was insignificant on number of florets opened at a time in this variety (Table 10c).

4.5.1.6. Nature of bending

The influence of pulsing treatments on nature of bending was insignificant for all the varieties (Table 10a ,Table 10a and Table 10c).

Oscar

Summer Sunshine

Plate 6. Pulsed spikes kept in tap water

Table 10c. Effect of pulsing treatments on the vase characters in gladiolus cv. White prosperity

Treatments	Percentage of fully opened florets +	Percentage of partially opened florets +	Percentage of unopened florets +	Longevity of individual florets (days) +	Number of florets opened at a time +	Nature of bending		Water uptake (ml)	Vase life (days)
						From which day in vase +	From which floret +		
Sucrose 10% + 8- HQC 100 ppm	33.33	22.22	44.44	1.33	3.00	3.00	4.00	34.80^{b}	4.00^{c}
Sucrose 10% + 8- HQC 200 ppm	44.44	22.22	33.33	1.67	4.00	4.00	5.00	45.37^{a}	5.00^{b}
Sucrose 20% + 8- HQC 100 ppm	33.33	22.22	44.44	1.33	3.00	3.00	4.00	36.77^{b}	4.00^{c}
Sucrose 20% + 8- HQC 200 ppm	44.44	33.33	22.22	2.25	4.00	5.00	6.00	44.67a	6.00^{a}
Sucrose 10%	33.33	22.22	44.44	1.33	3.00	3.00	4.00	35.93^{b}	4.00^{c}
Sucrose 20%	33.33	22.22	44.44	1.33	3.00	3.00	4.00	35.53^{b}	4.00^{c}
Control	33.33	22.22	44.44	1.33	3.00	3.00	4.00	34.33^{b}	4.00^{c}

Treatment means having similar alphabets in superscript, do not differ significantly

\+ Not statistically different

Fig 27. Effect of pulsing treatments on water uptake (ml) in gladiolus cv. White prosperity

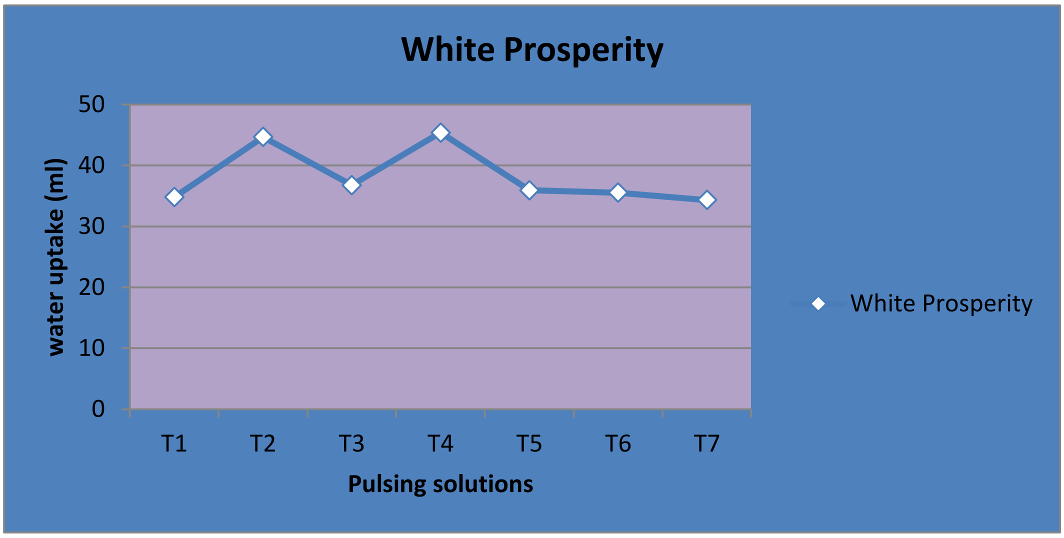
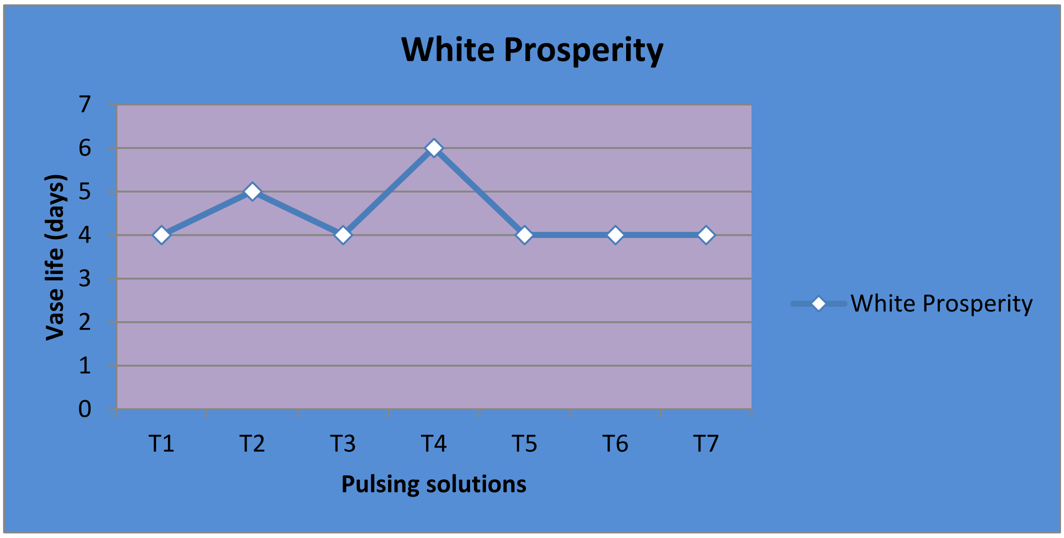


Fig 28. Effect of pulsing treatments on vase life (days) in gladiolus cv. White prosperity



T_1 - Sucrose 10% + 8- HQC 100 ppm, **T_2** - Sucrose 10% + 8- HQC 200 ppm

T_3 - Sucrose 20% + 8- HQC 100 ppm, **T_4** - Sucrose 20% + 8- HQC 200 ppm

T_5 - Sucrose 10%, **T_6** - Sucrose 20%, **T_7** - Control

4.5.1.7. Water uptake

4.5.1.7.1 Oscar

Water uptake was significantly influenced by pulsing treatments in this variety (Table 10a). The maximum water uptake (36.07 ml) was observed in T_4 (Sucrose 20% + 8- HQC 200 ppm).T_7 (Control) recorded the minimum water uptake (24.00 ml).

4.5.1.7.2. Summer Sunshine

Pulsing treatments significantly influenced the water uptake in this variety (Table 10b). The maximum water uptake (47.00 ml) was recorded by T_4 (Sucrose 20% + 8- HQC 200 ppm). T_7 (Control) recorded the minimum water uptake (31.23 ml).

4.5.1.7.3. White prosperity

The influence of pulsing treatments on water uptake was significant in this variety (Table 10c and Fig 27). The maximum water uptake (47.00 ml) was recorded by T_2 (Sucrose 10% + 8- HQC 200 ppm) which was statistically on par with T_4 (Sucrose 20% + 8- HQC 200 ppm). T_7 (Control) recorded the minimum water uptake (34.33 ml) which was statistically on par with T_1 (Sucrose 10% + 8- HQC 100 ppm), T_3(Sucrose 20% + 8- HQC 100ppm),T_5 (Sucrose 10%) and T_6 (Sucrose 20%) .

4.5.1.8. Vase life

4.5.1.8.1 Oscar

Pulsing treatments exerted significant influence on vase life in this variety (Table 10a and Fig 24). T_4 (Sucrose 20% + 8- HQC 200 ppm) recorded the maximum vase life (6 days) which was statistically on par with T_2 (Sucrose 10% + 8- HQC 200 ppm). The minimum vase life (5 days) was recorded by T_1 (Sucrose 10% + 8- HQC 100 ppm), T_3(Sucrose 20% + 8- HQC 100ppm), T_5 (Sucrose 10%), T_6 (Sucrose 20%) and T_7 (Control).

4.5.1.8.2. Summer Sunshine

The influence of pulsing treatments on vase life was significant in this variety (Table 10b and Fig 26). T_4 (Sucrose 20% + 8- HQC 200 ppm) recorded the maximum vase life (8 days) and the minimum (6 days) by T_7 (Control).

4.5.1.8.3. White prosperity

Vase life in this variety was significantly influenced by pulsing treatments (Table 10c and Fig 28). T_4 (Sucrose 20% + 8- HQC 200 ppm) recorded the maximum vase life (6 days). The minimum vase life (4 days) was recorded by T_1 (Sucrose 10% + 8- HQC 100 ppm), T_3 (Sucrose 20% + 8- HQC 100ppm), T_5 (Sucrose 10%), T_6 (Sucrose 20%) and T_7 (Control).

4.5.2. Holding

The data pertaining to investigations on holding treatments are presented in Table 11a to Table 11c.

4.5.2.1. Percentage of fully opened florets

4.5.2.1.1 Oscar

Holding treatments exerted significant influence on percentage of fully opened florets in this variety (Table 11a). T_2 (Sucrose 5% + $AgNO_3$ 50 ppm) recorded the maximum percentage of fully opened florets (70.00%). The minimum percentage (30.00%) was recorded by T_8(Control).

4.5.2.1.2. Summer Sunshine

Percentage of fully opened florets was significantly influenced by holding treatments in this variety (Table 11b and Fig 31). The maximum percentage (66.67 %) was observed in T_1 (Sucrose 5% + $AgNO_3$ 25 ppm) and T_2 (Sucrose 5% + $AgNO_3$ 50 ppm). T_8 (Control) recorded the minimum percentage (33.33 %).

Table 11a. Effect of different holding treatments on the vase characters in gladiolus cv. Oscar

Treatments	Percentage of fully opened florets	Percentage of partially opened florets ++	Percentage of unopened florets	Longevity of individual florets (days)	Number of florets opened at a time +	Nature of bending		Water uptake (ml)	Vase life (days)
						From which day in vase +	From which floret +		
Sucrose 5% + $AgNO_3$ 25 ppm	60.00^{b}	20.00	20.00^{d}	2.17^{a}	3.00	7.00	8.00	37.83^{b}	6.33^{a}
Sucrose 5% + $AgNO_3$ 50 ppm	70.00^{a}	20.00	10.00^{e}	2.29^{a}	3.00	7.00	8.00	41.93^{a}	7.00^{a}
Sucrose5% + BA 50 ppm	40.00^{d}	20.00	40.00^{b}	2.00^{b}	2.00	6.00	6.00	30.67^{cd}	6.00^{b}
Sucrose 5% + BA 100 ppm	53.33^{c}	20.00	26.67^{c}	2.00^{b}	2.00	6.00	6.00	32.67^{cd}	6.00^{b}
Sucrose 5% + GA 50 ppm	40.00^{d}	20.00	40.00^{b}	2.00^{b}	2.00	6.00	6.00	29.70^{d}	6.00^{b}
Sucrose 5% + GA 100 ppm	40.00^{d}	20.00	40.00^{b}	2.00^{b}	2.00	6.00	6.00	33.80^{c}	6.00^{b}
Sucrose 5%	36.37^{e}	20.00	43.33^{b}	1.89^{b}	2.00	6.00	6.00	37.23^{b}	5.67^{b}
Control	30.00^{f}	20.00	50.00^{a}	1.67^{c}	2.00	5.33	5.00	26.10^{e}	5.00^{c}

Treatment means having similar alphabets in superscript, do not differ significantly

\+ Not statistically different ++ No statistical analysis done

Fig 29. Effect of holding treatments on longevity of individual florets (days) in gladiolus cv. Oscar

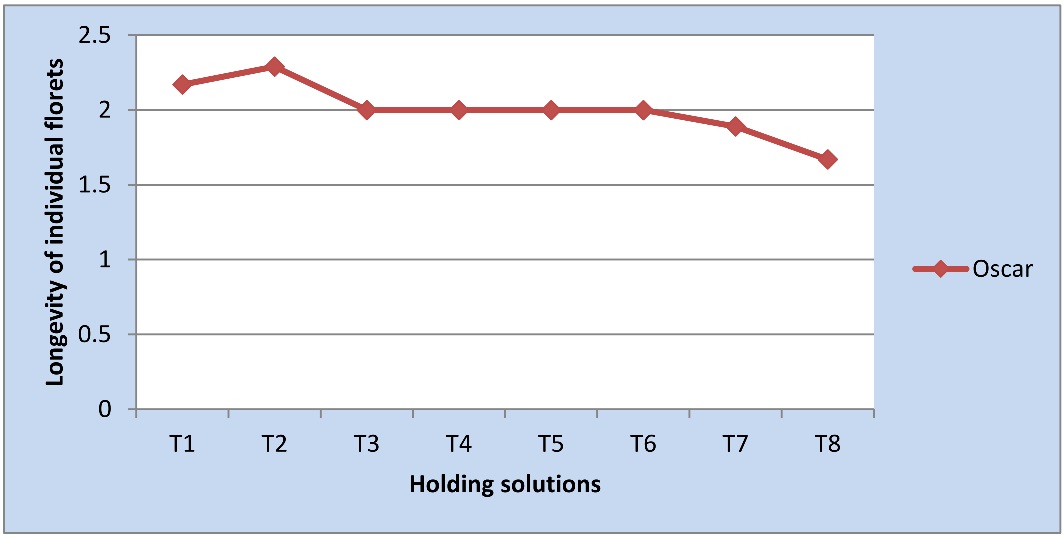
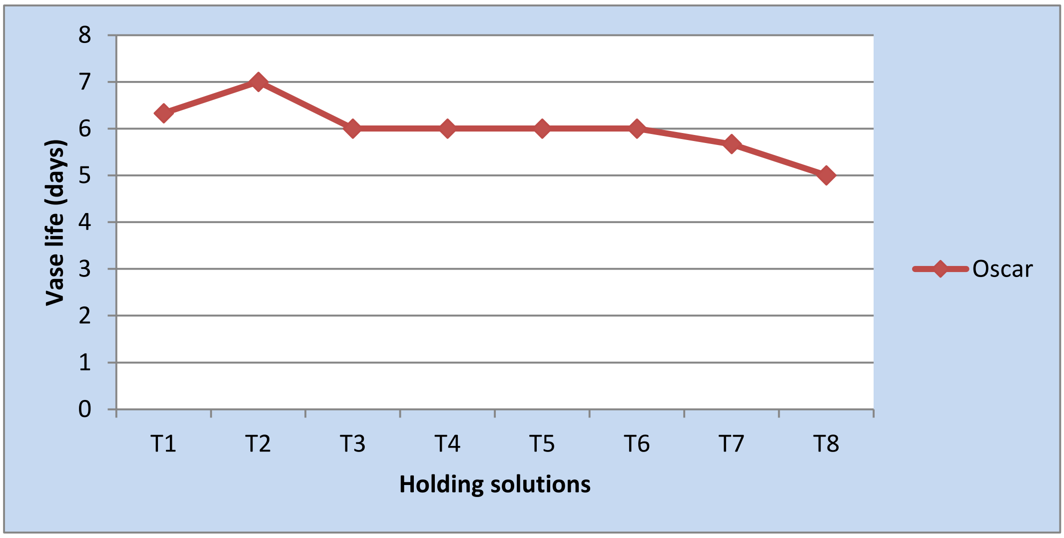


Fig 30. Effect of holding treatments on vase life (days) in gladiolus cv. Oscar



T_1 - Sucrose 5% + $AgNO_3$ 25 ppm,	**T_2** - Sucrose 5% + $AgNO_3$ 50 ppm
T_3 - Sucrose5% + BA 50 ppm,	**T_4** - Sucrose 5% + BA 100 ppm
T_5 - Sucrose 5% + GA 50 ppm,	**T_6** - Sucrose 5% + GA 100 ppm,
T_7 - Sucrose 5%,	**T_8** - Control

4.5.2.1.3. White prosperity

Holding treatments significantly influenced the percentage of fully opened florets in this variety (Table 11c). T_1 (Sucrose 5% + $AgNO_3$ 25 ppm) and T_2 (Sucrose 5% + $AgNO_3$ 50 ppm) recorded the maximum percentage of fully opened florets (62.50 %). The minimum percentage (37.50 %) was recorded by T_8 (Control).

4.5.2.2. Percentage of partially opened florets

4.5.2.2.1 Oscar

The influence of holding treatments on percentage of partially opened florets was not significant in this variety (Table 11a).

4.5.2.2.2. Summer Sunshine

Percentage of partially opened florets was significantly influenced by holding treatments in this variety (Table 11b). The maximum percentage (33.33 %) was observed in T_2 (Sucrose 5% + $AgNO_3$ 50 ppm). T_1 (Sucrose 5% + $AgNO_3$ 25 ppm) T_3(Sucrose 5% + BA 50 ppm), T_5 (Sucrose 5% + GA 50 ppm), T_6 (Sucrose 5% + GA 100 ppm), T_7 (Sucrose 5%) and T_8 (Control) recorded the minimum percentage (22.22 %).

4.5.2.2.3. White prosperity

Holding treatments had no significant influence on percentage of partially opened florets in this variety (Table 11c).

4.5.2.3. Percentage of unopened florets

4.5.2.3.1. Oscar

Holding treatments exerted significant influence on percentage of unopened florets in this variety (Table 11a). T_8 (Control) recorded the maximum percentage of unopened florets (50.00%). The minimum percentage (10.00%) was recorded by T_2 (Sucrose 5% + $AgNO_3$ 50 ppm).

4.5.2.3.2. Summer Sunshine

Percentage of unopened florets was significantly influenced by holding treatments in this variety (Table 11b). The maximum percentage (44.44 %) in T_8 (Control). T_2 (Sucrose 5% + $AgNO_3$ 50 ppm) recorded the minimum percentage (0 %).

4.5.2.3.3. White prosperity

Holding treatments had significant influence on percentage of unopened florets in this variety (Table 11c). The maximum percentage (50.00 %) was recorded by T_8 (Control). T_1 (Sucrose 5% + $AgNO_3$ 25 ppm) and T_2 (Sucrose 5% + $AgNO_3$ 50 ppm) recorded the minimum percentage of unopened florets (12.50 %).

4.5.2.4. Longevity of individual florets

4.5.2.4.1. Oscar

Holding treatments exerted significant influence on longevity of individual florets in this variety (Table 11a and Fig 29). Longevity of individual florets was maximum (2.29 days) in T_2 (Sucrose 5% + $AgNO_3$ 50 ppm) which was statistically on par with T_1 (Sucrose 5% + $AgNO_3$ 25 ppm). T_8 (Control) recorded the minimum longevity of individual florets (1.67 days)

4.5.2.4.2. Summer Sunshine

Longevity of individual florets in this variety was not significantly influenced by holding treatments (Table 11b).

4.5.2.4.3. White prosperity

Holding treatments significantly influenced longevity of individual florets in this variety (Table 11c). Longevity of individual florets was maximum (2.33 days) in T_2 (Sucrose 5% + $AgNO_3$ 50 ppm) which was statistically on par with T_1

Table 11 b. Effect of different holding treatments on the vase characters in gladiolus cv. Summer Sunshine

Treatments	Percentage of fully opened florets	Percentage of partially opened florets	Percentage of unopened florets	Longevity of individual florets (days) +	Number of florets opened at a time +	Nature of bending		Water uptake (ml)	Vase life (days)
						From which day in vase +	From which floret +		
Sucrose 5% + $AgNO_3$25 ppm	66.67[a]	22.22[c]	11.11[d]	3.67	4.00	7.00	7.00	72.83[b]	8.33[b]
Sucrose 5% + $AgNO_3$ 50 ppm	66.67[a]	33.33[a]	0[e]	3.83	5.00	7.00	8.00	75.30[a]	9[a]
Sucrose5% + BA 50 ppm	44.44[c]	22.22[c]	33.33[b]	3.50	3.00	5.00	6.00	65.93[c]	7[d]
Sucrose 5% + BA 100 ppm	55.56[b]	25.92[b]	18.52[c]	3.60	3.00	6.00	6.00	64.13[c]	7.67[c]
Sucrose 5% + GA 50 ppm	37.03[d]	22.22[c]	40.74[a]	3.50	3.00	5.00	6.00	47.53[d]	7[d]
Sucrose 5% + GA 100 ppm	37.03[d]	22.22[c]	40.74[a]	3.50	3.00	5.00	6.00	47.66[d]	7[d]
Sucrose 5%	37.03[d]	22.22[c]	40.74[a]	3.50	3.00	5.00	6.00	46.67[d]	7[d]
Control	33.33[d]	22.22[c]	44.44[a]	3.33	3.00	5.00	6.00	42.73[e]	6[e]

Treatment means having similar alphabets in superscript, do not differ significantly

\+ Not statistically different

Fig 31. Effect of holding treatments on fully opened florets (%) in gladiolus cv. Summer Sunshine

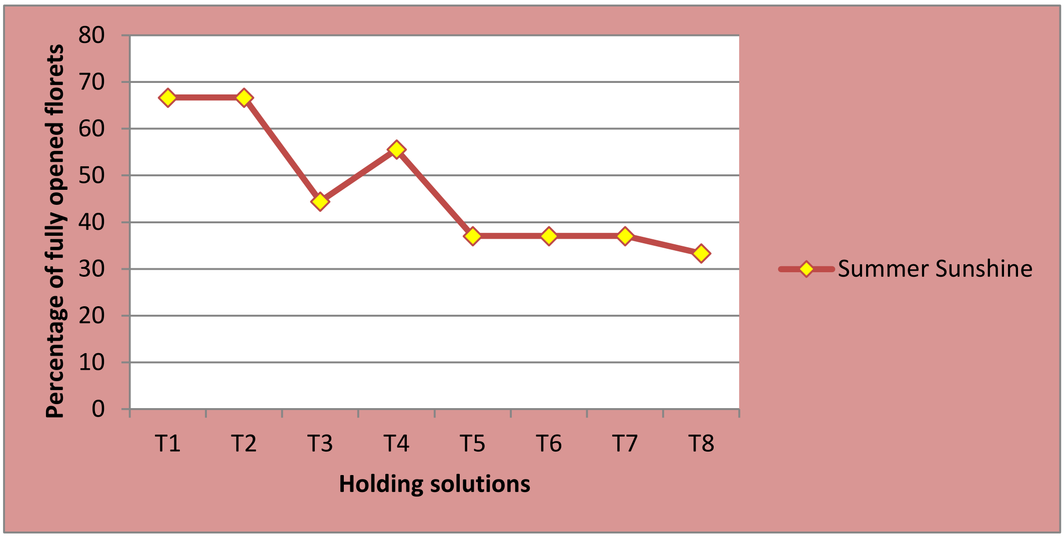
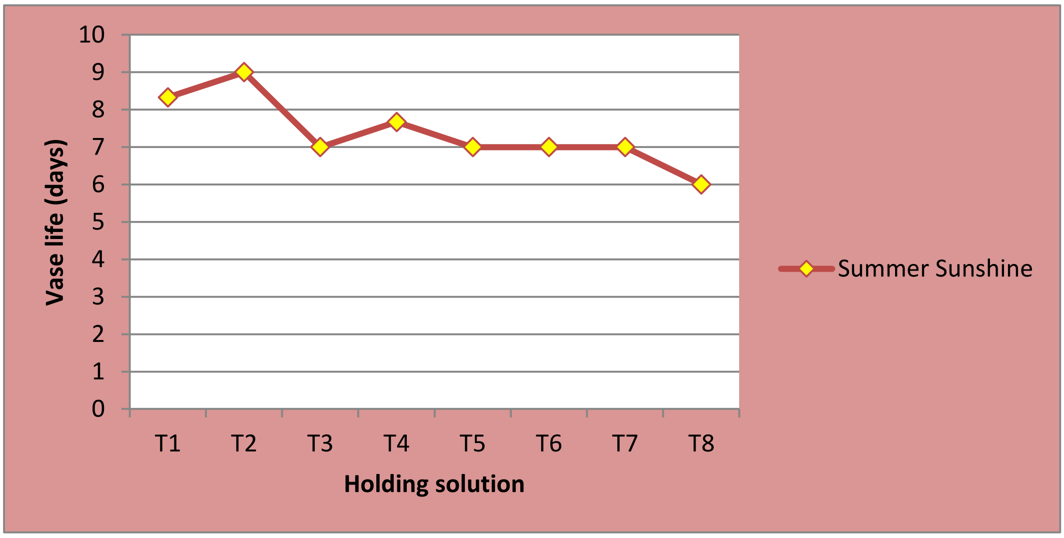


Fig 32. Effect of holding treatments on vase life (days) in gladiolus cv. Summer Sunshine



T_1 - Sucrose 5% + $AgNO_3$ 25 ppm, **T_2** - Sucrose 5% + $AgNO_3$ 50 ppm

T_3 - Sucrose5% + BA 50 ppm, **T_4** - Sucrose 5% + BA 100 ppm

T_5 - Sucrose 5% + GA 50 ppm, **T_6** - Sucrose 5% + GA 100 ppm,

T_7 - Sucrose 5%, **T_8** - Control

(Sucrose 5% + $AgNO_3$ 25 ppm). T_8 (Control) recorded the minimum longevity of individual florets (1.75 days)

4.5.2.5. Number of florets opened at a time

The influence of holding treatments was insignificant in all the varieties, with respect to number of florets opened at a time (Table 11a, Table 11b and Table 11c).

4.5.2.6. Nature of bending

Nature of bending was not significantly influenced by holding treatments, in all the varieties (Table 11a, Table 11b and Table 11c).

4.5.2.7. Water uptake

4.4.2.7.1. Oscar

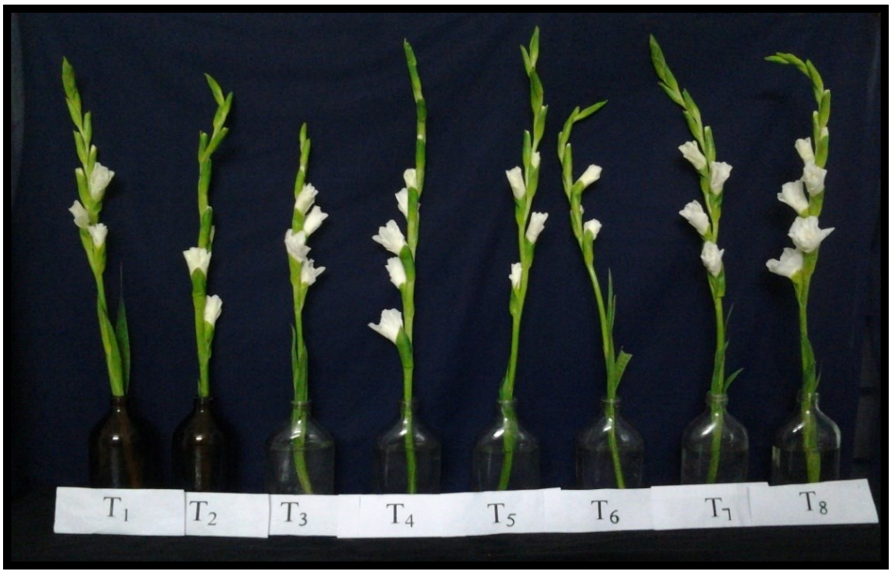
Holding treatments significantly influenced water uptake in this variety (Table 11a). Maximum water uptake (41.93 ml) was recorded by spikes held in T_2 (Sucrose 5% + $AgNO_3$ 50 ppm) and the minimum (26.10 ml) in control.

4.5.2.7.2. Summer Sunshine

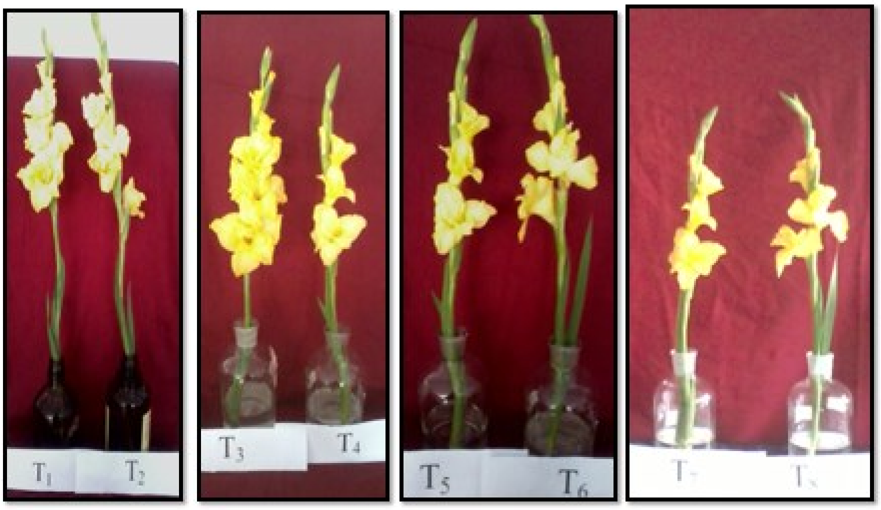
Holding treatments had significant influence on water uptake by spikes of this variety (Table 11b). T_2 (Sucrose 5% + $AgNO_3$ 50 ppm) recorded maximum water uptake (75.30 ml) and the minimum (42.73 ml) was recorded in T_8 (Control).

4.5.2.7.3. White prosperity

Holding treatments significantly influenced the water uptake in this variety (Table 11c and Fig 33). Water uptake recorded was maximum (47.03 ml) in T_2 (Sucrose 5% + $AgNO_3$ 50 ppm). T_8 (Control) recorded the minimum water uptake (27.73 ml) which was statistically on par with T_7 (Sucrose 5 %).



White Prosperity



Summer Sunshine

Plate7. Spikes of gladiolus varieties kept in holding solutions

Table 11 c. Effect of different holding treatments on the vase characters in gladiolus cv. White Prosperity

Treatments	Percentage of fully opened florets	Percentage of partially opened florets +	Percentage of unopened florets	Longevity of individual florets (days)	Number of florets opened at a time +	Nature of bending		Water uptake (ml)	Vase life (days)
						From which day in vase +	From which floret +		
Sucrose 5% + $AgNO_3$ 25 ppm	62.50[a]	25.00	12.50[c]	2.27[a]	5.00	7.00	7.00	40.20[b]	6.67[a]
Sucrose 5% + $AgNO_3$ 50 ppm	62.50[a]	25.00	12.50[c]	2.33[a]	5.00	7.00	7.00	47.03[a]	7.00[a]
Sucrose5% + BA 50 ppm	50.00[b]	25.00	25.00[b]	2.00[c]	4.00	4.00	5.00	34.30[cd]	5.00[c]
Sucrose 5% + BA 100 ppm	50.00[b]	25.00	25.00[b]	2.17[b]	4.00	5.00	6.00	36.13[c]	6.00[b]
Sucrose 5% + GA 50 ppm	50.00[b]	25.00	25.00[b]	2.00[c]	4.00	5.00	5.00	31.67[d]	5.00[c]
Sucrose 5% + GA 100 ppm	50.00[b]	25.00	25.00[b]	2.00[c]	4.00	5.00	5.00	32.23[d]	5.00[c]
Sucrose 5%	50.00[b]	25.00	25.00[b]	2.00[c]	4.00	5.00	5.00	29.37[e]	5.00[c]
Control	37.50[c]	12.50	50.00[a]	1.75[d]	3.00	3.00	4.00	27.73[e]	4.00[d]

Treatment means having similar alphabets in superscript, do not differ significantly

\+ Not statistically different

Fig 33. Effect of holding treatments on water uptake (ml) in gladiolus cv. White prosperity

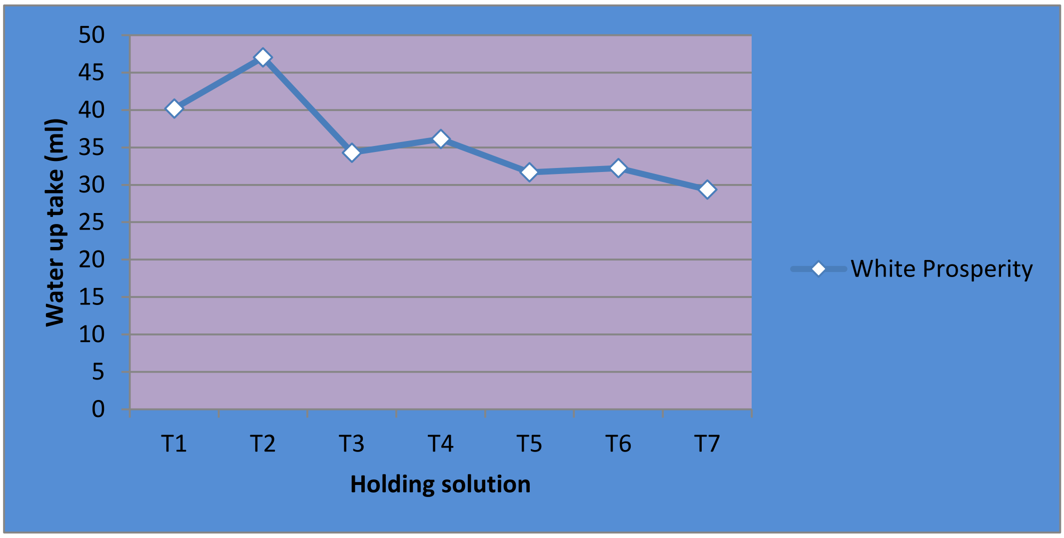
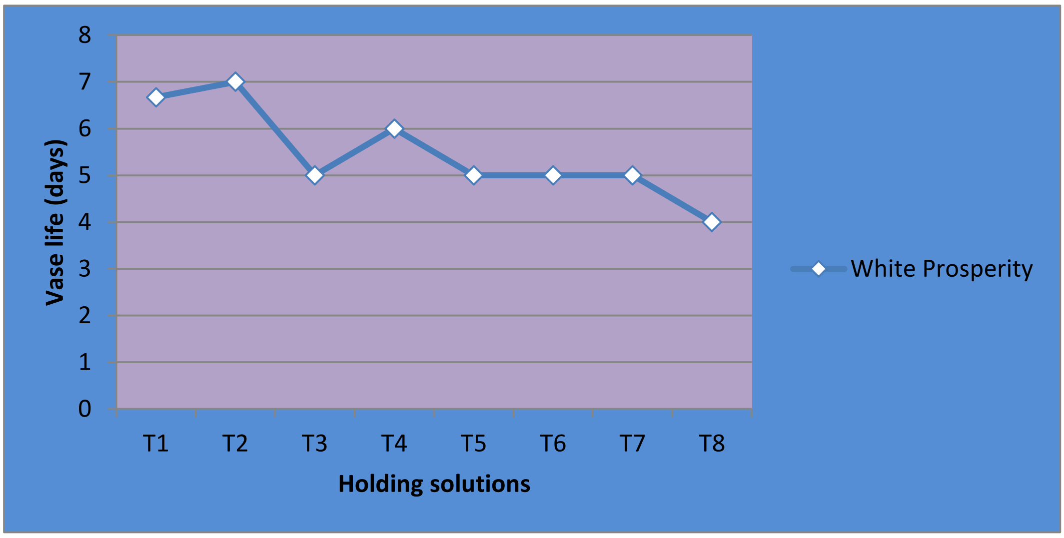


Fig 34. Effect of holding treatments on vase life (days) in gladiolus cv. White prosperity



T_1 - Sucrose 5% + $AgNO_3$ 25 ppm, **T_2** - Sucrose 5% + $AgNO_3$ 50 ppm

T_3 - Sucrose5% + BA 50 ppm, **T_4** - Sucrose 5% + BA 100 ppm

T_5 - Sucrose 5% + GA 50 ppm, **T_6** - Sucrose 5% + GA 100 ppm,

T_7 - Sucrose 5%, **T_8** - Control

4.5.2.8. Vase life

4.5.2.8.1. Oscar

Vase life was significantly influenced by holding treatments in this variety (Table 11a and Fig 30).Vase life was maximum (7.00 days) in T_1 (Sucrose 5% + $AgNO_3$ 25 ppm) and T_2 (Sucrose 5% + $AgNO_3$ 50 ppm). T_8 (Control) recorded the minimum vase life (5.00 days).

4.5.2.8.2. Summer Sunshine

Holding treatments had significant influence on vase life of this variety (Table 11b and Fig 32). T_2 (Sucrose 5% + $AgNO_3$ 50 ppm) recorded maximum vase life of 9 days and the minimum (6 days) was recorded in T_8 (Control).

4.5.2.8.3. White prosperity

Holding treatments significantly influenced the vase life in this variety (Table 11c and Fig 34). Vase life recorded was maximum (7 days). T_8 (Control) recorded the minimum vase life (6 days).

4.5.3. Storage treatments

The results of studies on the effect of storage temperatures on vase characters of gladiolus are presented in Table 12a to 12 c.

4.5.3.1. Percentage of fully opened florets

4.5.3.1.1 Oscar

Storage temperature exerted significant influence on percentage of fully opened florets in this variety (Table 12a and Fig 35). T_1 (8^0C) recorded the maximum percentage of fully opened florets (71.67%). The minimum percentage (63.33 %) was recorded by T_3 (Control) which was statistically on par with T_2 (12^0C).

Table 12a. Effect of storage temperatures on the vase characters in gladiolus cv. Oscar

Treatments	Percentage of fully opened florets	Percentage of partially opened florets	Percentage of unopened florets	Longevity of individual florets (days)	Number of florets opened at a time	Nature of bending		Water uptake (ml)	Vase life (days)
						From which day in vase ++	From which floret ++		
12^0C	68.34^{ab}	20.00^{b}	11.67^{b}	2.40^{b}	3.20^{b}	8.00	8.00	70.80^{b}	8.80^{ab}
8^0C	71.67^{a}	25.00^{a}	3.33^{c}	2.54^{a}	4.00^{a}	8.00	8.00	88.74^{a}	9.00^{a}
Control	63.33^{b}	18.34^{b}	20.00^{a}	2.33^{c}	3.20^{b}	8.00	8.00	60.70^{c}	8.40^{b}

Treatment means having similar alphabets in superscript, do not differ significantly

++ No statistical analysis done

Fig 35. Effect of storage temperatures on fully opened florets (%) in gladiolus cv. Oscar

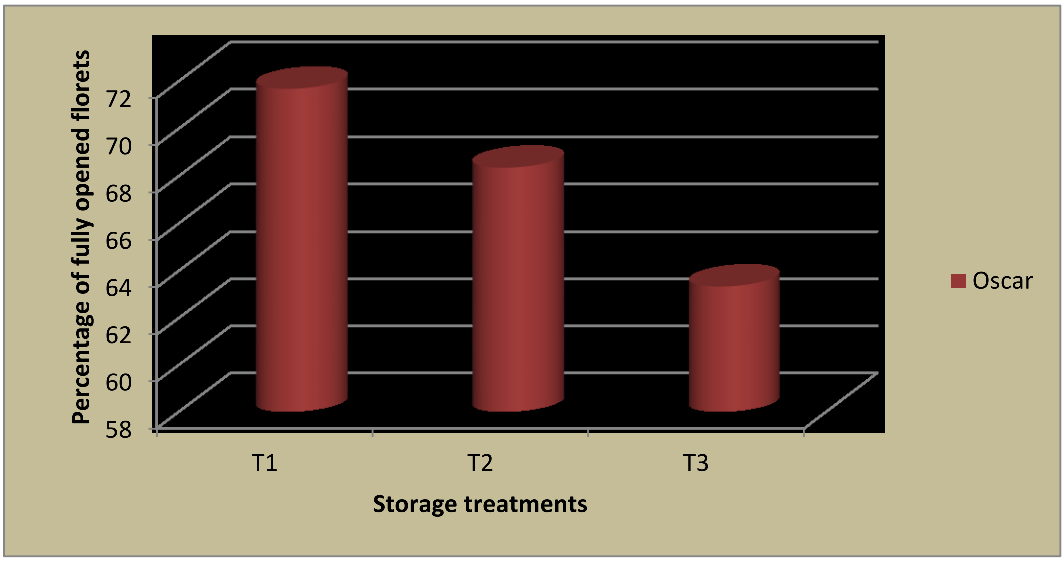
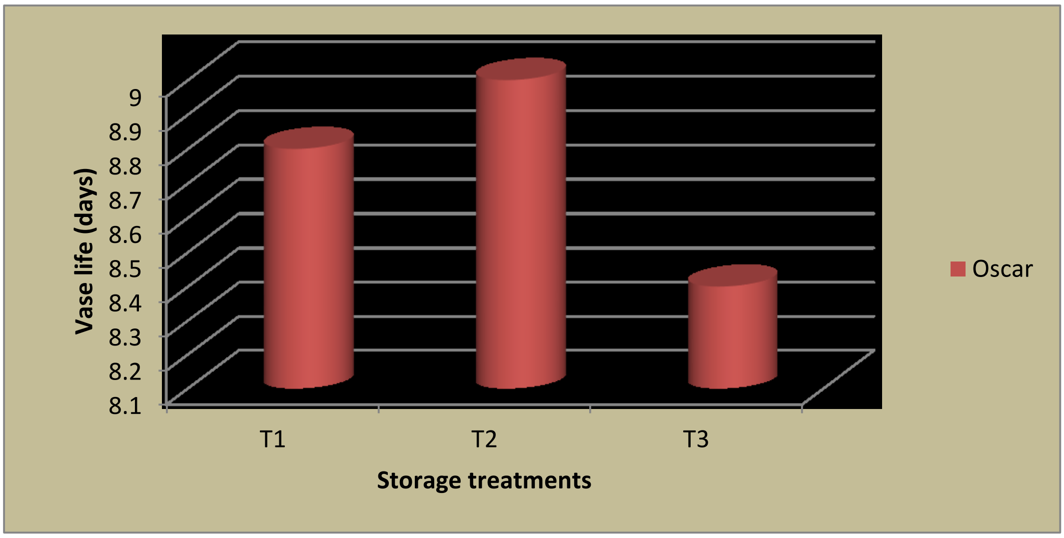


Fig 36. Effect of storage temperatures on vase life (days) in gladiolus cv. Oscar



$\mathbf{T_1}$ - 12^0 C , $\mathbf{T_2}$ - 8^0 C, $\mathbf{T_3}$ - Control

4.5.3.1.2. Summer Sunshine

Percentage of fully opened florets was significantly influenced by storage temperature in this variety (Table 12b). The maximum percentage (75.82 %) was observed in T_1 (8^0C). The minimum (62.86%) was recorded in T_2 (Control)

4.5.3.1.3. White prosperity

Storage temperature significantly influenced the percentage of fully opened florets in this variety (Table 12c). T_1 (8^0C) recorded the maximum percentage of fully opened florets (67.73 %),which was statistically on par with T_2 (12^0C). The minimum percentage (58.33%) was recorded by T_3 (Control).

4.5.3.2. Percentage of partially opened florets

4.5.3.2.1 Oscar

Percentage of partially opened florets was significantly influenced by storage temperature in this variety (Table 12a). The maximum percentage (25.00 %) was observed in T_1 (8^0C). The minimum (18.34%) was recorded in T_3 (Control) which was statistically on par with T_1 (12^0C).

4.5.3.2.2. Summer Sunshine

Storage temperature had no significant influence on percentage of partially opened florets in this variety (Table 12b).

4.5.3.2.3. White prosperity

Percentage of partially opened florets in this variety was not significantly influenced by holding solutions (Table 12c).

4.5.3.3. Percentage of unopened florets

4.5.3.3.1 Oscar

Percentage of unopened florets was significantly influenced by storage temperature in this variety (Table 12a). The maximum percentage (20.00 %) was observed in T_3 (Control). The minimum (3.33%) was recorded in T_2 (12^0C).

4.5.3.3.2. Summer Sunshine

Storage temperature exerted significant influence on percentage of unopened florets in this variety (Table 12b). T_3 (Control) recorded the maximum percentage of unopened florets (22.86 %). The minimum percentage (7.58 %) was recorded by T_1 (8^0C).

4.5.3.3.3. White prosperity

Storage temperature significantly influenced the percentage of unopened florets in this variety (Table 12c). The maximum percentage of unopened florets (23.33%) T_3 (Control), The minimum percentage (8.66 %) was recorded by T_2 (12^0C), which was statistically on par with T_1(8^0C).

4.5.3.4. Longevity of individual florets

4.5.3.4.1 Oscar

Storage temperature exerted significant influence on longevity of individual florets in this variety (Table 12a). T_1 (8^0C) recorded the maximum longevity of

individual florets (2.54 days). The minimum longevity (2.33 days) was recorded by T_3 (Control).

4.5.3.4.2. Summer Sunshine

Longevity of individual florets was significantly influenced by storage temperature in this variety (Table 12b). The maximum longevity of individual

Table 12b. Effect of storage temperatures on the vase characters in gladiolus cv. Summer Sunshine

Treatments	Percentage of fully opened florets	Percentage of partially opened florets	Percentage of unopened florets	Longevity of individual florets (days)	Number of florets opened at a time	Nature of bending		Water uptake (ml)	Vase life (days)
						From which day in vase ++	From which floret +		
12^0C	71.42^b	14.29^a	14.29^b	4.52^b	5^a	10	11	107.86^b	11^a
8^0C	75.82^a	16.59^c	7.58^a	4.61^a	5.2^a	10	11	123.7^a	11.6^a
Control	62.86^c	14.29^a	22.86^a	4.29^c	4^b	10	11	93.06^c	10.2^b

Treatment means having similar alphabets in superscript, do not differ significantly

++ No statistical analysis done

Fig 37. Effect of storage temperatures on water uptake (ml) in gladiolus cv. Summer Sunshine

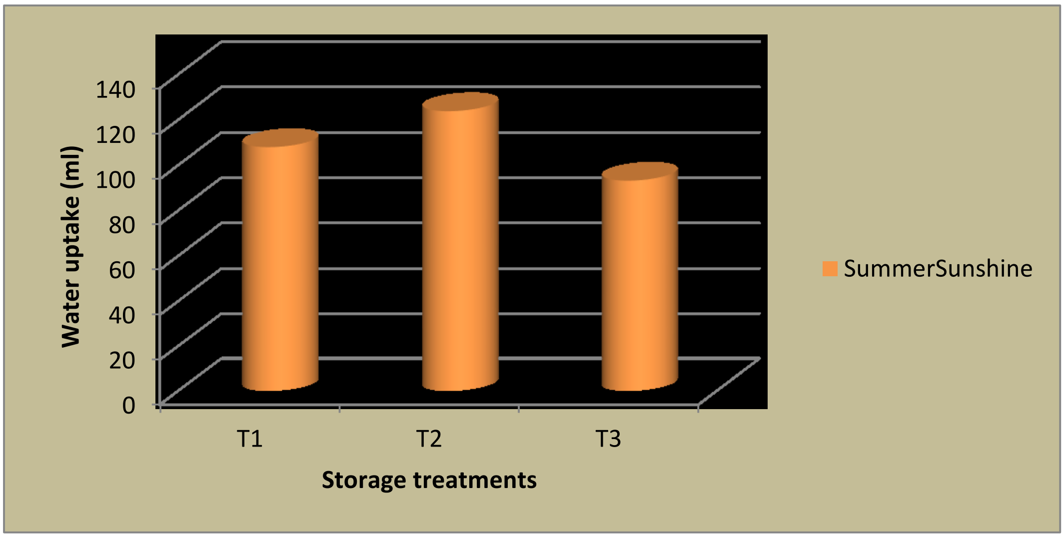
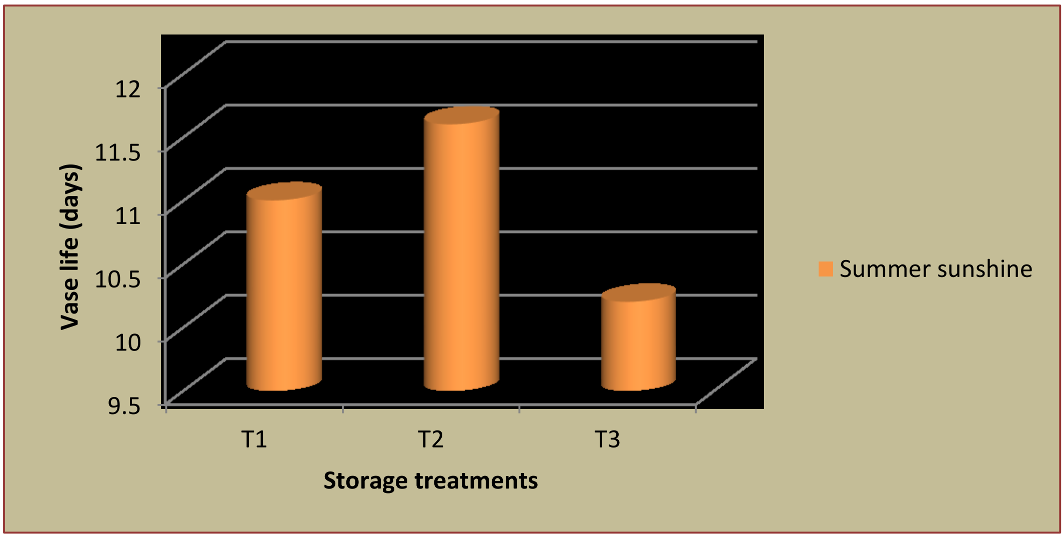


Fig 38. Effect of storage temperatures on vase life (days) in gladiolus cv. Summer Sunshine



$\mathbf{T_1}$ - 12^0 C , $\mathbf{T_2}$ - 8^0 C, $\mathbf{T_3}$ - Control florets (4.61 days) was observed in T_1 (8^0C). The minimum (4.29 days) was recorded in T_3 (Control).

4.5.3.4.3. White prosperity

Storage temperature significantly influenced the longevity of individual florets in this variety (Table 12c and Fig 39). T_1 (8^0C) recorded the maximum longevity of individual florets (2.75 days). The minimum longevity (2.32 days) was recorded by T_3 (Control).

4.5.3.5. Number of florets opened at a time

4.5.3.5.1 Oscar

Storage temperature exerted significant influence on number of florets opened at a time in this variety (Table 12a). T_1 (8^0C) recorded the maximum number of florets opened at a time (4.00). The minimum (3.20) was recorded by T_2 (12^0C) and T_3 (Control) .

4.5.3.5.2. Summer Sunshine

Number of florets opened at a time was significantly influenced by storage temperature in this variety (Table 12b). The maximum number of florets opened at a time (5.2) was observed in T_1 (8^0C) which was statistically on par with T_2 (12^0C). The minimum (4.0) was recorded in T_3 (Control).

4.5.3.5.3. White prosperity

Storage temperature significantly influenced the number of florets opened at a time in this variety (Table 12c). T_1 (8^0C) recorded the maximum number of florets opened at a time (4.6). The minimum (2.4) was recorded by T_3 (Control).

4.5.3.6. Nature of bending

Nature of bending was not significantly influenced by storage temperatures, in all the varieties (Table 12a, Table 12b and Table 12c).

4.5.3.7. Water uptake

4.5.3.7.1 Oscar

Storage temperature exerted significant influence on water uptake in this variety (Table 12a). T_1 (8^0C) recorded the maximum water uptake (88.74 ml) and T_3 (Control) recorded the minimum (60.70 ml).

4.5.3.7.2. Summer Sunshine

Water uptake was significantly influenced by storage temperature in this variety (Table 12b and Fig 37). The maximum water uptake (123.7 ml) was observed in T_1 (8^0C), which was statistically on par with T_2 (12^0C). The minimum (93.06 ml) was recorded in T_3 (Control).

4.5.3.7.3. White prosperity

Storage temperature significantly influenced water uptake in this variety (Table 12c). T_1 (8^0C) recorded the maximum water uptake (67.5 ml). The minimum (44.06 ml) was recorded in T_3 (Control).

4.5.3.8. Vase life

4.5.3.8.1 Oscar

Storage temperature exerted significant influence on vase life in this variety (Table 12a and Fig 36). T_1 (8^0C) recorded the maximum vase life (9.00 days), which was statistically on par with T_2 (12^0C). T_3 (Control) recorded the minimum (8.4 days) vase life, which was also statistically on par with T_2 (12^0C).

4.5.3.8.2. Summer Sunshine

Vase life was significantly influenced by storage temperature in this variety (Table 12b and Fig 38). The maximum vase life (11.6days) was observed in T_1(8^0C) which was statistically on par with T_2 (12^0C). The vase life was minimum (10.2 days) in T_3 (Control).

Table 12c. Effect of storage temperatures on the vase characters in gladiolus cv. White Prosperity

Treatments	Percentage of fully opened florets	Percentage of partially opened florets +	Percentage of unopened florets	Longevity of individual florets (days)	Number of florets opened at a time	Nature of bending		Water uptake (ml)	Vase life (days)
						From which day in vase ++	From which floret ++		
12^0C	65.34[a]	26	8.66[b]	2.55[b]	3.6[b]	6	7	55.98[b]	6.8[b]
8^0C	67.73[a]	21.97	10.30[b]	2.75[a]	4.6[a]	6	7	67.5[a]	7.8[a]
Control	58.33[b]	18.33	23.33[a]	2.32[c]	2.4[c]	6	7	44.06[c]	6[c]

Treatment means having similar alphabets in superscript, do not differ significantly

\+ Not statistically different ++ No statistical analysis done

Fig 39. Effect of storage temperatures on longevity of individual florets (days) in gladiolus cv. White Prosperity

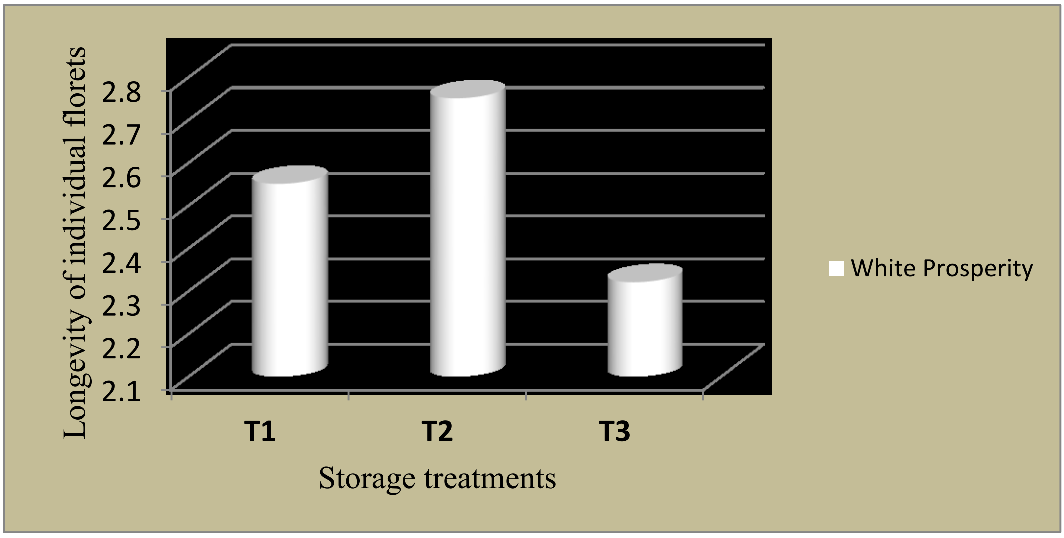
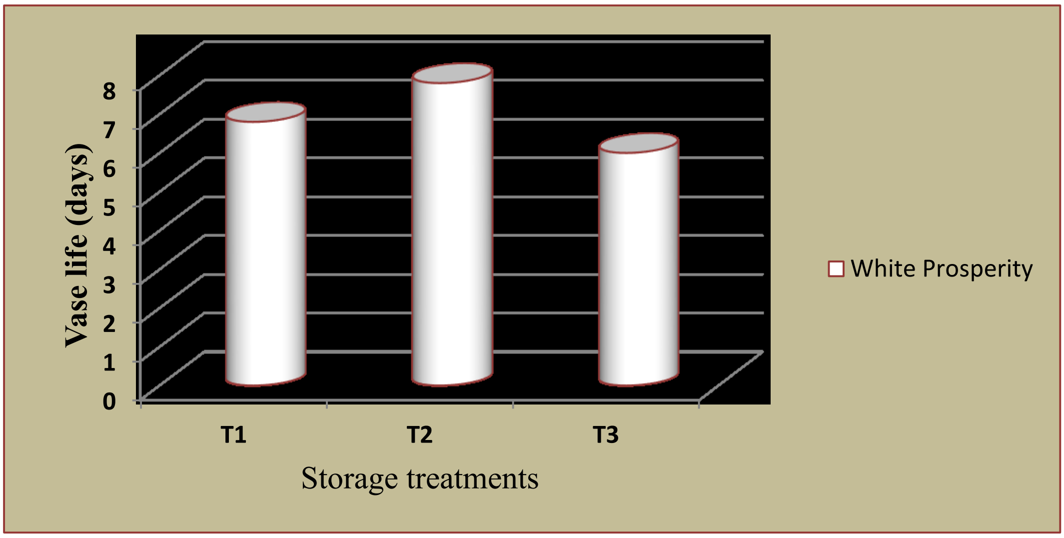


Fig 40. Effect of storage temperatures on vase life (days) in gladiolus cv. White Prosperity



T_1 - 12^0 C , **T_2** - 8^0 C, **T_3** - Control

4.5.3.8.3. White prosperity

Storage temperature significantly influenced vase life in this variety (Table 12c and Fig 40). T_1 (8^0C) recorded the maximum vase life (7.8 days). The minimum vase life (6 days) was recorded in T_3 (Control).

4.5.4. Packing

The results of studies on the effect of different lining materials on the vase characters are presented in Table 13a to Table 13c.

4.5.4.1. Percentage of fully opened florets

4.5.4.1.1 Oscar

Lining materials had significant influence on percentage of fully opened florets in this variety (Table 13a). The maximum percentage (70 %) was recorded by spikes wrapped in T_3 (polypropylene) and T_4 (polythene sheet)) which was statistically on par with T_1 (brown paper) and T_2 (news paper).The minimum (65.91%) was recorded in T_5 (Control).

4.5.4.1.2. Summer Sunshine

Percentage of fully opened florets was significantly influenced by lining materials in this variety (Table 13b). The maximum percentage (72.73 %) was observed in T_3 (polypropylene) which was statistically on par with T_4 (polythene sheet) .T_5 (Control) recorded the minimum percentage (63.64 %) which was statistically on par with T_1 (brown paper) and T_2 (news paper).

4.5.2.1.3. White prosperity

Lining materials significantly influenced the percentage of fully opened florets in this variety (Table 13c). T_3 (polypropylene) recorded the maximum percentage of fully opened florets (67.50 %) which was statistically on par with T_4 (polythene sheet). The minimum percentage (60.63%) was recorded by T_5 (Control)

Table 13a. Effect of different lining materials on the vase characters in gladiolus cv. Oscar

Treatments	Percentage of fully opened florets	Percentage of partially opened florets	Percentage of unopened florets	Longevity of individual florets (days)	Number of florets opened at a time ++	Nature of bending		Water uptake (ml)	Vase life (days)
						From which day in vase ++	From which floret ++		
Brown paper	67.5^{a}	20^{c}	12.5^{ab}	2.29^{c}	3	7	8	60.98^{b}	8^{c}
News paper	67.5^{a}	20^{c}	12.5^{ab}	2.29^{c}	3	7	8	59.68^{b}	8^{c}
Polypropylene sheet	70^{a}	30^{a}	0^{c}	2.54^{a}	3	7	8	66.13^{a}	9^{a}
Polythene sheet	70^{a}	25^{b}	5^{bc}	2.40^{b}	3	7	8	62.75^{ab}	8.5^{b}
Control	65.91^{b}	19.55^{c}	14.55^{a}	2.26^{c}	3	7	8	59.3^{b}	8^{c}

Treatment means having similar alphabets in superscript, do not differ significantly

++ No statistical analysis done

Fig 41. Effect of lining materials on water uptake (ml) in gladiolus cv. Oscar

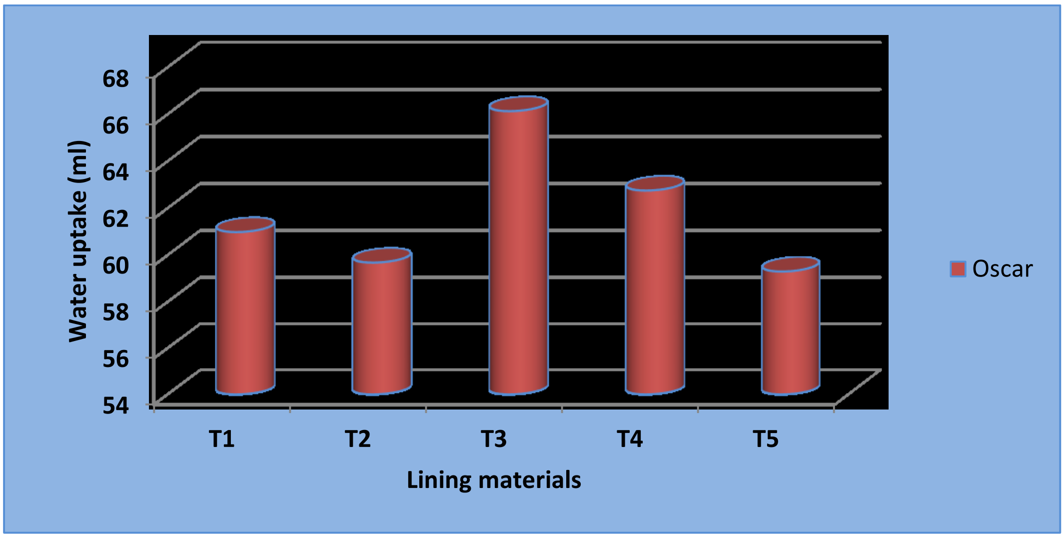
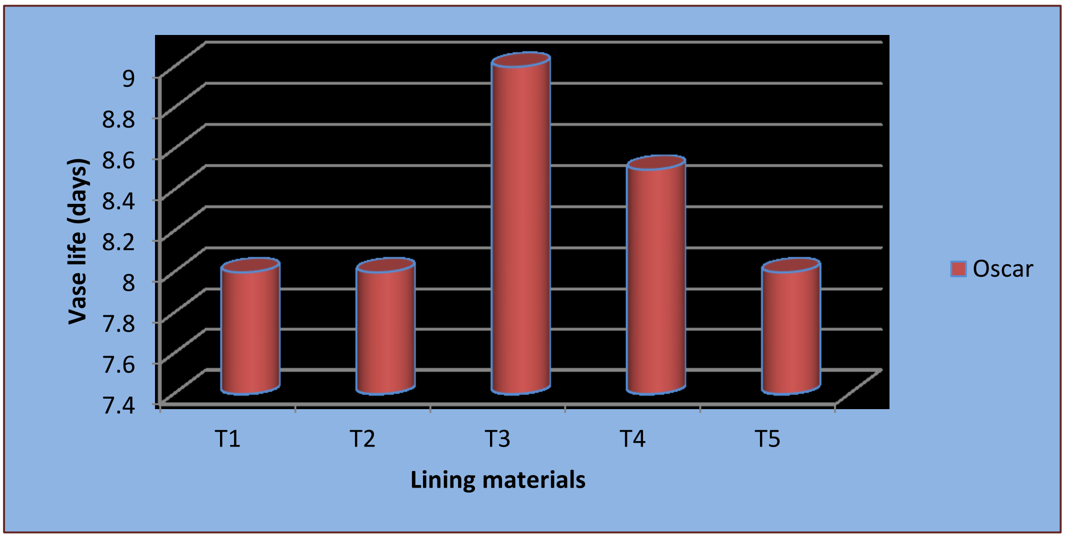


Fig 42. Effect of lining materials on vase life (days) in gladiolus cv. Oscar



T_1 - Brown paper, T_2 - News paper, T_3 - Polypropylene sheet,

T_4 - Polythene sheet, T_5 - Control

4.5.4.2. Percentage of partially opened florets

4.5.4.2.1 Oscar

Lining materials exerted significant influence on percentage of partially opened florets in this variety (Table 13a). T_4 (polythene sheet) recorded the maximum percentage of partially opened florets (30.00%). The minimum percentage (19.55%) was recorded by T_5 (Control).

4.5.4.2.2. Summer Sunshine

Percentage of partially opened florets was not significantly influenced by lining materials in this variety (Table 13b).

4.5.4.2.3. White prosperity

Lining materials had no significant influence the percentage of partially opened florets in this variety (Table 13c).

4.5.4.3. Percentage of unopened florets

4.5.4.3.1 Oscar

Lining materials exerted significant influence on percentage of unopened florets in this variety (Table 13a). T_5 (Control) recorded the maximum percentage of unopened florets (14.55%) which was statistically on par with T_1 (brown paper) and T_2 (news paper). The minimum percentage (0 %) was recorded by T_3 (polypropylene).

4.5.4.3.2. Summer Sunshine

Percentage of unopened florets was significantly influenced by lining materials in this variety (Table 13b). The maximum percentage (18.18 %) was observed in T_1 (brown paper) and T_5 (Control) which was statistically on par with T_2 (news paper) and T_4 (polythene sheet).T_3 (polypropylene) recorded the minimum percentage (6.82 %) which was statistically on par with T_4 (polythene sheet).

Table 13 b. Effect of different lining materials on the vase characters in gladiolus cv. Summer Sunshine

Treatments	Percentage of fully opened florets	Percentage of partially opened florets +	Percentage of unopened florets	Longevity of individual florets (days)	Number of florets opened at a time ++	Nature of bending		Water uptake (ml)	Vase life (days)
						From which day in vase ++	From which floret ++		
Brown paper	63.64[a]	18.18	18.18[a]	3.70[b]	5	8	8	73.63[c]	8.00[c]
News paper	65.23[b]	18.64	16.14[ab]	3.71[b]	5	8	8	73.53[c]	8.00[c]
Polypropylene sheet	72.73[a]	20.45	6.82[b]	3.94[a]	5	8	8	92.88[a]	9.75[a]
Polythene sheet	72.05[a]	18.64	9.32[ab]	3.87[a]	5	8	8	81.93[b]	9[b]
Control	63.64[b]	18.18	18.18[a]	3.68[b]	5	8	8	72.53[c]	7.75[d]

Treatment means having similar alphabets in superscript, do not differ significantly

\+ Not statistically different ++ No statistical analysis done

Fig 43. Effect of lining materials on water uptake (ml) in gladiolus cv. Summer Sunshine

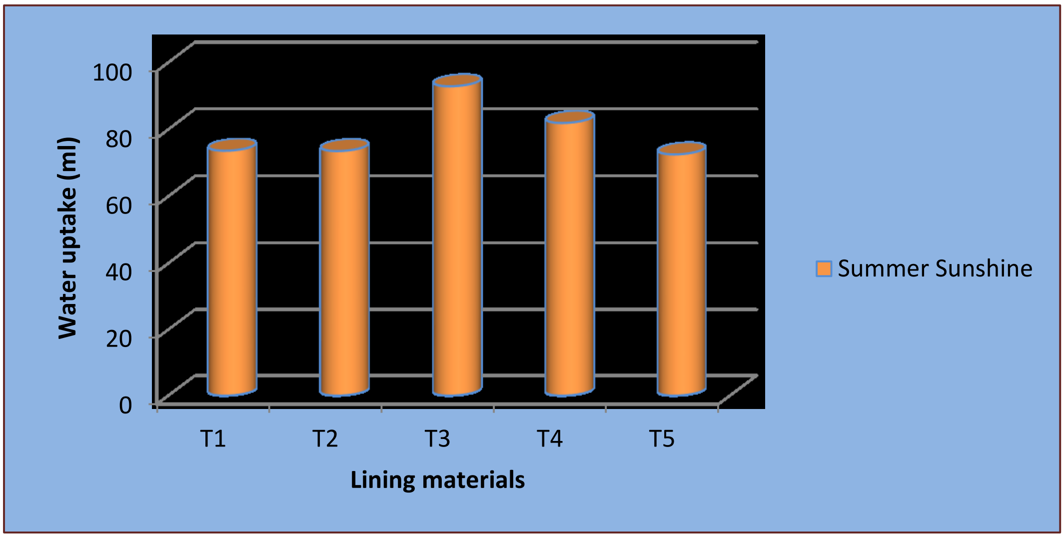
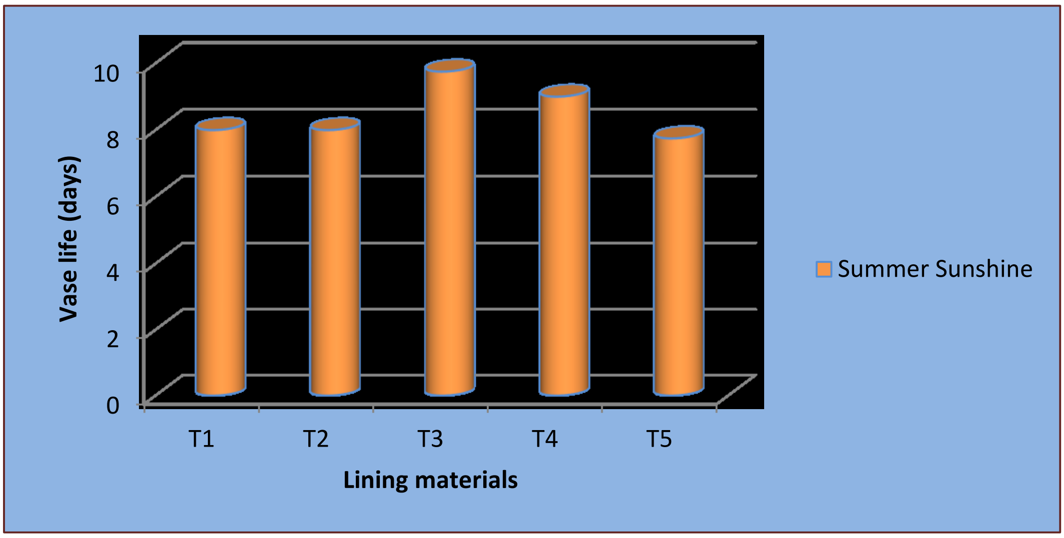


Fig 44. Effect of lining materials on vase life (days) in gladiolus cv. Summer Sunshine



T_1 - Brown paper, **T_2** - News paper, **T_3** - Polypropylene sheet,

T_4 - Polythene sheet, **T_5** - Control

4.5.4.3.3. White prosperity

Lining materials significantly influenced the percentage of unopened florets in this variety (Table 13c). T_5 (Control) recorded the maximum percentage of unopened florets (18.13 %). The minimum percentage (10.83%) was recorded by T_3 (polypropylene) which was statistically on par with T_1 (brown paper), T_2 (news paper) and T_4 (polythene sheet).

4.5.4.4. Longevity of individual florets

4.5.4.4.1 Oscar

Lining materials exerted significant influence on longevity of individual florets in this variety (Table 13a). T_3 (polypropylene) recorded the maximum longevity of individual florets (2.54 days). The minimum longevity (2.26 days) was recorded by T_5 (Control) which was statistically on par with T_1 (brown paper) and T_2 (news paper)..

4.5.4.4.2. Summer Sunshine

Longevity of individual florets was significantly influenced by lining materials in this variety (Table 13b). The maximum longevity (3.94 days) was observed in T_3 (polypropylene), which was statistically on par with T_4 (polythene sheet). T_5 (Control) recorded the minimum longevity (3.87 days) which was statistically on par with T_1 (brown paper) and) T_2 (news paper).

4.5.4.4.3. White prosperity

Lining materials significantly influenced the longevity of individual florets in this variety (Table 13c). T_3 (polypropylene) recorded the maximum longevity of individual florets (2.68 days) which was statistically on par with T_1 (brown paper), T_2 (news paper) and T_4 (polythene sheet).. The minimum percentage (2.45 days) was recorded by T_5 (Control).

Plate 8. Spikes packed in different lining materials

4.5.4.5. Number of florets opened at a time

Number of florets opened at a time was not significantly influenced by lining materials in all the varieties (Table 13a, Table 13b and Table 13c).

6. Nature of bending

The influence of lining materials on nature of bending was insignificant in all the varieties (Table 13a, Table 13b and Table 13c).

4.5.4.7. Water uptake

4.5.4.7.1 Oscar

Lining materials exerted significant influence on water uptake in this variety (Table 13a and Fig 41). T_3 (polypropylene) recorded the maximum water uptake (66.13 ml), which was statistically on par with T_4 (polythene sheet). The minimum water uptake (59.3 ml) was recorded by T_5 (Control) which was statistically on par with T_1 (brown paper), T_2 (news paper) and T_4 (polythene sheet) .

4.5.4.7.2. Summer Sunshine

Water uptake was significantly influenced by lining materials in this variety (Table 13b and Fig 43). The maximum water uptake (92.88 ml) was observed in T_3 (polypropylene), which was statistically on par with T_4 (polythene sheet). T_5 (Control) recorded the minimum (72.53 ml) which was statistically on par with T_1 (brown paper) and T_2 (news paper).

4.5.4.7.3. White prosperity

Lining materials significantly influenced the water uptake in this variety (Table 13c and Fig 45). T_3 (polypropylene) recorded the maximum water uptake (62.87 ml) which was statistically on par with T_1 (brown paper), T_2 (news paper) and T_4 (polythene sheet). The minimum (50.28 ml) was recorded by T_5 (Control).

Table 13c. Effect of different lining materials on the vase characters in gladiolus cv. White prosperity

Treatments	Percentage of fully opened florets	Percentage of partially opened florets +	Percentage of unopened florets	Longevity of individual florets (days)	Number of florets opened at a time +	Nature of bending		Water uptake (ml)	Vase life (days)
						From which day in vase ++	From which floret ++		
Brown paper	64.58^{b}	23.61	11.81^{b}	2.64^{a}	3.25	6	7	57.90^{ab}	7.00^{b}
News paper	61.25^{c}	25.00	13.75^{b}	2.63^{a}	3	6	7	57.65^{ab}	7.00^{b}
Polypropylene sheet	67.50^{a}	21.67	10.83^{b}	2.68^{a}	3.25	6	7	62.87^{a}	8.00^{a}
Polythene sheet	66.67^{ab}	22.22	11.11^{b}	2.67^{a}	3	6	7	61.08^{a}	7.00^{b}
Control	60.63^{c}	21.25	18.13^{a}	2.45^{b}	3.25	6	7	50.28^{b}	6.25^{c}

Treatment means having similar alphabets in superscript, do not differ significantly

\+ Not statistically different ++ No statistical analysis done

Fig 45. Effect of lining materials on water uptake (ml) in gladiolus cv. White prosperity

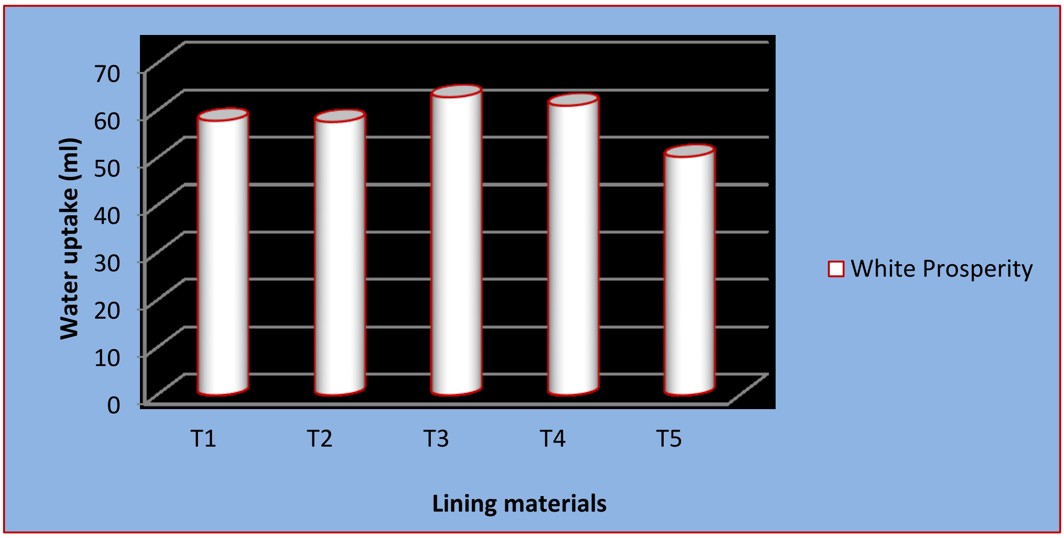
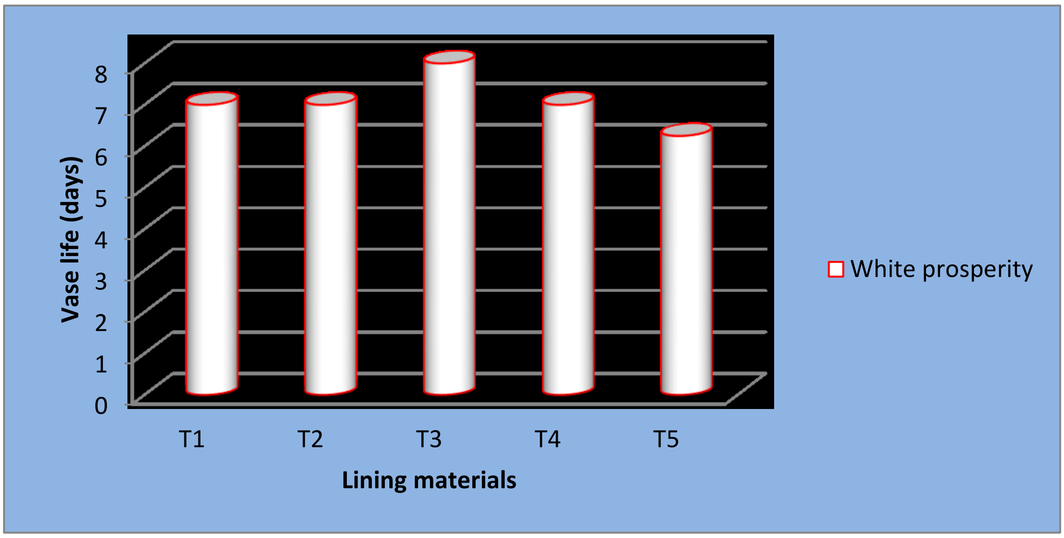


Fig 46. Effect of lining materials on vase life (days) in gladiolus cv. White prosperity



T_1 - Brown paper, **T_2** - News paper, **T_3** - Polypropylene sheet,

T_4 - Polythene sheet, **T_5** - Control

4.5.4.8. Vase life

4.5.4.8.1 Oscar

Lining materials exerted significant influence on vase life in this variety (Table 13a and Fig 42). T_3 (polypropylene) recorded the maximum vase life (9.00 days). The minimum vase life (8.00 days) was recorded by T_5 (Control) which was statistically on par with T_1 (brown paper) and T_2 (news paper).

4.5.4.8.2. Summer Sunshine

Vase life was significantly influenced by lining materials in this variety (Table 13b and Fig 44). Vase life was maximum (9.75 days) in T_3 (polypropylene) and minimum (7.75 days) in T_5 (Control).

4.5.4.8.3. White prosperity

Lining materials significantly influenced the vase life in this variety (Table 13c and Fig 46). Maximum vase life (8.00 days) was observed in T_3 (polypropylene). The minimum (6.25 days) was recorded by T_5 (Control).

Discussion

5. DISCUSSION

Gladiolus is the queen of bulbous flowers and is one of the most popular cut flower grown throughout the world. Intense rain fall and high relative humidity during monsoon and slightly high temperature during summer hinder the commercial production of gladiolus under Kerala conditions. Traditional cultivation practices do not provide any opportunity for environmental control. Rain shelter cultivation facilitates quality improvement and productivity enhancement, which help to compete in the global market.

Gladiolus is very rich in its varietal wealth and every year there is an addition of new varieties; hence varietal evaluation becomes necessary to find out suitable variety for a particular region. Hence there is a need to evaluate some of the promising varieties of gladiolus with extended vase life, so that suitable varieties could be recommended for cultivation in Kerala.

In cut flower industry, the most important aspect is post harvest handling in order to maintain flower freshness and original colour of the flower for longer period after harvest. Gladiolus flower spikes usually last for 7-8 days in tap water (Singh and Sharma, 2003; Singh *et al*., 2008). Lack of proper storage facilities, improper handling, long distance transport and microbial spoilage owing to high temperatures etc are the factors pre-disposing the flowers to damage. Hence the investigations to standardize the post harvest treatments to improve the spike qualities are very relevant.

The present study was conducted to compare the performance of gladiolus varieties under open and rain shelter (open ventilated polyhouse) conditions and to standardize the post harvest treatments to improve the spike qualities of gladiolus. The results generated from the studies are discussed hereunder.

5.1. Effect of growing conditions and variety on performance of gladiolus

5.1.1. Plant characters

5.1.1.1. Plant height

When gladiolus is grown for cut flower trade, it should have vigorous vegetative growth, which in turn is reflected through the plant height, number of leaves and leaf area. All these vegetative traits are genetically controlled and sometimes express differently depending on the growing environment (Bichoo *et al.,* 2002). The varietal difference can be attributed to the genetic makeup of the varieties (Hemalata *et al*., 1992).

Growing conditions exerted significant influence on plant height of all the varieties under study, during both the seasons (Table 1a and 1b). The plants showed better plant height in rain shelter than in open field from two weeks after planting itself up to eight weeks after planting. The light intensity available inside the rain shelter, observed in the present study ranged between 52-72 per cent. Optimum light intensity in combination with warmer environment and higher relative humidity inside the rain shelter might have helped in good vegetative growth inside the rainshelter. Differential response of gladiolus with respect to plant height in different growing conditions was also observed by Rama *et al.*, 2000; Sivasamy and Dadlani, 2002; Sarkar and Maitra, 2005; Saud *et al*., 2005; Islam and Haque, 2011; Kirtimala *et al,* 2011. Dadlani *et al* (1990) reported that there was 19 per cent increase in plant height for plants grown under plastic green house.

Summer Sunshine maintained a better plant height, both in rain shelter and open field starting from two weeks after planting itself stretched towards eight weeks after planting, during both seasons. Several scientists have conducted evaluation works on gladiolus varieties and reported varietal difference with regard to plant height (Ravidas, 1990; Rai *et al.*, 2000; Rao *et al.*, 2000;

Seetharamu *et al*., 2003; Swaroop and Singh, 2007; Gawali *et al*., 2012; Susila, 2013).

5.1.1.2. Number of leaves

Of all the vegetative characters, the number and size of leaves are the prominent factors that influence the growth and yield of a crop. During the first season, the response of the three varieties to different growing conditions with respect to the number of leaves, were significant at two weeks after planting, four weeks after planting and six weeks after planting. The growing conditions had no significant influence on number of leaves, at eight weeks after planting for all the three varieties. During the second season, growing conditions had significant effect on number of leaves, for all the three varieties under consideration, both at six weeks after planting and eight weeks after planting. In general more number of leaves was seen in rain shelter for all the varieties. High temperature and high relative humidity inside rain shelter were probably responsible for the increased plant height and number of leaves per plant (Asahira *et al*., 1968; Imanishi *et al*., 1970).

Difference in varietal response for number of leaves in different growing conditions was also observed by Saud *et al*., 2005; Islam and Haque, 2011; Kirtimala *et al,* 2011.

During first season there was no significant difference among varieties with respect to number of leaves. But during second season, there was variation among varieties in number of leaves and maximum number of leaves was observed in Summer Sunshine and Oscar in rain shelter and open field respectively. Differences in number of leaves among varieties were also reported by Kishan *et al*., 2005; Swaroop and Singh, 2007 and Susila, 2013.

5.1.1.3. Length of the leaf

Though the number of leaves is an important factor, its significance will be more pronounced when the size of leaves is also taken into account. This in turn relates to leaf area. Length and breadth of leaves determine the leaf area. It was revealed that the growing conditions had significant influence on leaf length in all the varieties during both the seasons. All the varieties had better leaf length in rain shelter starting from two weeks after planting itself up to eight weeks after planting.

Among the varieties, the maximum leaf length was observed in Summer Sunshine at all stages of growth, both in rain shelter and open field during first season. During second season, leaf length was highest in Summer Sunshine in rainshelter and White prosperity in open field. In general, the varieties varied significantly among themselves in leaf length at all stages of growth during the first as well as second season. Choudhary *et al*., (2011) also compared gladiolus varieties and observed variation in leaf length among varieties.

5.1.1.4. Breadth of the leaf

Growing conditions had significant influence in the leaf breadth of all the varieties during both the seasons. Rain shelter grown plants of all the varieties recorded more leaf breadth compared to open field grown plants.

During the first season the maximum leaf breadth was noticed in Summer Sunshine in rain shelter and the minimum in Oscar. In open field, White prosperity had the highest leaf breadth and the least was recorded in Oscar. During the second season, White prosperity had the highest leaf breadth and Oscar had the lowest, both in rain shelter and open field. Difference in leaf breadth among varieties was also reported by Kumar *et al*, 2011 and Choudhary *et al*., 2011.

5.1.1.5. Leaf area

Leaf area was significantly influenced by growing condition for all the varieties during both the seasons. In general highest leaf area was recorded by all the three varieties in rain shelter, during both the seasons.

The varieties varied significantly among themselves, in their leaf area, from two weeks after planting itself, under both the growing conditions, during both the seasons. Summer Sunshine maintained a better leaf area from two weeks after planting itself, up to eight weeks after planting both in rain shelter and open field, during the first season. During the second season also Summer Sunshine maintained a better leaf area from two weeks after planting itself, up to eight weeks after planting, in rain shelter and White prosperity recorded maximum leaf area from four weeks after planting up to eight weeks after planting, in open field. Ravidas, 1990 and Choudhary *et al*., 2011, also reported variation among varieties with respect to leaf area.

5.1.1.6. Duration from planting to spike emergence

Duration from planting to spike emergence indicates early or late flowering habit. Earliness in spike emergence is beneficial to gladiolus growers as it leads to availability of flowers in the market earlier. It was revealed from this study that spike emergence was earlier in rain shelter than in open field for all the varieties during both the seasons [Oscar (S1- 87.35 days, S2- 73.25 days), Summer Sunshine (S1- 61.90 days, S2- 56.22 days) and White Prosperity (S1- 72.05 days, S2- 62.08 days)]. Optimum light intensity, favourable temperature and moist air inside the rainshelter might have favoured accumulation of more carbohydrate in plants in rain shelter than in open field. This might be the reason for early spike emergence in rain shelter. Malhotra and Kumar (2000) earlier reported that plants come to reproductive phase earlier if they have enough carbohydrate accumulation. According to Sivasamy and Dadlani (2002), greenhouse grown plants showed 20% reduction in time taken for spike emergence and flowering compared to those in the field. Islam and Haque (2011) reported that plants grown under poly tunnel produced flower earlier compared to plants grown without poly tunnel.

Oscar was found to be the latest and Summer Sunshine was the earliest in spike emergence, both in rain shelter and open field, during both the seasons. So it can be concluded that varieties varied significantly among themselves in duration from planting to spike emergence. These results are in conformity with Dadlani *et al*, 1990; Ravidas (1990); Pant *et al* (1998); Rashmi, 2006; Gawali *et al*. (2012); Kumar and Roy (2012); Susila (2013).

5.1.1.7. Duration from spike emergence to opening of floret

Rain shelter grown plants recorded less number of days, from spike emergence to opening during both the seasons. Similar results were reported by Sivasamy and Dadlani (2002) and Islam and Haque (2011).

Duration from spike emergence to opening was found to be the shortest in Oscar and longest in White prosperity, both in rain shelter and open field, during both the seasons. Similar variation in duration from spike emergence to opening are reported by Ravidas (1990); Pant *et al* (1998); Rashmi, 2006; Gawali *et al*. (2012); Kumar and Roy (2012); Susila (2013).

5.1.1.8. Time taken for flowering

The time taken from planting to flowering was significantly influenced by growing condition in all the varieties during both the seasons. Rain shelter grown plants showed significant reduction in the time taken for flowering compared to open field, for all the varieties, during both the seasons [Oscar (S1- 94.63 days, S2- 79.85 days), Summer Sunshine (S1- 69.98 days, S2- 62.95 days) and White Prosperity (S1- 80.58 days, S2- 69.75 days)]. Similar results were observed by Sivasamy and Dadlani (2002) and Islam and Haque (2011).

The maximum and minimum time for flowering are observed in Oscar and Summer Sunshine respectively, both in rain shelter and open field, during both the seasons. So it is revealed that there was differential response of varieties with respect to time taken from planting to flowering. Ravidas, 1990; Pant *et al*, 1998 and Susila, 2013 also reported similar observations.

5.1.1.9. Blooming period

In a gladiolus spike, the florets open in succession. The blooming period varies with the number of florets. From the present investigation it is found that growing condition significantly influenced the blooming period of all the varieties during both seasons. The blooming period is longer in rain shelter than in open field. It may be due to the fact that rain shelter grown spikes are longer and had more number of florets per spike compared to that in open field.

Summer Sunshine exhibited maximum blooming period both in rain shelter and open field, during both the seasons. The minimum blooming period was observed in Oscar both in rain shelter and open field during the first season. During the second season, Oscar and White prosperity recorded the minimum blooming period in rain shelter and open field respectively. The variation in blooming period among the varieties was also reported by Ravidas (1990) and Choudhary *et al* (2011).

5.1.1.10. Total duration

The duration from planting to the end of blooming period gives the total duration. A lesser crop duration is preferred always, as more number of crops could be taken a year. The growing conditions significantly influenced the total duration in all the varieties during both the seasons. In all the varieties, the rain shelter grown plants exhibited shorter duration than plants grown in open field. [Oscar (S1- 102.21 days, S2-89.93 days), Summer Sunshine (S1- 81.65 days, S2-75.98 days), and White prosperity (S1- 90.25 days, S2-81.80 days)] Optimum light intensity, favourable temperature and moist air inside the rain shelter might have favoured accumulation of more carbohydrate in plants in rain shelter than in open field. Malhotra and Kumar (2000) earlier reported that plants come to reproductive phase earlier if it has enough carbohydrate in it. This might be the reason for shorter duration of rain shelter grown plants compared to open field plants.

The varieties significantly varied among themselves in total duration. Oscar recorded the highest total duration, both in rain shelter and open field, during both the seasons. The lowest total duration was observed in Summer Sunshine, both in rain shelter and open field, during both the seasons. Similar variations in total duration among varieties was also reported by Ravidas (1991).

5.1.2. Spike characters

Gladiolus has gained popularity as a cut flower owing to its attractive spikes. Its great size, elegance and large number of florets per spike make it magnificent. Florets of massive size, brilliant colours and excellent keeping quality make it an ideal cut flower. Spike characters are significant in determining the suitability of gladiolus as a cut flower. The long spikes are usually preferred for flower arrangements and decorations to create a bold effect. Longer spikes with more number of large attractive florets are found to fetch premium prices in the market. Florets in a spike open one after another starting from the lower most floret. Thus one particular spike may last for a week or more, depending upon the number of florets per spike and the life of individual florets. This in turn is influenced by genotype and environmental conditions.

The varieties under study exhibited significant variation in spike characters like spike length, spike diameter, rachis length, number of florets per spike, floret size and number of florets opened at a time. Variation in performance among varieties might be due to the difference in their genetical characters (Ponnuswamy *et al*., 1985)

5.1.2.1. Length of the spike

From this study it was revealed that the spike length was significantly influenced by growing condition. All the varieties had better spike length in rain shelter than in open field. The results are in conformity with Sarkar and Maitra (2005). Mohanty *et al*. (2011) reported that availability of optimum light intensity inside poly house will maintain higher chlorophyll content which would produce and maintain higher carbohydrate reserve that will be diverted for quality flower production. So the optimum light intensity might have resulted in longer spikes in rain shelter. The high relative humidity inside rain shelter would have reduced evaporation loss from plants. Rajasekar *et al*. (2013) reported that high relative humidity inside poly house reduced evaporation form plants and helped in maintaining turgidity of cells which in turn was useful in enzyme activity and optimum nutrient utilization, leading to a higher yield.

Summer Sunshine had maximum spike length both in rain shelter and open field, during both the seasons. In rain shelter, Oscar recorded the minimum spike length, whereas White Prosperity showed minimum spike length in open field, during both the seasons. The difference in spike length among varieties was earlier reported by Ravidas, 1990; Pant *et al*., 1998; Shrigmagond and Hanamashetti, 1999; Sidhu and Arora, 2000; Rai *et al*., 2000; Roy and Sharga, 2000; Gupta *et al*., 2001; Kamble, 2001; Gupta *et al*., 2002; Jagdish *et al*., 2003; Patil, 2003; Kamble *et al*., 2004; Choudhary *et al*., 2011; Gawali *et al*. (2012) and Susila (2013).

5.1.2.2. Diameter of the spike

Spike diameter determines the stiffness and strength of the spike. There was significant influence of growing condition on spike diameter of all the varieties, during both the seasons. It was seen that spike diameter of all the varieties were highest in rain shelter.

During the first season, White prosperity exhibited the maximum spike diameter, both in rain shelter and open field. The minimum was recorded in Summer Sunshine and Oscar, in rain shelter and open field respectively. During the second season, Oscar had the highest spike diameter, both in rain shelter and open field. The lowest spike diameter was recorded in White prosperity both in rain shelter and open field. Ravidas (1991) and Choudhary *et al*. (2011) also reported variation in spike diameter among varieties.

5.1.2.3. Length of the rachis

Rachis length determines the number of florets as well as the spacing between the florets. The florets are usually arranged alternately in the rachis. A longer rachis with more number of florets arranged at closer spacing is usually desirable as it gives a compact look to the spike. Rachis length of all the varieties was significantly influenced by growing condition. The maximum rachis length of all the varieties was recorded in rain shelter.

Summer Sunshine had better rachis length in rain shelter, where as in open field rachis length was highest in Oscar, during the first season. Rachis length was lowest in Oscar and White prosperity in rain shelter and open field respectively. During the second season, rachis length was maximum in Summer Sunshine, both in rain shelter and open field. Oscar recorded the shortest rachis length in rain shelter. In open field, White prosperity had the lowest rachis length. Ravidas (1991) and Choudhary *et al*. (2011) also had recorded variation among varieties with respect to rachis length.

5.1.2.4. Number of florets per spike

The beauty of gladiolus spikes is reflected by the number of florets it holds. Larger spikes with more number of florets are ideal for cut flowers, bouquets and indoor decorations. In this study, rain shelter grown plants exhibited higher number of florets compared to open field. So it is revealed that growing condition significantly influence the number of florets per spike in gladiolus. The modified microclimate inside rain shelter would have contributed to more number of florets per spike in rain shelter grown plants. Mohanty *et al*. (2011) reported that availability of optimum light intensity inside poly house will maintain higher chlorophyll content which would produce and maintain higher carbohydrate reserve that will be diverted for quality flower production. So the optimum light intensity might have resulted in longer spikes with more number of florets in rain shelter. Islam and Haque (2011) also reported that plants grown under poly tunnel performed better in respect of number of florets per spike. According to

Sivaswamy and Dadlani (2002), number of florets was better under green house condition than in open field in cv. American beauty.

The number of florets per spike was maximum in Summer Sunshine in rain shelter and in Oscar in open field, during the first season. During the second season, Summer Sunshine had highest number of florets both in rain shelter and open field. White prosperity had the lowest number of florets, both in rain shelter and open field, during both the seasons. Several scientists like Ravidas, 1991; Shrigmagond and Hanamashetti, 1999; Rai *et al*., 2000; Roy and Sharga, 2000; Gupta *et al*., 2001; Kamble, 2001; Patil, 2003; Seetharamu *et al*, 2003; Nair and Shiva, 2003; Kamble *et al*., 2004; Choudhary *et al*., 2011and Gawali *et al*. (2012) earlier reported differences among varieties with respect to number of florets per spike.

5.1.2.5. Size of the florets

Another important quality parameter of a gladiolus spike is the size of the florets. Size of the floret is determined by the length and diameter of the florets. As the diameter of floret increases, the tendency for overlapping of the nearest floret increases. This in turn enhances the beauty of the spike. Floret size of all the varieties under study was significantly influenced by growing condition during both the seasons. Floret size was more for rain shelter grown spikes. The results are in conformity with Sivaswamy and Dadlani (2002) and Sarkar and Maitra (2005). Mohanty *et al*. (2011) reported that availability of optimum light intensity maintained higher chlorophyll content which would produce and maintain higher carbohydrate reserve that will be diverted for quality flower production. Hence the optimum temperature, relative humidity and light intensity would have contributed to larger florets in spikes of rain shelter grown plants.

Oscar had the maximum floret size, both in rain shelter and open field, during both the seasons. White prosperity had smaller florets compared to other varieties, under both growing conditions in both the seasons studied. Gupta *et al*., 2001; Kamble, 2001; Sidhu and Arora, 2003 and Choudhary *et al*., 2011 also reported variation in floret size among varieties.

5.1.2.6. Number of florets opened at a time

The number of florets opened at a time is an important character that adds to the beauty and quality of gladiolus spikes. The growing condition exerted a significant influence on number of florets opened at a time, during both the seasons. All the varieties recorded more number of florets opened at a time, in rain shelter. Dadlani *et al.* (1990) had reported that number of florets opened at a given time was 26% greater in gladiolus grown in plastic green house compared to open field.

Summer Sunshine had the maximum number of florets opened at a time, both in rain shelter and open field, during both the seasons. Oscar exhibited the minimum number of florets, under both growing conditions, in both the seasons studied. The difference in number of florets opened at a time between varieties was also reported by Nair and Shiva, 2003; Singhla *et al*., 2008; Choudhary *et al*., 2011 and Ahmed *et al*., 2014.

5.1.3. Vase characters

The performance of the spike in vase determines the value of gladiolus as cut flower. The vase characters like percentage of fully opened florets, percentage of partially opened florets, percentage of unopened florets, longevity of individual florets, number of florets opened at a time, nature of bending, water uptake and vase life are very important.

5.1.3.1. Fresh weight of the spike

Fresh weight of the spike indicates its size and freshness. Fresh spike weighs more because of its high water content. The growing condition exerted significant influence on fresh weight of spike for all the varieties, during both the seasons. Fresh weight of the spike recorded was higher for rain shelter grown plants. Mohanty *et al*. (2011) reported that availability of optimum light intensity inside poly house will maintain higher chlorophyll content which would produce and maintain higher carbohydrate reserve that will be diverted for quality flower production. So the optimum light intensity together with high temperature and relative humidity might have resulted in heavier spikes in rain shelter grown plants.

Summer Sunshine had the heaviest spikes under both growing conditions in both seasons. Oscar recorded the minimum spike fresh weight both in rain shelter and open field, during both the seasons. Ravidas, 1990; Pant *et al*., 1998 and Kamble, 2001 also found variation in spike fresh weight among varieties.

5.1.3.2. Percentage of fully opened florets

Significant influence of growing condition was noticed on percentage of fully opened florets in vase for all the varieties, during the first season. The maximum percentage of fully opened florets in vase for all the varieties was recorded in rain shelter.

The influence of growing condition on the percentage of fully opened florets in vase was not statistically significant for all the varieties, during the second season. Even then, all the varieties had more percentage of fully opened florets in vase, for rain shelter grown spikes.

In the case of spikes from rain shelter, during the first season, Summer Sunshine recorded the highest percentage of fully opened florets in vase, where as among spikes from open field, the maximum percentage was recorded in White prosperity. The lowest percentage of fully opened florets in vase was found in Oscar, among spikes from both rain shelter and open field. During second season, the maximum percentage of fully opened florets was observed in Summer Sunshine under both growing conditions. In rain shelter, minimum percentage of fully opened florets was recorded in Oscar. In the case of open field grown spikes, Oscar and White prosperity showed the minimum percentage of fully opened florets. Singhla *et al*., 2008 and Ahmed *et al*., 2014 also reported variation in percentage of fully opened florets among varieties.

5.1.3.3. Percentage of partially opened florets

During the first season, growing conditions significantly influenced the percentage of partially opened florets of all the varieties. It was higher in rain shelter grown spikes for all the varieties. Even though the effect of growing condition on percentage of partially florets of all the varieties was not statistically significant during the first season, it was better in rain shelter than in open field for all the varieties.

During the first season, spikes of White prosperity from both rain shelter and open field exhibited the maximum percentage of partially opened florets in vase. The minimum was observed in Summer Sunshine and Oscar from rain shelter and open field respectively. During second season, Summer Sunshine from rain shelter recorded the maximum percentage of partially opened florets in vase and the minimum was shown by both Oscar and White prosperity. In open field, Oscar and White prosperity recorded the maximum percentage and Summer Sunshine recorded the minimum. This variation may be due to difference in genetic makeup, growth rate and environmental conditions.

5.1.3.4. Percentage of unopened florets

Although the percentage of unopened florets of all the varieties was not significantly influenced by growing condition during the first season, it was lower in rain shelter than in open field for all the varieties. During the second season, growing conditions significantly influenced the percentage of unopened florets of all the varieties. It was lower in rain shelter for all the varieties.

The maximum percentage of unopened florets was observed in spikes of Oscar from both rain shelter and open field, during the first season. The minimum was recorded in Summer Sunshine and White prosperity from rain shelter and open field respectively. During the second season, among rain shelter grown spikes, Oscar and White prosperity showed maximum and minimum percentage of unopened florets respectively. In open field Oscar and White prosperity recorded the maximum percentage of unopened florets in vase and the minimum was shown by Summer Sunshine.

5.1.3.5. Longevity of individual florets

Longevity of individual florets of all the varieties was not significantly influenced by growing condition, during the first season. Even then the longevity was more in rain shelter than in open field for all the varieties.

Growing conditions had significant influence on longevity of individual florets, during the second season. Rain shelter grown spikes had more longevity of individual florets than open field grown spikes. Dadlani *et al* (1990) also reported that life of the florets on the spike was 30% longer in the case of plastic green house grown spikes compared to that in open field. Mohanty *et al*. (2011) reported that availability of optimum light intensity inside poly house will maintain higher chlorophyll content which would produce and maintain higher carbohydrate reserve that will be diverted for quality flower production. So the optimum light intensity might have resulted in more carbohydrate reserve in spikes in rain shelter grown plants which in turn would have resulted in more longevity of individual florets in vase.

Maximum longevity of individual florets was recorded in spikes of Summer Sunshine from both rain shelter and open field, during both seasons. During first season the minimum was observed in White Prosperity from both rain shelter and open field and during second season by Oscar from both rain shelter and open field.

5.1.3.6. Number of florets opened at a time

Number of florets opened at a time adds to the beauty of spikes in vase. The effect of growing condition was statistically insignificant on number of florets opened at a time of all the varieties during the first season. During the second season growing conditions exerted significant influence on number of florets opened at a time of all the varieties. Rain shelter grown spikes recorded more number of florets opened at time than the open field grown spikes.

During both seasons, in the case of spikes from rain shelter, Summer Sunshine and White prosperity recorded the highest number of florets opened at a time and Oscar recorded the lowest. During first season, in the open field all the varieties recorded similar number of florets opened at a time. During second season, in the open field Summer Sunshine had the maximum number of florets opened at a time. Oscar and White prosperity had similar number of florets opened at a time

5.1.3.7. Nature of bending

The growing conditions and genotype could not significantly influence the nature of bending in any of the varieties during both seasons.

5.1.3.8. Water uptake

Water uptake in vase of all the varieties was significantly influenced by growing condition, during both seasons. Rain shelter grown spikes exhibited maximum water uptake during both seasons.

There was significant variation among varieties with respect to water uptake, during both seasons. During both seasons, Summer Sunshine had the highest water uptake both in rain shelter and open field. During both seasons, the lowest water uptake was seen in Oscar in open field. In rain shelter, the minimum was recorded by Oscar and White Prosperity during first and second season respectively. According to Ahmed *et al*. (2014), among the varieties observed, PG-18-1 recorded maximum water absorption per spike (67.79 ml).

5.1.3.9. Vase life

Vase life is an important character which determines the quality of cut flowers. From this study it can be concluded that growing conditions significantly influenced the vase life of gladiolus spikes. Rain shelter grown plants of Oscar (S1-5.00 days, S2-6.00 days), Summer Sunshine (S1-6.67 days, S2- 8.67 days) and White Prosperity (S1-3.3 days, S2- 4.00 days) recorded significantly more vase life, during both seasons.. This was in accordance with the findings of Sarkar and Maitra (2005).They reported that longevity of spikes on vase was found to increase by 16.88 per cent under poly house condition. The optimum light intensity might have resulted in more carbohydrate reserve in spikes in rain shelter grown plants which in turn would have resulted in more longevity of individual florets in vase. The improved flower longevity of rain shelter grown spikes might be the reason for more vase life of rain shelter grown spikes.

Varieties exhibited significant variation in vase life during both seasons. Summer sunshine and White Prosperity showed the highest and lowest vase life respectively both in rain shelter and open field, during both seasons. Several scientists like Ravidas(1990); Singhla *et al*. (2008); Neha (2011); Gawali *et al*. (2012) and Ahmed *et al*. (2014) also reported variation among varieties with respect to vase life.

5.1.4. Corm and cormel yield

Corms and cormels are the propagules of gladiolus. So corm and cormel yield is very important since it determines the availability of planting material for the next crop. The size of the corms has direct influence on growth, flowering and spike qualities of gladiolus (Vidya, 1997).

Varieties showed significant differences in corm and cormel during both seasons. Dadlani *et al*. (1990); Seetharamu *et al*. (2003) and Choudhary *et al*. (2011) also reported significant difference among different gladiolus varieties in terms of corm and cormel yield.

5.1.4.1. Weight of corms

The growing condition could significantly influence the corm weight in all the varieties during both seasons. Corms of rain shelter grown plants of all the varieties showed maximum weight during both seasons. The optimum light intensity coupled with high temperature and relative humidity might have resulted in more carbohydrate reserve in rain shelter grown plants which in turn would have diverted for larger corm production. Dadlani *et al*. (1990) reported that corm weight was 21 per cent greater for the plants grown in the greenhouse. Sivasamy and Dadlani (2002) found that corm weight was 38 per cent higher in the greenhouse than in the field. Islam and Haque (2011) also reported better performance with respect to corm weight, in poly tunnel grown gladiolus.

Summer Sunshine had the heaviest corms both in rain shelter and open field, during both seasons. The lowest corm weight was recorded in White prosperity both in rain shelter and open field, during both seasons

5.1.4.2. Size of corms

The size of corms was also significantly influenced by growing condition during both seasons. Maximum corm size was recorded in rain shelter grown plants of all the varieties during both seasons. Sivasamy and Dadlani (2002) reported 20.40 per cent increase in corm size in the greenhouse than in the field.

Summer Sunshine and White prosperity had the largest and smallest corms respectively, both in rain shelter and open field, during both seasons.

5.1.4.3. Number of cormels

During both seasons, number of cormels produced was significantly influenced by growing conditions in all the varieties. Rain shelter grown plants recorded more number of cormels compared to open field grown plants of all the varieties. This was in conformity with the findings of Islam and Haque (2011).

During both seasons, the maximum number of cormels was recorded by Oscar in rain shelter and by Summer Sunshine in open field . White prosperity showed the minimum number of cormels, both in rain shelter and open field.

5.1.4.4. Weight of cormels

Growing conditions significantly influenced the weight of cormels of all the varieties during both seasons. Rain shelter grown cormels weighed more than open field grown cormels, during both seasons. Islam and Haque (2011) also had similar findings.

During both seasons, the maximum cormel weight was recorded by Oscar in rain shelter and by Summer Sunshine in open field. White prosperity showed the minimum cormel weight, both in rain shelter and open field.

5.2. Effect of season on performance of gladiolus varieties

When the effect of seasons is considered, it was revealed from this study that the performance of gladiolus was better during the second season (November planting) under both growing conditions, with respect to most of the plant characters, spike characters, vase characters and corm and cormel yield. Second season recorded more plant height, leaf area, took minimum time for spike emergence and flowering and lengthened the blooming period. Spike characters like spike length, spike diameter, rachis length, number of florets per spike, floret size and number of florets opened at a time were better during the second season. Corm and cormel yield was also higher during second season. These results are in conformity with Ravidas (1991) who also conducted studies on performance of gladiolus varieties under Vellanikkara conditions. During second season, day temperatures are mild and nights are cooler, which is reported to be best suited for gladiolus cultivation. Mukhopadhay and Banker (1987) reported that more number of florets was obtained from October and November plantings when the weather is mild. They also reported that spikes obtained from corms planted in November lasted longer. Date of planting plays an important role in regulating growth and quality of gladiolus (Khan *et al.* 2008.). Vegetative growth and quality of gladiolus is improved by proper planting times which also satisfies the consumer's demands (Zubair *et al.* 2006).

5.4. Post harvest treatment studies

Cut flowers are living, actively metabolizing heterogenous organs, composed of floral parts which may be at different physiologically developing stages (Ajithkumar *et al*, 2013). About 20 – 30 per cent of the flowers are lost due to faulty harvest, handling, package, storage, transport and marketing. The rate of senescence in cut flowers depends on the status of carbohydrates (Chandran *et al*., 2006). Appropriate post harvest management of any cut flower is of utmost importance to ensure the long lasting quality. Hence investigations were done to standardize the post harvest treatments like pulsing, holding, storage and packing, to improve the spike qualities. The results of the studies are discussed below.

5.4.1 Pulsing

Pulsing is a pre-shipment short term treatment by the growers, the effect of which should last throughout the shelf life of flower. Pulsing of flowers before storage helps to improve post-storage opening of buds (Somani, 2009). Pulsing is highly beneficial for flowers intended to long distance transport. Gladiolus spikes last for only six to seven days when placed in water which is too less a postharvest life for marketing of gladiolus for distant market (Murali and Reddy, 1993). Hence, pulsing of spikes with sucrose found to increase vase life of spikes (Halevy and Mayak 1981, Nowak and Rudnicki 1990, Singh *et al*., 2000, 2001).

In the present study 7 pulsing treatments were done. The treatments were Sucrose 10% + 8 HQC 100 ppm (T_1), Sucrose 10% + 8 HQC 200 ppm (T_2), Sucrose 20% + 8 HQC 100 ppm(T_3), Sucrose 20% + 8 HQC 200 ppm(T_4), Sucrose 10% (T_5), Sucrose 20% (T_6), and Control (tap water) (T_7). The objective was to find the best pulsing solution to improve the vase characters of gladiolus. The first four treatments were found superior over control for most of the vase characters of all the three varieties. The results are discussed below.

5.4.1.1 Percentage of fully opened florets

In the case of Oscar, pulsing treatments exerted significant influence on percentage of fully opened florets in vase. T_4 (Sucrose 20% + 8- HQC 200 ppm) recorded the maximum percentage of fully opened florets (45.45%). The minimum percentage (27.27%) was recorded by T_5 (Sucrose 10%), T_6 (Sucrose 20%) and T_7 (Control). But in Summer Sunshine and White Prosperity, percentage of fully opened florets in vase was not significantly influenced by pulsing treatments. However, in these varieties also, the maximum percentage of fully opened florets was observed in pulsing solutions of sucrose in combination with 8- HQC . These results are in conformity with the findings of several scientists. Sucrose may have promoted bud opening (Ichimura and Hisamatsu, 1999). Sucrose in the pulsing solution was the main carbohydrate source, which decreased the water potential (Halevy and Mayak, 1974) and thus improved the water uptake of the stem in gladiolus (Kofranek and Halevy, 1976). This improved water uptake by sucrose might have resulted in maximum percentage of opened florets. 8-HQC prevented growth of microorganisms in xylem and thus maintained water uptake by flower stems (Kwon *et al*., 2000).

Singh and Sharma (2003) and Singh *et al* (2008) also reported maximum number of fully opened florets, when the spikes were treated with sucrose in combination with 8- HQC. According to Bhat *et al*. (2012), a sucrose treatment alone was not effective; however, treatments with sucrose in combination of 8-HQC can be recommended to improve per centage of opened florets. Post harvest pulsing treatments of cut tuberose spikes revealed that pulsing solution treatment of 20 % S + 250 ppm 8-HQS significantly improved flower opening of cut tuberose spikes (Reid *et al*., 2001). With the presence of sucrose, adding germicide such as 8-HQS was necessary to inhibit microbial growth (Sacalis, 1993).

5.4.1.2. Percentage of partially opened florets

Pulsing treatments failed to influence the percentage of partially opened florets of all the varieties. In Oscar, the percentage of partially opened florets remained the same irrespective of different pulsing treatments. However, in Summer Sunshine and White Prosperity, the maximum percentage was recorded in T_4 (20% S + 250 ppm 8-HQS).

5.4.1.2. Percentage of unopened florets

It was observed that percentage of unopened florets in Oscar was significantly influenced by pulsing treatment. The minimum percentage was recorded with T_4 (20% S + 250 ppm 8-HQS) and the maximum in sucrose 10%, sucrose 20% and control. Pulsing treatments had no significant influence on percentage of unopened florets, both in Summer Sunshine and White Prosperity. However more percentage of unopened florets in both the varieties were also recorded in sucrose 10%, sucrose 20% and control. In contrast, Babaji *et al*. (2014) reported that pulsing treatment of spikes of gladiolus cv. American Beauty with 20% sugar resulted in a greater number of opened flowers (11.33 florets) compared to control. This may be due to genotypic differences and difference in duration of pulsing. He had pulsed the spikes for 20 hours and in this study the spikes were pulsed for 3 hours. The more percentage of unopened florets in sucrose 10%, sucrose 20% and control might be due to inability of the spikes to absorb water because of blockage of xylem vessels (Loubaud and Van Doorn, 2004; Hassan, 2005) due to microorganisms accumulation in vase solution (Hassan, 2005).The less supply of carbohydrates to support the process like respiration may also be a reason (Halevy and Mayak, 1979; Murali and Reddy, 1993).

5.4.1.4. Longevity of individual florets

Pulsing treatments had no significant influence on longevity of individual florets of Oscar and White Prosperity. However the maximum floret longevity was observed in pulsing treatment with sucrose 20 percent + 8- HQC 200 ppm. In Summer Sunshine, longevity of individual florets was significantly influenced by pulsing treatments. The maximum longevity (3.83 days) was recorded in sucrose 20 percent + 8- HQC 200 ppm. Sucrose in the pulsing solution was the main carbohydrate source, which decreased the water potential (Halevy and Mayak, 1974) and thus improved the water uptake of the stem in gladiolus (Kofranek and Halevy, 1976). This improved water uptake by sucrose might have resulted in maximum longevity of individual florets. 8-HQC at higher concentrations might have prevented growth of microorganisms in xylem and thus maintained water uptake by flower stems.

5.4.1.5. Number of florets opened at a time

In Oscar and Summer Sunshine, pulsing treatments exerted significant influence on number of florets opened at a time. In Oscar the maximum number of florets opened at a time was recorded in sucrose 20 percent + 8- HQC 200 ppm. In Summer Sunshine the maximum number of florets opened at a time was recorded in sucrose 20 percent + 8- HQC 200 ppm, which was statistically on par with that in sucrose 10 percent + 8- HQC 200 ppm. But in White Prosperity pulsing solutions had no significant influence on number of florets opened at a time. Even then more number of florets opened at a time was recorded both in sucrose 10 percent + 8- HQC 200 ppm and sucrose 20 percent + 8- HQC 200 ppm. This may also be due to improved water uptake by sucrose and the antimicrobial property of 8- HQC that prevented microbial growth in xylem there by maintaining continuous water uptake by spikes.

5.4.1.6. Nature of bending

Pulsing treatments had no significant influence on nature of bending of spikes in vase of all the three varieties studied.

5.4.1.7. Water uptake

Water uptake by spikes was significantly influenced by pulsing solutions in all the varieties studied. In all the varieties the maximum water uptake was recorded in sucrose 20 percent + 8- HQC 200 ppm. This may also be due to improved water uptake by sucrose and the antimicrobial property of 8- HQC that prevented microbial growth in xylem there by maintaining continuous water uptake by spikes.

5.4.1.8. Vase life

Pulsing treatments exhibited significant influence on vase life of all the three gladiolus varieties. Maximum vase life was noticed in spikes pulsed with sucrose 20 percent and 8- HQC 200 ppm, in all the varieties. As discussed earlier, the improved water uptake by sucrose together with antimicrobial property of 8- HQC that prevented microbial growth in xylem there by maintaining continuous water uptake by spikes, might have resulted in increased percentage of fully opened florets, longevity of individual florets and water uptake. The cumulative effect of all these might have resulted in maximum vase life in spikes pulsed with sucrose 20 percent and 8- HQC 200 ppm, in all the varieties life (Oscar -6 days, Summer Sunshine - 8 days and White prosperity- 6 days),.

It was also revealed from the present study that, among the different pulsing treatments with different concentrations of sucrose in combination with different concentrations of 8- HQC, sucrose 20 percent and 8- HQC 200 ppm was found to be the best. So it can be concluded that higher concentrations of sucrose and 8- HQC will be needed if pulsing is done for 3 hours. The spikes for further studies on holding, storage and packing were therefore pulsed with sucrose 20 percent and 8- HQC 200 ppm.

5.4.2. Holding treatments

Vase characters are important parameters for the evaluation of cut flower quality, for both domestic and export markets. One of the greatest problems in postharvest flower physiology is the blockage of vascular system, due to air or bacterial growth, which reduces water uptake and this blocks xylem vessels leading to water stress (Van Meetern *et al*., 2001) this will be expressed in the form of early wilting of flowers (Henriette and Clerkx, 2001), as a result of premature loss of cell turgidity. So adding chemical preservatives to the holding solution is recommended to prolong the vase-life of the cut flowers.

The main objective of the present study was to find out best holding solution for enhancing the vase-life of gladiolus cut spikes. The eight holding treatments done were Sucrose 5% + $AgNO_3$ 25 ppm, Sucrose 5% + $AgNO_3$ 50 ppm, Sucrose 5% + BA 50 ppm, Sucrose 5% + BA 100 ppm, Sucrose 5% + GA 50 ppm, Sucrose 5% + GA 100 ppm, Sucrose 5% and control (tap water). Holding treatments exerted significant influence on most of the vase characters of all the varieties. All the holding solutions were found superior to control with respect to most of the vase characters. The results are discussed below.

5.4.2.1. Percentage of fully opened florets

Holding solutions significantly influenced the percentage of fully opened florets of all the varieties. In Oscar maximum percentage (70%) was found in Sucrose 5% + $AgNO_3$ 50 ppm. Both Sucrose 5% + $AgNO_3$ 25 ppm and Sucrose 5% + $AgNO_3$ 50 ppm recorded the maximum percentage in the case of Summer Sunshine and White Prosperity. The increase in floret opening percentage with holding solutions containing sucrose and silver nitrate had already been reported by several scientists like Wang and Gu (1985); Barman *et al*.(2004); Kumar *et al*. (2006) and Kumar and Avasti (2012).

Sucrose is widely used in floral preservatives, which acts as a carbohydrate source or respiratory substrate and delays the degradation of proteins and improves the water balance of cut flowers (Sujatha *et al*., 2003). Silver nitrate which acts as a microbicide, reduces vascular plugging at the cut end of spikes (Choi and Roh, 1980; Deswal and Patel, 1982). The interactive effect of sucrose and silver nitrate might have resulted in more solution uptake which in turn resulted in more number of fully opened florets compared to control

5.4.2.2. Percentage of partially opened florets

In Summer Sunshine**,** holding treatments significantly influenced the percentage of partially opened florets. The maximum percentage was noticed in Sucrose 5% + $AgNO_3$ 50 ppm.But in Oscar and White Prosperity, the percentage of partially opened florets was not influenced by different holding treatments.

5.4.2.3. Percentage of unopened florets

It was observed that percentage of unopened florets in all the varieties was significantly influenced by holding treatments. The minimum percentage was recorded in Sucrose 5% + $AgNO_3$ 50 ppm and the maximum in control. Murali (1990) and Ezhilmathi *et al*. (2007) also reported more percentage of unopened florets in water compared to holding solutions with preservatives. The more percentage of unopened florets in control might be due to inability of the spikes to absorb water because of blockage of xylem vessels (Loubaud and Van Doorn, 2004; Hassan, 2005) due to microorganisms accumulation in vase solution (Hassan, 2005).The less supply of carbohydrates to support the process like respiration may also be a reason (Halevy and Mayak, 1979; Murali and Reddy, 1993).

5.4.2.4. Longevity of individual florets

In Summer Sunshine, longevity of individual florets was not significantly influenced by holding treatments. However the maximum longevity was observed in Sucrose 5% + $AgNO_3$ 50 ppm. Holding treatments had significant influence on longevity of individual florets of Oscar (2.29 days) and White Prosperity (2.33 days). The maximum longevity was recorded in Sucrose 5% + $AgNO_3$ 50 ppm. Sucrose in the holding solution was the main carbohydrate source, which decreased the water potential (Halevy and Mayak, 1974) and thus improved the water uptake of the stem in gladiolus (Kofranek and Halevy, 1976). This improved water uptake by sucrose might have resulted in maximum longevity of individual florets. In addition, sucrose inhibited ethylene synthesis and flower senescence (Ichimura and Hisamatsu, 1999). According to Sashikala *et al*, (2001), Silver thiosulphate inhibited ethylene action and reduced lipoxygenase activity as well as served as an antibacterial component when used in vase solutions and resulted in increased florets longevity. So it can be concluded that in the present study, holding solution with sucrose (5%) in combination with silver nitrate (50 ppm) inhibited ethylene synthesis and increased the floret longevity. Silver nitrate also serves as an antibacterial agent. Kumar *et al*. (2006) also reported increased floret longevity of gladiolus in holding solution with sucrose (4 %) in combination with silver nitrate (50 ppm).

5.4.2.5. Number of florets opened at a time

Holding solutions had no significant influence on number of florets opened at a time in all the varieties.

5.4.2.6. Nature of bending

Nature of bending of spikes in vase was also not significantly influenced by holding solutions in all the three varieties studied.

5.4.2.7. Solution uptake

Solution uptake by spikes was significantly influenced by holding treatments in all the varieties studied. In all the varieties the maximum water uptake was recorded in Sucrose 5% + $AgNO_3$ 50 ppm. This may also be due to improved water uptake by sucrose and the antimicrobial property of Silver nitrate that prevented microbial growth in xylem there by facilitating continuous water uptake by spikes. Kumar *et al*. (2006); Singh *et al*. (2006) and Kumar and Avasthi (2012) also reported maximum solution uptake in holding solutions of sucrose in combination with silver nitrate.

5.4.2.8. Vase life

Holding treatments had significant influence on vase life of all the three gladiolus varieties. Maximum vase life was noticed in spikes held in Sucrose 5% + $AgNO_3$ 50 ppm, in all the varieties. Similar findings on improvement of vase life in holding solutions of sucrose and silver nitrate had already been reported by Singh and Sharma (2003); Kumar *et al*. (2006); Singh *et al* (2006) and Kumar and Avasthi (2012).

Sucrose is widely used in floral preservatives, which acts as a carbohydrate source or respiratory substrate and delays the degradation of proteins and improves the water balance of cut flowers (Sujatha *et al*., 2003). Steinitz (1982) reported that addition of sucrose to the vase solution increased the mechanical rigidity of the stem by inducing cell wall thickening and lignification of vascular tissues. Sucrose antagonizes the effect of ABA, which promotes senescence (Halevy and Mayak, 1979). Sugars alone, however, tends to promote microbial growth. The effect of silver nitrate in enhancing the vase life of cut gladiolus spikes could be attributed to its role as a bactericide (Halevy and Mayak, 1981). It also reduces vascular plugging at the cut end of spikes (Choi and Roh, 1980; Deswal and Patel, 1983). As discussed above, the improved water uptake by sucrose together with antibacterial property of silver nitrate that prevented microbial growth in xylem there by maintaining continuous water uptake by spike might have resulted in increased vase solution uptake. The water uptake by the cut flowers placed in a keeping solution resulted in better water balance and flower freshness (Reddy *et al*., 1996) and reduced early wilting, and thus the vase-life of the cut flowers was enhanced. The cumulative effect of all these might have resulted in maximum vase life in spikes held in Sucrose 5% + $AgNO_3$ 50 ppm (Oscar -7 days, Summer Sunshine - 9 days and White prosperity- 7days).

All the holding solutions were found superior to control with respect to most of the vase characters. It can be concluded that among the eight treatments, Sucrose 5% + $AgNO_3$ 50 ppm proved to be better for most of the vase characters of all the varieties. Hence Sucrose 5% + $AgNO_3$ 50 ppm was used as holding solution for storage and packaging studies.

5.4.3. Storage treatments

It is important to evolve an appropriate storage technique for cut flowers during the periods of decline in demand and also to facilitate long term sea-shipment for export. During storage and transportation generally low temperature and high relative humidity (95 to 98%) are beneficial to reduce postharvest loss for most of the cut flowers. Storage of cut flowers at low temperature will delay senescence and maintain flower quality. Dry storage of flowers causes deterioration in the flower quality (Van Doorn and Hont, 1994). Moreover, the best flowers without mechanical damages can be obtained under wet storage or a wet transportation method, i.e., when stem bases of flowers are stored in a container with water or with a floral preservative solution. So in the present investigation, spikes kept in 4% sucrose solution were used for storage studies. The harvested spikes were subjected to the best pulsing treatment and then kept in three storage conditions, viz., at low temperature (10^0C ± 2^0C) and at ambient condition (30^0C ± 2^0C), for a period of 24 hours and the vase characters were recorded by keeping it in the best holding solution of Sucrose 5% + $AgNO_3$ 25 ppm.The results of the investigation are discussed below.

5.4.3.1. Percentage of fully opened florets

The percentage of fully opened florets of all the varieties was significantly influenced by storage temperature. The maximum percentage (Oscar-71.67%, Summer Sunshine- 75.82%, White Prosperity- 67.73%) was recorded in spikes stored at 8^0C and the minimum in control.

5.4.3.2. Percentage of partially opened florets

Storage temperature significantly influenced the percentage of fully opened florets of all the varieties. The maximum percentage was recorded in spikes stored at 8^0C and the minimum in control.

5.4.3.3. Percentage of unopened florets

It was observed that percentage of unopened florets in all the varieties was also significantly influenced by storage temperature. The minimum percentage was recorded in spikes stored at 8^0C and the maximum in control.

5.4.3.4. Longevity of individual florets

Storage temperature significantly influenced longevity of individual florets in vase of all the varieties. Maximum longevity (Oscar – 2.54 days, Summer Sunshine - 4.61 days and White prosperity- 2.75 days) was recorded in spikes stored at 8^0C and the minimum in control.

5.4.3.5. Number of florets opened at a time

Number of florets opened at a time was also significantly influenced by storage temperature. The number of florets opened at a time was observed highest in spikes stored at 8^0C and the lowest in control.

5.4.3.6. Nature of bending

Nature of bending of spikes in vase was not significantly influenced by storage temperature in all the three varieties.

5.4.3.7. Solution uptake

Solution uptake by spikes was significantly influenced by storage temperature in all the varieties studied. In all the varieties the highest water uptake was recorded in spikes stored at 8^0C and the lowest in control.

5.4.3.8. Vase life

Storage temperature had significant influence on vase life of all the three gladiolus varieties. Maximum vase life (Oscar- 9 days, Summer Sunshine- 11.6 days, White Prosperity- 7.8 days)was noticed in spikes stored at 8^0C and the minimum in control.

It can be concluded that storage at 8^0C was found to be beneficial for all the varieties with respect to most of the vase characters compared to storage at room temperature and at 12^0C. This might be due to lower metabolic activity at 8^0C compared to that at room temperature and at 12^0C. The beneficial impact of low storage temperature on post harvest qualities of gladiolus was earlier reported by Palanikumar and Bhattacharjee (2001); Beura and Singh (2003) and Srivastava *et al*. (2005).

5.4.4. Packing treatments

The technique of appropriate packing along with cold storage can contribute in maintaining flower quality through modified atmosphere storage (Zeltser *et al.,* 2001). The key to successful modified storage of fresh flowers is to use packaging films of suitable permeability so to ensure and establish the optimal Equilibrium Modified Atmosphere (EMA) at low temperature (Day, 2001). Thus, the present experiment was conducted to investigate the effect of different lining materials on the quality of gladiolus cut spikes in order to evolve an optimum packing technique.

Harvested spikes, treated with the best pulsing solution are packed with any of the five different lining materials namely brown paper, news paper, polypropylene sheet, polythene sheet and control (without packing) and packed in cartons of 75×30×10 cm^3 size. Then they were placed at 8^0C. After 24 hours, the spikes were transferred to the best holding solution of Sucrose 5% + $AgNO_3$ 25 ppm and the vase characters were recorded. Lining materials exerted significant influence on most of the vase characters of all the varieties. All the lining materials were found superior to control with respect to most of the vase characters. The results of the studies on lining materials are discussed below.

5.4.4.1. Percentage of fully opened florets

The percentage of fully opened florets of all the varieties was significantly influenced by lining materials. In Oscar, spikes wrapped with polypropylene sheet and polythene sheet exhibited maximum percentage of fully opened florets (70%). In Summer Sunshine (72.73%) and White Prosperity (67.50%), maximum percentage was recorded by spikes wrapped in polypropylene sheet which was statistically on par with those packed in polythene sheet .The minimum percentage was recorded in control for all the varieties. The enhanced bud opening in cut flowers is associated with high cell turgidity (Torre *et al.,* 1999) and up-regulation of optimum metabolic activities with high petal sugar status (Singh *et al.,* 2005). Polypropylene packaging has been earlier reported to retain higher level of sugars in gladiolus tepals (Singh et *al.,* 2007). Thus, the higher number of florets opening in polypropylene packaged cut spikes could be attributed to turgidity of the spikes on account of higher water uptake and optimum cell metabolism with sustained levels of the carbohydrates in the tepals. Similar effects of improved bud opening with modified atmosphere packaging have been reported by Meir, *et al.* (1995); Grover *et al.* (2005).

5.4.4.2. Percentage of partially opened florets

The percentage of partially opened florets of Oscar was significantly influenced by lining materials. In Oscar, maximum percentage of partially opened florets was recorded by spikes wrapped in polypropylene sheet which was statistically on par with those packed in polythene sheet. In Summer Sunshine and White Prosperity the percentage of partially opened florets was not significantly influenced by lining materials.

5.4.3.3. Percentage of unopened florets

It was observed that percentage of unopened florets in all the varieties was also significantly influenced by lining materials. The minimum percentage was recorded in spikes wrapped in polypropylene sheet and the maximum in control.

5.4.3.4. Longevity of individual florets

Lining materials significantly influenced longevity of individual florets in vase of all the varieties. In Oscar, maximum longevity (2.54 days) was recorded in spikes wrapped in polypropylene sheet. The minimum was observed in control which was statistically on par with spikes wrapped in brown paper and news paper. In Summer Sunshine, maximum longevity (3.94 days) was recorded in spikes wrapped in polypropylene sheet which was statistically on par with spikes wrapped in polythene sheet. The minimum was observed in control which was statistically on par with spikes wrapped in brown paper and news paper. In White prosperity, maximum longevity (2.68 days) was recorded in spikes wrapped in polypropylene sheet which was statistically on par with spikes wrapped in brown paper, news paper and polythene sheet. The minimum longevity was noticed in control. Due to wrapping with polypropylene sheet the microenvironment may become rich in carbondioxide with less oxygen thus retarding the rate of respiration as well as inhibiting ethylene action (Munsi *et al*., 2011). This might have increased longevity of individual florets when spikes where wrapped with polypropylene sheet.

5.4.4.5. Number of florets opened at a time

Number of florets opened at a time was not significantly influenced by lining materials in all the varieties.

5.4.4.6. Nature of bending

Nature of bending of spikes in vase was not significantly influenced by lining materials in all the varieties.

5.4.4.7. Solution uptake

Solution uptake by spikes was significantly influenced by lining materials in all the varieties studied. In all the varieties the highest solution uptake was recorded in spikes wrapped in polypropylene sheet and the lowest in control. The polypropylene packing might possesses low air diffusion rate across the film compared to other lining materials. Initially, continued metabolic activities especially respiration and transpiration of the flowers, might have led to the evolution of beneficial equilibrium of modified atmosphere (EMA) with high CO_2

and low O_2 and high relative humidity within the package. This further might have caused closure of stomata and minimized the respirational loss of carbohydrates as well as transpirational loss of water from the cut spikes (Zeltser *et al.,* 2001). This would further contribute towards minimal cell damage during storage and retain normal cell conditions after storage, which ultimately resulted in increased water uptake.

5.4.4.8. Vase life

Lining materials significantly influenced vase life of all the varieties. Vase life recorded was maximum in spikes wrapped with polypropylene sheet in all the varieties (Oscar- 9 days, Summer Sunshine- 9.75 days and White Prosperity- 8 days). According to Singh *et al.* (2006), polypropylene packed spikes under refrigerated storage at 6-10^0 C, retained best flower quality and vase life. Singh *et al.* (2003); Grover *et al.* (2005) and Singh *et al.* (2007) also reported beneficial effect of polypropylene packing in improving vase life of gladiolus spikes. The increased solution uptake by spikes wrapped in polypropylene sheet might have improved vase life.

So from the present post harvest treatment studies, it may be concluded that pulsing of gladiolus spikes with sucrose 20 percent and 8- HQC 200 ppm for 3 hours, packing with polypropylene sheet, storing at 8^0C for 24 hours and holding in Sucrose 5% + $AgNO_3$ 50 ppm, can significantly improve the vase characters of gladiolus.

Summary

6. SUMMARY

The study entitled 'Enhancement of spike qualities of Gladiolus (*Gladiolus grandiflorus* L)' was conducted during the year 2012-2013, at the Department of Pomology & Floriculture, College of Horticulture, Vellanikkara, in two seasons, from May 2012 to October 2012 (first season) and from November 2012 to March 2013 (second season). The objectives of the study were to compare the performance of gladiolus varieties under open and rain shelter conditions and to standardize the post harvest treatments to improve the spike qualities.

The three gladiolus varieties namely Oscar, Summer Sunshine and White Prosperity, were grown as per KAU recommendation, observed for growth, flowering and post harvest characters. The crop was raised both in open field and rain shelter (open ventilated poly house). The time of planting was May 2012 during first season and November 2012 during the second season.

The study clearly indicated that growing condition, season and genotype had significant influence on vegetative as well as floral characters of gladiolus. Growing conditions significantly influenced plant height of all the varieties during both seasons starting from two weeks after planting up to eight weeks after planting. All the varieties recorded significantly higher plant height in rain shelter starting from two weeks after planting up to eight weeks after planting [Oscar (S1- 51.06 cm, S2- 56.76 cm), Summer Sunshine (S1- 63.59 cm, S2- 71.47 cm) and White Prosperity (S1- 54.98 cm, S2- 64.06 cm)], during both seasons. The varieties also varied significantly among themselves with respect to plant height in both growing conditions during both seasons. Summer Sunshine maintained a better plant height, both in rain shelter (S1- 63.59 cm, S2- 71.47 cm) and open field (S1- 52.58, S2- 53.19 cm) ,during both seasons. Season also had significant influence on plant height of all the varieties in both growing conditions. All the varieties recorded significantly higher plant height during second season.

During first season, number of leaves of gladiolus was significantly influenced by growing condition and variety, from two weeks after planting up to

six weeks after planting. But at eight weeks after planting there was no significant influence of growing condition and variety on number of leaves. During second season, growing condition and variety showed no significant influence on number of leaves at two weeks after planting and four weeks after planting. But at six weeks after planting and eight weeks after planting, number of leaves was significantly influenced by growing condition and variety in second season. The maximum number of leaves was recorded in rain shelter by all the varieties compared to open field, at eight weeks after planting during second season. Among the varieties Summer Sunshine (8.93) produced more number of leaves during second season. Season also significantly influenced the number of leaves of all the varieties in rain shelter. But in open field number of leaves was not significantly influenced by season.

Leaf length was significantly influenced by growing condition and variety during first season from two weeks after planting up to eight weeks after planting. Summer Sunshine (57.40 cm), White Prosperity (56.20 cm) and Oscar (53.65 cm) recorded significantly higher leaf length in rain shelter. During second season, leaf length was not significantly influenced by growing condition and genotype at two weeks after planting. But from four weeks after planting up to eight weeks after planting, leaf length was significantly influenced by growing condition, during second season. Oscar (54.18 cm), Summer Sunshine (59.29 cm) and White Prosperity (57.64 cm) recorded significantly higher leaf length in rain shelter, during second season. The varieties varied significantly among themselves in leaf length at all stages of growth during the first as well as second season. During first season, Summer Sunshine recorded maximum leaf length in rain shelter (57.40 cm) as well as in open field (51.03 cm). But during second season, Summer Sunshine (59.29 cm) and White Prosperity (57.29 cm) recorded maximum leaf length in rain shelter and open field respectively.

Growing condition and variety exhibited significant influence on leaf breadth, starting from two weeks after planting stretching up to eight weeks after planting, during both seasons. Summer Sunshine, White Prosperity and Oscar showed significantly higher leaf breadth in rain shelter than in open field, during first season. In all the varieties leaf breadth was more in second season compared to first season.

Leaf area of gladiolus was significantly influenced by growing condition, variety and season. All the varieties showed significantly higher leaf area in rain shelter from two weeks after planting up to eight weeks after planting than in open field, during both seasons. The varieties also varied significantly among themselves, in their leaf area. Summer Sunshine maintained a better leaf area from two weeks after planting itself, up to eight weeks after planting compared to Oscar and White Prosperity. November planting registered a higher leaf area in all the three varieties in both growing conditions.

Growing condition, variety and season had significant influence on number of days taken from planting to spike emergence of gladiolus. The spike emergence was earlier in rain shelter [Oscar (S1- 87.35 days, S2- 73.25 days), Summer Sunshine (S1- 61.90 days, S2- 56.22 days) and White Prosperity (S1- 72.05 days, S2- 62.08 days)] than in open field for all the varieties, during both seasons. Among the varieties, Summer Sunshine took lowest number of days to spike emergence, both in rain shelter(S1- 61.90 days, S2- 56.22 days) and open field (S1- 72.03 days, S2- 64.05 days) , during both seasons. All the varieties showed early spike emergence in second season.

Number of days taken from spike emergence to opening was significantly influenced by growing condition, genotype and season. It was observed that all the varieties took lesser number of days from spike emergence to opening in rain shelter [Oscar (S1- 5.83 days, S2- 6.60 days), Summer Sunshine (S1- 8.08 days, S2- 6.73 days) and White Prosperity (S1- 8.53 days, S2- 7.68 days)] than in open field. Duration from spike emergence to opening was found to be the shortest in Oscar and longest in White prosperity, both in rain shelter and open field, during both the seasons. All the varieties took lesser number of days from spike emergence to opening during second season.

Time taken to flowering was significantly influenced by growing condition, genotype and season. Time taken to flowering was found to be shorter in rain shelter [Oscar (S1- 94.63 days, S2- 79.85 days), Summer Sunshine (S1- 69.98 days, S2- 62.95 days) and White Prosperity (S1- 80.58 days, S2- 69.75 days)] than in open field. Duration from planting to flowering was found to be the shortest in Summer Sunshine, both in rain shelter and open field, during both the seasons. All the varieties took shorter time for flowering during second season, in both growing conditions.

Blooming period was also significantly influenced by growing condition, genotype and season. Oscar (S1- 9.03 days, S2-10.08 days), Summer Sunshine (S1- 11.68 days, S2-13.03days), and White prosperity (S1- 9.68 days, S2-12.05 days) exhibited longer blooming period in rain shelter than in open field. Among the varieties, Summer Sunshine recorded maximum blooming period, both in rain shelter and open field, during both the seasons. All the varieties had more blooming period during second season.

Variety, growing condition and season had significant influence on total duration. All the varieties recorded shorter duration in rain shelter [Oscar (S1- 102.21 days, S2-89.93 days), Summer Sunshine (S1- 81.65 days, S2-75.98 days), and White prosperity (S1- 90.25 days, S2-81.80 days)]. Among the varieties, Summer Sunshine recorded minimum total duration, both in rain shelter and open field, during both the seasons. Second season showed lesser total duration than first season in all the varieties, in both growing conditions.

Spike length, spike diameter and rachis length was significantly influenced by growing condition, genotype and season. All varieties produced longer spikes in rain shelter than open field during both seasons. Summer Sunshine recorded maximum spike length compared to other varieties during both seasons in both growing conditions. All the varieties had better spike diameter during second season and rain shelter grown plants recorded maximum diameter.

Growing condition, genotype and season exerted significant influence on spike diameter of gladiolus. Oscar (S1- 0.90 cm, S2- 1.34 cm), Summer Sunshine (S1- 0.89 cm, S2- 1.22 cm) and White Prosperity (S1- 1.02 cm, S2- 1.02 cm) had significantly more spike diameter in rain shelter, during both seasons. All the varieties had better spike diameter during second season. White prosperity and Oscar recorded maximum spike diameter in both growing conditions, during first and second season respectively. Rachis length was also significantly influenced by growing condition, genotype and season. Oscar (S1- 33.51 cm, S2- 42.66 cm), Summer Sunshine (S1- 44.42 cm, S2- 51.09 cm) and White Prosperity (S1- 37.39 cm, S2- 44.90 cm) showed maximum rachis length in rain shelter, during both seasons. It was also noticed that all the varieties exhibited better rachis length during second season. Summer Sunshine had longer rachis in rain shelter during both seasons. In open field, Oscar (25.73 cm) and Summer Sunshine (42.74 cm) had better rachis length during first and second season respectively.

The treatments could significantly influence the number of florets per spike. Oscar (S1-10.35, S2-12.00), Summer Sunshine (S1-11.38, S2- 13.80) and White Prosperity (S1-9.23, S2- 11.57) exhibited significantly more florets per spike in rain shelter, during both seasons. It can also be inferred that the spikes of all the varieties had more number of florets during second season. Among the varieties Summer Sunshine recorded more number of florets per spike compared to other varieties, in both growing condition during both seasons.

Floret size was significantly influenced by growing condition, genotype and season .Rain shelter grown plants of Oscar (S1-9.47 cm, S2-10.31cm), Summer Sunshine (S1-8.79 cm, S2- 9.90 cm) and White Prosperity (S1-7.53 cm, S2- 9.15 cm) recorded larger florets, during both seasons. Florets of all the varieties produced during second season in both growing conditions were larger than those in first season. Oscar had larger florets than other varieties in both growing conditions during both seasons.

Significant influence of treatments was noticed on the number of florets opened at a time in all the varieties. Oscar (S1-3.93, S2-4.30), Summer Sunshine (S1-6.33, S2- 6.25) and White Prosperity (S1-4.20, S2- 5.55) had more the number of florets opened at a time in rain shelter during both seasons. Varieties recorded more number of florets opened at a time, during second season than in first season. Among the varieties Summer Sunshine exhibited higher number florets opened at a time in both growing conditions during both seasons.

Significant difference could be observed in the fresh weight of spike as influenced by the treatments. Oscar (S1-23.90 g, S2-34.97 g), Summer Sunshine (S1-46.13g, S2-55.67g) and White Prosperity (S1-36.83 g, S2- 41.03 g) exhibited heavier spikes in rain shelter during both seasons. All the varieties recorded more number of florets opened at a time, during second season, in both growing conditions. Among the varieties Summer Sunshine exhibited higher number florets opened at a time in both growing conditions during both seasons.

During first season, percentage of fully opened florets was significantly influenced by growing condition and genotype. Oscar (27.27%), Summer Sunshine (41.37%) and White Prosperity (33.33%) recorded maximum percentage in rain shelter. During second season, percentage of fully opened florets was not significantly influenced by time of planting, growing condition and genotype. But in open field, season exerted significant influence on percentage of fully opened florets. In open field, all the varieties had more percentage of fully opened florets during second season.

During first season, percentage of partially opened florets was significantly influenced by growing condition and genotype. Oscar (20.00%), Summer Sunshine (16.67%) and White Prosperity (22.22%) recorded maximum percentage in rain shelter. During second season, percentage of partially opened florets was not significantly influenced by growing condition and genotype.

Percentage of unopened florets was not significantly influenced by growing condition and genotype, during first season. During second season, percentage of unopened florets was significantly influenced by growing condition and genotype. Oscar (41.67%), Summer Sunshine (35.71%) and White Prosperity (33.33%) recorded minimum percentage in rain shelter.

Longevity of individual florets was not significantly influenced by growing condition and genotype, during first season. During second season, floret longevity was significantly influenced by growing condition and genotype. Oscar (2.00 days), Summer Sunshine (3.67 days) and White Prosperity (2.20 days) exhibited maximum longevity of individual florets in rain shelter. Season had significant influence on longevity of individual florets of all the varieties in both growing condition. All the varieties recorded significantly higher floret longevity during second season.

Number of florets opened at a time in vase was not significantly influenced by growing condition and genotype, during first season. During second season, number of florets opened at a time was significantly influenced by growing condition and genotype. Oscar (2.00), Summer Sunshine (4.00) and White Prosperity (4.00) recorded more number of florets opened at a time in rain shelter. There was no significant influence of season on number of florets opened at a time of all the varieties in both growing condition.

Nature of bending of spike in vase was not significantly influenced by growing condition, season and genotype.

Water uptake was significantly influenced by growing condition and genotype. Rain shelter grown plants of Summer Sunshine (S1-35.93 ml, S2- 41.43 ml), Oscar (S1-31.23 ml, S2-35.87 ml), and White Prosperity (S1-24.00 ml, S2-31.23 ml) recorded significantly higher water up take, during both seasons. Among the varieties Summer Sunshine exhibited more water uptake in both growing conditions during both seasons.

Treatments could significantly influence the vase life of gladiolus. Rain shelter grown plants of Summer Sunshine (S1-6.67 days, S2- 8.67 days), Oscar

(S1-5.00 days, S2-6.00 days), and White Prosperity (S1-3.3 days, S2- 4.00 days) recorded significantly more vase life, during both seasons. Among the varieties, Summer Sunshine exhibited maximum vase life in both growing conditions during both seasons. All the varieties recorded significantly higher vase life during second season.

Corm weight was significantly influenced by growing condition, genotype and season. Summer Sunshine (S1-108.11 g, S2- 147.33g), Oscar (S1-59.57 g, S2-75.59 g), and White Prosperity (S1-42.79 g, S2-57.22 g) recorded significantly higher corm weight in rain shelter, during both seasons. Among the varieties, Summer Sunshine exhibited maximum corm weight in both growing conditions during both seasons. All the varieties recorded significantly more corm weight during second season.

Corm size was also significantly influenced by treatments. Oscar (S1-5.95 cm, S2-6.02 cm), Summer Sunshine (S1-7.24 cm, S2- 8.10 cm) and White Prosperity (S1-5.15 cm, S2-5.30cm) recorded maximum corm size in rain shelter, during both seasons. Among the varieties, Summer Sunshine registered highest corm size in both growing conditions during both seasons and season wise, November planting was the best.

Treatments could significantly influence the number and weight of cormels also. Oscar and White Prosperity recorded maximum number and weight of cormels in rain shelter, during both seasons. But Summer Sunshine recorded more number and weight of cormels in open field, during both seasons. Oscar and Summer Sunshine registered maximum cormel weight in rain shelter and openfield repectively, during both seasons. All the varieties recorded significantly more weight of cormels during second season.

For post harvest studies, gladiolus spikes were harvested when the first floret showed colour. Spikes were subjected to the post harvest treatments - pulsing, holding, storage and packing. Harvested spikes were kept under the pulsing solutions for three hours. Pulsed spikes were then placed in vase (with distilled water) and the vase characters were recorded. Seven pulsing treatments were done. The treatments were T_1-Sucrose 10% + 8 HQC 100 ppm,T_2- Sucrose 10% + 8 HQC 200 ppm, T_3 Sucrose 20% + 8 HQC 100 ppm, T_4 Sucrose 20% + 8 HQC 200 ppm, T_5 Sucrose 10%, T_6 Sucrose 20% and T_7 Control (tap water). Pulsing treatments had significant influence on percentage of fully opened florets, percentage of unopened florets, number of florets opened at time, water uptake and vase life of gladiolus variety Oscar. Among the pulsing solutions, Sucrose 20% + 8 HQC 200 ppm was found to be better than other treatments, with respect to percentage of fully opened florets (45.45%), percentage of unopened florets (36.36%), number of florets opened at a time (3.00), water uptake (36.07 ml) and vase life (6.00 days).

In the case of Summer Sunshine, pulsing treatments significantly influenced the longevity of individual florets, number of florets opened at a time, water uptake and vase life. Pulsing solution of Sucrose 20% + 8 HQC 200 ppm recorded maximum longevity of individual florets (3.83 days), number of florets opened at a time (4.00), water uptake (47.00 ml) and vase life (8.00 days).

Pulsing treatments significantly influenced water uptake and vase life of White Prosperity. Pulsing solution of Sucrose 20% + 8 HQC 200 ppm recorded maximum water uptake (45.37 ml) and vase life (6.00 days).

The other vase characters were not significantly influenced by pulsing solutions.

The spikes after treating with the best pulsing solution were put into eight different holding solutions and the vase characters were recorded. The holding treatments were T_1 - Sucrose 5% + $AgNO_3$ 25 ppm, T_2 - Sucrose 5% + $AgNO_3$ 50 ppm, T_3- Sucrose 5% + BA 50 ppm, T_4 - Sucrose 5% + BA 100 ppm, T_5 - Sucrose 5% + GA 50 ppm, T_6 - Sucrose 5% + GA 100 ppm, T_7 - Sucrose 5% and T_8 - control (tap water).

Holding treatments significantly influenced percentage of fully opened and unopened florets, longevity of individual florets, water uptake and vase life in the variety Oscar. T_2 exhibited maximum percentage of fully opened florets (70.00%), longevity of individual florets (2.29 days), water uptake (41.93 ml). Vase life

(7.00 days) recorded was maximum in T_1 and T_2 .The percentage of unopened florets (10.00%) was minimum in spikes of Oscar kept in holding solution of T_2.

In the case of Summer Sunshine, holding treatments exerted significant influence on percentage of fully opened, partially opened and unopened florets, water uptake and vase life. Holding solution of Sucrose 5% + $AgNO_3$ 25 ppm as well as Sucrose 5% + $AgNO_3$ 50 ppm exhibited maximum percentage of fully opened florets (66.67%). Holding solution of Sucrose 5% + $AgNO_3$ 50 ppm registered maximum percentage of partially opened florets (33.33%), water uptake (73.50 ml) and vase life (9.00 days). The percentage of unopened florets was minimum (0%) in spikes of Summer Sunshine kept in holding solution of Sucrose 5% + $AgNO_3$ 50 ppm.

Holding treatments significantly influenced the percentage of fully opened and unopened florets, longevity of individual florets, water uptake and vase life in the variety White prosperity. Holding solutions of Sucrose 5% + $AgNO_3$ 25 ppm as well as Sucrose 5% + $AgNO_3$ 50 ppm exhibited maximum percentage of fully opened florets (62.50%). Holding solution of Sucrose 5% + $AgNO_3$ 50 ppm recorded maximum longevity of individual florets (2.33 days), water uptake (47.03 ml) and vase life (7.00 days). The percentage of unopened florets was minimum (12.50%) in spikes of Summer Sunshine kept in holding solutions of Sucrose 5% + $AgNO_3$ 25 ppm and Sucrose 5% + $AgNO_3$ 50 ppm.

The harvested spikes were subjected to the best pulsing treatment and then kept in three storage conditions, viz., at low temperature (10^0C ± 2^0C) and at ambient condition (30^0C ± 2^0C), for a period of 24 hours and vase characters were recorded by keeping it in the best holding solution.

Storage temperature significantly influenced percentage of fully opened, partially opened and unopened florets, longevity of individual florets, number of florets opened at a time, water uptake and vase life of variety Oscar. Spikes stored at 8^0C exhibited maximum percentage of fully opened florets (71.67%), percentage of partially opened florets (25.00%), longevity of individual florets (2.54 days), water uptake (88.74 ml) and vase life (9.00 days).The percentage of unopened florets (3.33%) was minimum in spikes of Oscar stored at 8^0C.

In the case of Summer Sunshine, storage temperature exerted significant influence on percentage of fully opened, partially opened and unopened florets, longevity of individual florets, number of florets opened at a time, water uptake and vase life. Spikes stored at 8^0C registered maximum percentage of fully opened florets (75.82%), partially opened florets (16.59%), longevity of individual florets (4.61 days), number of florets opened at a time (5.2), water uptake (123.7 ml) and vase life (11.6 days). The percentage of unopened florets was minimum (7.58%) in spikes stored at 8^0C.

Storage temperature significantly influenced the percentage of fully opened and unopened florets, longevity of individual florets, number of florets opened at a time, water uptake and vase life. Spikes stored at 8^0C registered maximum percentage of fully opened florets (67.73%), longevity of individual florets (2.75 days), number of florets opened at a time (4.6), water uptake (67.5 ml) and vase life (7.8 days). The percentage of unopened florets was minimum (8.66%) in spikes stored at 12^0C.

Harvested spikes, treated with the best pulsing solution and packed in cartons of 75×30×10 cm^3 size with five different lining materials namely brown paper, news paper, polypropylene sheet, polythene sheet and control (without packing) and were placed in the best storage condition. After 24 hours, the spikes were transferred to the best holding solution and the vase characters were recorded.

Lining materials had significant influence various vase characters of variety Oscar. Spikes packed in polypropylene sheet and polythene sheet exhibited maximum percentage of fully opened florets (70.00%). Spikes packed in polypropylene sheet exhibited maximum percentage of partially opened florets (30.00%), longevity of individual florets (2.54 days), water uptake (66.13 ml) and vase life (9.00 days).The percentage of unopened florets (0%) was minimum in spikes of Oscar packed in polypropylene sheet.

Lining materials exerted significant influence on percentage of fully opened and unopened florets, longevity of individual florets, water uptake and vase life of Summer Sunshine. Spikes packed in polypropylene sheet exhibited maximum percentage of fully opened florets (72.73%), longevity of individual florets (3.94 days), water uptake (92.88 ml) and vase life (9.75 days).The percentage of unopened florets (6.82 %) was minimum in spikes of Oscar packed in polypropylene sheet.

Lining materials significantly influenced percentage of fully opened and unopened florets, longevity of individual florets, number of florets opened at a time, water uptake and vase life of White prosperity. Spikes packed in polypropylene sheet exhibited maximum percentage of fully opened florets (67.50%), longevity of individual florets (2.68 days), number of florets opened at a time (3.25), water uptake (62.87 ml) and vase life (8.00 days). The percentage of unopened florets (10.83 %) was minimum in spikes of White prosperity packed in polypropylene sheet.

The results of studies on performance evaluation showed that spike qualities as well as corm yield can be enhanced by rain shelter (open ventilated poly house) cultivation. Among the varieties Summer Sunshine exhibited better performance with respect to vegetative characters and yield attributes. It was also noticed that November planting was found to be better than May planting, in order to obtain quality spikes as well as good corm yield in gladiolus under Vellanikkara conditions. The post harvest studies revealed that pulsing of gladiolus spikes with sucrose 20 percent and 8- HQC 200 ppm for 3 hours, packing with polypropylene sheet, storing at 8^0C for 24 hours and holding in Sucrose 5% + $AgNO_3$ 50 ppm solution can significantly improve the vase characters of gladiolus varieties Oscar, Summer Sunshine and White prosperity.

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APPENDICES

Appendix 1.Monthly mean temperatures (^0C) during the period from May 2012 to April 2013 in different growing conditions

Month	Open field (O)		Rain shelter (R)	
	8:00 am	2:30 pm	8:00 am	2:30 pm
May	26.8	32.3	28.1	34.5
June	25	29.1	28.5	30.6
July	25	29.4	27.4	30.3
August	24.6	28.5	26.1	30.2
September	23.8	28.9	24.6	31.9
October	24.3	29.9	25.1	32.1
November	25.2	31.6	26.2	33.8
December	23.6	31.8	25.9	33.4
January	24.2	32.2	26.6	33.4
February	24.1	33.6	26.1	34.9
March	25.8	34.5	28.3	37.1
April	26.8	34.3	28.5	37.0

Appendix 2. Monthly mean relative humidity (per cent) during the period from May 2012 to April 2013 in different growing conditions

Month	Open field (O)		Rain shelter (R)	
	8:00 am	2:30 pm	8:00 am	2:30 pm
May	88.23	64.29	83.46	69.53
June	94.61	77.05	92.34	77.23
July	95.46	74.22	90.29	72.58
August	95.11	77.32	91.64	73.44
September	94.73	68.39	92.21	72.47
October	95.87	69.68	92.94	71.68
November	86.63	59.73	80.63	62.13
December	75.97	49.90	74.00	51.94
January	64.71	39.13	62.48	45.29
February	72.36	42.75	71.46	45.32
March	76.35	38.74	76.29	43.87
April	26.8	34.3	28.5	37.0

Appendix 3. Monthly mean light intensity (lux) from May 2012 to April 2013 in different growing conditions

Month	Open field	Rain shelter
May	86483.32	60028.79
June	66757.54	35661.24
July	69853.55	38958.08
August	77638.24	46019.88
September	79878.50	50766.81
October	80512.9	50981.13
November	88926.67	64062.64
December	93864.52	57480.81
January	88803.23	62410.34
February	74882.14	49770.11
March	79083.87	57161.31
April	90227.62	59049.96

Appendix 4. Monthly mean rainfall (mm) from May 2012 to April 2013 in different growing conditions

Month	Rainfall (mm)
May	117.3
June	551.5
July	375.8
August	616.5
September	191.8
October	145.6
November	46.7
December	20.0
January	0
February	67.4
March	6.8
April	0

ENHANCEMENT OF SPIKE QUALITIES OF GLADIOLUS (*Gladiolus grandiflorus* L.)

By

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ABSTRACT OF THE THESIS

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ABSTRACT

The studies on 'Enhancement of spike qualities of Gladiolus (*Gladiolus grandiflorus* L)" were conducted during 2012-13 in the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara, in two seasons, from May 2012 to October 2012 (first season) and from November 2012 to April 2013 (second season). The objectives were to compare the performance of gladiolus varieties under open and rain shelter conditions and to standardize the post harvest treatments to improve the spike qualities.

The three gladiolus varieties namely Oscar, Summer Sunshine and White Prosperity, were grown as per KAU recommendation, both in open field and rain shelter. Detailed observations were made on growth, flowering and post harvest characters.

The study clearly indicated that growing condition, season and genotype had significant influence on vegetative as well as floral characters of gladiolus. The vegetative characters like plant height, number of leaves and leaf area were noticed to be better in rain shelter grown plants, during both seasons. Early spike emergence [Oscar (S1- 87.35 days, S2- 73.25 days), Summer Sunshine (S1- 61.90 days, S2- 56.22 days) and White Prosperity (S1- 72.05 days, S2- 62.08 days)], shorter duration from spike emergence to opening and longer blooming period [Oscar (S1- 9.03 days, S2-10.08 days), Summer Sunshine (S1- 11.68 days, S2-13.03days), and White prosperity (S1- 9.68 days, S2-12.05 days)] were noticed in rain shelter grown plants. Total duration of the crop was shorter in rain shelter during both seasons. Spike length, spike diameter, rachis length, number of florets per spike [Oscar (S1-10.35, S2-12.00), Summer Sunshine (S1-11.38, S2- 13.80) and White Prosperity (S1-9.23, S2- 11.57)], floret size and number of florets opened at a time were observed better in rain shelter grown plants, during both seasons. Vase characters were also found to be superior in rain shelter grown plants. Rain shelter grown plants of Oscar (S1-5.00 days, S2-6.00 days), Summer Sunshine (S1-6.67 days, S2- 8.67 days) and White Prosperity (S1-3.3 days, S2- 4.00 days) recorded significantly more vase life, during both seasons. Corm yield recorded were maximum in plants grown in rain shelter. Cormel yield recorded was maximum in rain shelter for Oscar and White prosperity where as for Summer Sunshine, maximum cormel yield was observed in open field. Among the varieties, Summer Sunshine had better performance with respect to most

of the vegetative, spike and vase characters, compared to other varieties, both in rain shelter and open field. Oscar recorded relatively higher floret size (S1-9.47 cm, S2-10.31 cm) as well as cormel yield (S1- 14.71, S2- 21.63) compared to other varieties, during both seasons in both growing conditions.

The results showed that spike qualities as well as corm yield can be enhanced by rain shelter cultivation. It was also noticed that November planting was found to be better than May planting, in order to obtain quality spikes as well as good corm yield in gladiolus under Vellanikkara conditions.

For post harvest studies, gladiolus spikes were harvested when the first floret showed colour. Spikes were subjected to the post harvest treatments - pulsing, holding, storage and packing. Among the pulsing solutions Sucrose 20% + 8 HQC 200 ppm was found to be better than other treatments for all the varieties, with respect to percentage of fully opened florets , percentage of unopened florets, longevity of individual florets (Oscar -1.8 days, Summer Sunshine – 3.8 days and White prosperity- 2.25 days), number of florets opened at a time, water uptake and vase life.For all the varieties, holding solution of Sucrose 5% + $AgNO_3$ 50 ppm was found to record the maximum percentage of fully opened florets, longevity of individual florets, water uptake and vase life (Oscar -7 days, Summer Sunshine - 9 days and White prosperity- 7days).

Maximum percentage of fully opened florets, longevity of individual florets, water uptake and vase life were observed in spikes stored at 8^0C, for all the varieties. The spikes packed in polypropylene sheet exhibited the highest percentage of fully opened and partially opened florets, longevity of individual florets, number of florets opened at a time, water uptake and vase life (Oscar-9 days, Summer Sunshine- 9.75 days and White prospery- 8 days). Nature of spike bending of all the varieties was not significantly influenced by pulsing and holding solutions, packing and storage.

The post harvest studies revealed that pulsing of gladiolus spikes with sucrose 20 percent and 8- HQC 200 ppm for 3 hours, packing with polypropylene sheet, storing at 8^0C for 24 hours and holding in Sucrose 5% + $AgNO_3$ 50 ppm solution can significantly improve the vase characters of gladiolus.