Journal of Pure and Applied Agriculture (2023) 8(3): 1-9
ISSN (Print) 2617-8672, ISSN (Online) 2617-8680
http://jpaa.aiou.edu.pk/

# Assessment of four Gladiolus cultivars for the best production under Multan's agro-climatic conditions

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**Abstract**

Gladiolus is a prominent cut flower used worldwide for its attractive color and prolonged vase life. Evaluation of gladiolus cultivars under agro-climatic conditions of Multan is essential for sustainable cut flower production on commercial scale. Four different gladiolus cultivars viz: Amsterdam, White Prosperity, Essential, and Red Balance were evaluated for their physical and flowering & corm multiplication characteristics. The results displayed that the vegetative attributes of gladiolus cultivars were significantly influenced. The minimum numbers of days were recorded for corms sprouting in cv. Amsterdam (16.21 %) and White Prosperity (17.98 %). Maximum days for sprouting of corms were exhibited in Essential (22.28 days) and Red Balance (20.393 days). The tallest plant height (112.50 cm) and (98.42) was achieved by Amsterdam followed by White Prosperity. However, more leaves were produced in white prosperity (10.13). The findings of study depicted that floral traits in gladiolus cultivars were remarkably changed. Lowest days for emergence of spike were taken in Amsterdam (68.18) and White Prosperity (72.23). Late spike initiation was observed in Red Balance (80.19 days) and Essential (75.80 days). The early blooming (84.21 days), the longest spike length (92.167 cm), greater number of florets (18.38), large corm diameter (50.46 mm) and long vase life (14.41 days) were demonstrated in Amsterdam followed by White prosperity. The minimum numbers of corms were produced in red balance (1.08) and essential (1.41). Similarly highest flavonoids compounds (61.76 mg100g-$^{1}$ FM), total phenolic compounds (158.78 mg GAEg-$^{1}$ FM), total antioxidant activity (92.46 %), chlorophyll a (1.79 mg/g) and chlorophyll b (2.33 mg/g) were observed in cvs Amsterdam. The investigation of study proved that Amsterdam & white prosperity were found superior over other gladiolus cultivars. Hence, both cultivars are appropriate for commercial cultivation and propagation under agro-climatic conditions of Multan.

**Keywords**: Climatic conditions, Evaluation, Flowering attributes, Gladiolus cultivars, Growth

**To cite this article:** Ahmad, I., Saeed, T., Khan, S. A., Wahid, A., Ahmad, T., Akhtar, G., Abbas, Q., Ashraf, S., & Hussnain, H. (2023). Assessment of four Gladiolus cultivars for the best production under Multan's agro-climatic conditions. *Journal of Pure and Applied Agriculture, 8*(3), 1-9.

## Introduction

Gladiolus (*Gladiolus grandiflorus* Hort.), renowned for its exquisite spikes and graceful presence, holds a significant position in both domestic and international cut flower markets. This captivating bulbous crop has earned its place as a precious and popular flower (Schwab et al., 2015). Renowned for its vibrant and diverse colors, varying sizes of flowers, and impressive floret formations, gladiolus holds a significant place in the world of ornamental horticulture. Gladiolus is frequently used as a cut flower in different social and religious ceremonies, making its availability significant for meeting the demand (Datta & Gupta, 2022). Gladiolus is preferred because of beautiful floral characters and extended vase life (Dhiman et al., 2020). These florets open in a sequence over a long duration, which contributes to their good keeping quality. The spikes of gladiolus are popular in flower arrangements and for preparing high-class bouquets, adding vibrancy and elegance to various occasions.

Flower with long stems is mostly used on special events for purpose of beautification and flowering arrangement. Among the array of cut flowers available, Gladiolus stands out as a prominent choice in both local and international flower windows (Singh & Sisodia, 2017). Vegetative characteristics play a crucial part in determining the performance in term of physical and flowering characteristics of gladiolus genotypes. Parameters such as plant height, number of leaves, and leaf length and width provide insights into the vigor and health of the plants (Paiva, 2018). Understanding the variation in vegetative growth among different cultivars can help growers select cultivars that demonstrate robust growth and have the potential for high yield. The inflorescence characteristics of gladiolus cultivars also contribute to their market value and

desirability. Parameters such as spike length, number of florets per spike, and floret size are important determinants of the quality and aesthetic appeal of the flowers. Evaluating the inflorescence characteristics of different cultivars allows for the identification of cultivars with desirable flower traits, ensuring the production of high-quality spikes for the cut flower market (Mushtaq et al. 2018).

Gladiolus reproductive components particularly corm and cormel multiplication, are crucial for commercial cultivation. The growth and development of vegetative and yield parameters of plant directly impact the availability of planting material for subsequent seasons. Assessing the yield components of different cultivars provides insights into their productivity and potential for propagation, enabling growers to select cultivars that offer high yield and consistent performance (Urfi Fatmi & Kumar, 2021). Commercial flower cultivation is hardly possible due to occurrence of frost and snowfall during winter season in European countries resulting in a scarcity of fresh flowers in the market. However, countries like Pakistan with temperate, subtropical, and tropical climatic conditions can produce fresh flowers throughout the year with relatively minimal effort. Gladiolus cultivation in Pakistan, particularly in the subtropical region of Multan, has the potential to contribute to the domestic and international flower markets (Jinesh et al., 2010).

The performance of a potential gladiolus variety is affected due to genetic and climatic factors. The genetic makeup of plant and climate determine important functions in shaping the characteristics and traits of the flowers (Mushtaq et al., 2013). Traits such as yield and quality in Gladiolus are influenced by multiple polygenically inherited characteristics. These traits are susceptible to changes in the environment, and the phenotypic expression of a particular genotype can vary under different agro-climatic conditions. (Ali et al., 2016) Factors such as temperature, light intensity, humidity, soil composition, and cultural practices can significantly impact the final yield and quality of Gladiolus flowers. It is crucial to understand the dynamic relationship between genotype and environment to effectively manage and optimize these traits in Gladiolus cultivation. Understanding adaptability and performance of gladiolus cultivars are crucial, particularly under specific climatic conditions. The responses of plants to environmental conditions vary based on the species, primarily due to the distinct morpho-physiological characteristics of each plant. These responses modify the genetic components of the different cultivars, which ultimately lead to shape their reactions to different climatic conditions (Akhtar et al., 2023). The subtropical region of Multan presents unique challenges for gladiolus cultivation, requiring the identification of cultivars that exhibit superior performance in terms of vegetative characteristics and yield components. However, there is a lack of technical knowledge on the varietal evaluation of gladiolus under the climate of Multan.

The primary objective of this study is to assess and compare various gladiolus cultivars in terms of their vegetative and reproductive components under the subtropical conditions of Multan. The study aims to evaluate the growth parameters of the cultivars, including their height, leaf area, and number of leaves. Additionally, inflorescence characteristics such as spike length, number of florets, and flower diameter will be evaluated. By analyzing the overall performance and adaptability of different cultivars, the study aims to provide practical recommendations for selecting suitable cultivars in the subtropical region of Multan. This research will contribute valuable information to assist the growers in maximizing their yields and optimizing the quality of gladiolus flowers for better economic return.

## Materials and Methods

### Experiment location

The present study was conducted to evaluate the gladiolus cultivars for the vegetative and reproductive components at field area of Floriculture Research Sub-station, Multan during the 1st week of October, 2021.

### Selection of plant material

In this investigation, four commercial gladiolus cultivars named "White prosperity", "Amsterdam", "Essential" and "Red balance" were planted for their performance evaluation.

### Land preparation and use of inputs

The land was properly prepared by ploughing and planking to pulverize the soil for efficient use of inputs. The recommended dose of FYM & 1/3rd dose of NPK was incorporated in the soil at the time of soil preparation. The remaining 2/3rd dose was applied in two equal split doses; half dose was used at three leaf stage of gladiolus and remaining half was before the emergence of spike of gladiolus. The raised ridges of 30 cm in height were made for the plantation of gladiolus.

### Seed treatment of gladiolus

The gladiolus corms were treated with aqueous solution of thiophenate methyl @ 3g per liter & corms were dipped for 30 minutes and were shade dried for 24 h before planting.

### Plantation of corms

The gladiolus corms of uniform size having circumference (10-12 cm) were planted with a planting geometry of 45 cm between the ridges and 15 cm within the plant-to-plant distance. The corms were planted at the top of ridges 6 cm deep within the soil.

After planting corms, irrigation was practiced immediately in the field. The pre-emergence weedicide was sprayed 24 h after plantation of corms to check out the weeds.

**Experimental design**

The RCBD design was used with three replications for each treatment. For each replication 30 numbers of corms were used. Total 360 corms of gladiolus cultivars were used in the experiment. The net land area for research trial was 84 $m^2$. The block size was maintained at 6x3.5 m for each treatment.

**Earthing up of gladiolus**

The 1st earthing up of soil was performed after 45 days of planting to encourage the strong roots system and better crop stand. The 2nd earthing up of plants was practiced before emergence of spike to protect the plants from lodging and breaking of spike against strong winds and rainfall. All other cultural practices such as irrigation, fertilization, weed management and plant protection measured were adapted uniformly to all treatments during the entire period of study.

**Harvesting of corms**

The corms of gladiolus were uprooted during the 2nd week of May, 2022 and were dried under cool and well-ventilated room for 15 days. The standardized post-harvest management of gladiolus was carried out after drying process.

**Collection of morphological data**

The observations for different parameters like sprouting (%), plant height (cm), number of leaves/ plant, leaf length (cm), leaf width (cm), number of floret/ plant, floret size (cm), number of days to spike emergence (days), days to blooming (days), length of spike (cm), corms/ and cormels production etc were recorded to understand the gladiolus cultivars response under subtropical condition of Multan.

**Study of physiological parameters**

**Determination of chlorophyll contents (mg/g)**

The concentrations of chlorophyll a and chlorophyll b were determined using the method described by (Taiz and Zeiger, 2002). Leaf samples stored at -80 degrees Celsius were melted and 0.5 grams of each treatment were crushed in a 5 ml acetone solution (80%). The resulting crude extract was then refrigerated overnight at 4 degrees Celsius. Extraction was followed by centrifugation for 5 minutes, and the resulting solution was used for quantifying the levels of chlorophyll a and chlorophyll b using a spectrophotometer at 645 nm and 663 nm, as specified in the equations provided.

$$\text{Chl a(mg g-1 FW)} = [12.7(OD663) - 2.69(OD645)] \times (V/1000) \times W$$

$$\text{Chl b(mg g-1 FW)} = [22.9(OD645) - 4.68(OD663)] \times (V/1000) \times W$$

**Analysis of Anthocyanin and flavonoid contents (mg per 100 $g^{-1}$ FM)**

Anthocyanin and flavonoid contents were analyzed by the procedure as reported by (Amarante et al., 2017). The petals of flower were processed using an extracting solution (ethanol 95%: HCl 1.5 N - 85:15. v/v) and kept at 4°C for 12 hours for the analysis of anthocyanin and flavonoid. The mixture was obtained after filtration process of plant material. The spectrophotometer was utilized to determine the absorbance of anthocyanins at an electromagnetic wavelength (λ) of 535 nm, and flavonoids at a wavelength of 374 nm.

**Measurement of total phenolic content (TPC mg GAE$g^{-1}$ FM) and total antioxidant activity (TAA %)**

The method for obtaining hydro-alcoholic extract for the measurement of Total Phenolic Content (TPC) and Total Antioxidant Activity (TAA) was outlined by (Amarante et al., 2019). So, we took 10g of flowers that we had treated and soaked them in some methanol solution that was 50% concentration. We left them there for an hour. Then, we spun the mixture really fast in a centrifuge at 5,000 rpm for half an hour. The liquid that ended up on top after all that spinning was kept aside, while the solid stuff that was left behind was put through another extraction with some acetone that was 70% concentration. After 60 minutes, a second centrifugation was performed to separate the material. The final supernatant was then combined with the former material, resulting in a total volume of 100 ml when mixed with distilled water.

**Data analysis**

Analysis of variance (ANOVA) was performed for data analysis and LSD test @ 5% was applied to compare average values of different parameters by using statistical software statistix 8.1.

## Results

**Corm sprouting (days)**

The results of study revealed that significant differences were recorded in the vegetative parameters of four different gladiolus cultivars under climatic conditions of Multan (Table 1). It was observed that smaller number of days (16.21) and (17.98) for sprouting of gladiolus corms were noted in cvs. Amsterdam and White prosperity respectively. The maximum

number of days (22.28) & (20.393) for sprouting of corms were investigated by cvs. Essential this was statically similar with cvs. Red Balance.

**Table 1** Response of different growth parameters of gladiolus cultivars under agroclimatic conditions of Multan

| Cultivars | Corm sprouting (days) | Plant height (cm) | Number of leaves | Leaf length (cm) | Leaf width (cm) |
|---|---|---|---|---|---|
| White prosperity | 17.98bc | 98.42b | 10.13 | 48.15a | 4.65 |
| Amsterdam | 16.21c | 112.50a | 9.62 | 43.86b | 4.58 |
| Essential | 22.28a | 96.74b | 9.63 | 38.82c | 3.37 |
| Red balance | 20.39ab | 93.67c | 9.19 | 40.77c | 3.50 |
| LSD value @ 5% | 2.61 | 2.57 | 2.57 | 2.61 | 1.50 |

Mean sharing different letters differ significantly at 5 % level of significance.

**Plant height (cm)**

It was concluded from the findings that the maximum plant height (112.50 cm) was measured in the cultivar Amsterdam. Intermediate plant height (98.42 cm) & (96.74 cm) was noticed in cvs. White prosperity and Essential which were statistically at par with each other. The lowest plant height (93.67 cm) was recorded in Red Balance cultivar.

**Number of leaves/plant**

The data showed that number of leaves of different gladiolus cultivars were not statistically significant from each other. However, the highest number of leaves (10.13) were produced by cultivar White prosperity which were statistically similar with cultivars Essential (9.63), Amsterdam (9.62) and Red Balance (9.19) respectively.

**Leaf length (cm)**

The study depicted that gladiolus cultivars, White prosperity (48.15 cm) and Amsterdam (43.86 cm) produced longer leaves as compared to other cultivars. The lowest leaf length was measured in cultivars Red Balance (40.77 cm) and Essential (38.82 cm).

**Leaf width (cm)**

The broader leaves were found in White prosperity (4.65 cm) and Amsterdam (4.58 cm) which were statistically not different from each other while minimum leaf width was measured in Red Balance (3.50 cm) & Essential (3.37 cm).

**Table 2** Evaluation of different flowering parameters of gladiolus cultivars under Multan agro-climatic conditions

| Cultivars | Spike initiation (Days) | Number of days for blooming | Spike length (cm) | Rachis length (cm) | Number of florets/spike |
|---|---|---|---|---|---|
| White prosperity | 72.23c | 85.18c | 78.08b | 70.21b | 18.38a |
| Amsterdam | 68.18d | 84.21c | 92.16a | 74.97a | 16.76a |
| Essential | 75.80b | 90.80b | 76.40b | 61.40c | 12.48b |
| Red Balance | 80.19a | 95.19a | 77.34b | 62.34c | 14.14b |
| LSD value @ 5% | 2.25 | 2.15 | 2.57 | 2.50 | 2.57 |

Mean sharing different letters differ significantly at 5 % level of significance

**Spike initiation (Days)**

Results demonstrated that variations regarding flowering characteristics of gladiolus cultivars were highly significant as presented in (Table 2.) It was evident that early spike initiation was exhibited by Amsterdam (68.18 days) followed by White Prosperity which took 72.23 number of days for spike emergence. Late spike emergence was noted in gladiolus cvs. Red Balance (80.19) and Essential (75.80) respectively.

**Number of days for blooming**

Remarkable changes for blooming of gladiolus cultivars were recorded. It was noted that the minimum number of days (84.21) and (85.18) for blooming were recorded in cvs. Amsterdam and white prosperity respectively. While longer duration for blooming of gladiolus was taken by cv. Red balance (95.19 days) followed by cv. Essential with 90.80 days.

**Spike length (cm)**

The findings explained that spike length was influenced in different gladiolus cultivars. It was observed that Amsterdam had the longest spike length (92.167 cm). While cv. White Prosperity, Essential, and Red Balance attained the shorter spike lengths with values (78.083 cm), (76.403cm), and

(77.34cm), respectively.

**Rachis length (cm)**

The rachis length was recorded the highest in Amsterdam (74.97 cm) followed by white prosperity with rachis length (70.21 cm). The gladiolus cultivars Red Balance and Essential exhibited short rachis length (cm) (62.34) and (61.40) respectively.

**Number of florets/spike**

The greater numbers of florets were observed in White Prosperity (18.38) which was statistically not different from gladiolus cultivar Amsterdam (16.767). The gladiolus cultivar red balance produced (14.14) number of florets per spike followed by essential (12.48) with minimum florets per spike.

**Table 3** Yield attributes and vase life as affected in different gladiolus cultivars under Multan conditions

| Cultivars | Floret diameter (cm) | Corm diameter (mm) | Corm weight (g) | No. of corms/ plant | Number of cormels/ plant | Vase life (days) |
|---|---|---|---|---|---|---|
| White prosperity | 9.48a | 45.63b | 45.48b | 2.50a | 85.38a | 14.23 |
| Amsterdam | 10.31a | 50.46a | 60.21a | 1.66b | 40.46b | 14.41 |
| Essential | 8.41b | 37.58d | 35.58d | 1.41b | 32.48c | 12.98 |
| Red Balance | 8.67ab | 41.99c | 40.43c | 1.08c | 19.74d | 13.84 |
| LSD value @ 5% | 1.80 | 2.61 | 2.61 | 0.27 | 2.57 | 2.57 |

Mean sharing different letters differ significantly at 5 % level of significance

**Floret diameter (cm)**

The yield parameters and vase life of different gladiolus cultivars under investigation are shown in Table 3. The findings of study predicted that the highest floret diameter was noticed in Amsterdam (10.31 cm) and white prosperity (9.48 cm). While smaller floret size was exhibited in Red balance (8.67cm) and Essential (8.41 cm).

**Corm diameter (mm)**

The larger sized corm was recorded in Amsterdam (50.46) which was statistically similar to the corm size (45.63 mm) of white prosperity. Red balance produced medium corm size of (41.99 mm). The shorter corms size was noted in Essential (37.58 mm).

**Corm weight (g)**

The heavy corm weight was recorded in Amsterdam (60.21 g) followed by white prosperity (45.48 g). While average corm size was observed in cvs. Red balance (40.43 g) and Essential (35.58 g).

**No. of corms/ plant**

The production of corms was higher in white prosperity (2.50) as compared to other gladiolus cultivars. The minimum numbers of corms were yielded by cvs. Amsterdam (1.66) and Essential (1.41) which were statistically at par with one another. The minimum daughter corms (1.08) were recorded in Red Balance Gladiolus cultivar.

**Number of cormels/ Plant**

The maximum quantity of cormels per plant was obtained in cvs. White Prosperity and Amsterdam with average values (85.383) and (40.467) respectively. The average numbers of cormels were obtained in Red Balance (19.74). The lowest numbers of cormels were found in cv. Essential (32.48).

**Vase life (days)**

The study explained that maximum vase life was reported by Amsterdam (14.41) and white prosperity (14.233) respectively. While Red balance and Essential gladiolus cultivars presented lowest vase life of 13.84 and 12.98 days.

**Table 4** Physiological parameters as influenced in different gladiolus cultivars under Multan conditions

| Cultivars | Anthocyanin **(mg 100 g-$^{1}$)** | Flavonoids (mg 100 g-$^{1}$FM) | Total phenolic compounds (TPC; mgGAEg-$^{1}$FM) | Total antioxidant activity (TAA; %) | Chlorophyll a (mg/g) | Chlorophyll b (mg/g) |
|---|---|---|---|---|---|---|
| White prosperity | 0.35b | 51.78b | 151.96a | 84.51b | 1.41ab | 1.73b |
| Amsterdam | 0.63b | 61.76a | 158.78a | 92.46a | 1.79a | 2.33a |
| Essential | 0.36b | 41.38c | 138.90b | 91.56a | 1.40ab | 1.81b |
| Red Balance | 3.09a | 38.10c | 141.05b | 82.61b | 1.24a | 1.59b |
| LSD value @ 5% | 0.34 | 5.52 | 7.58 | 6.01 | 0.40 | 0.40 |

Mean sharing different letters differ significantly at 5 % level of significance.

**Anthocyanin contents. (mg 100 g$^{-1}$)**

It is evident from the data that different physiological parameters were significantly influenced in different gladiolus cultivars when planted under Multan agroclimatic conditions as presented in Table 4. The maximum anthocyanin contents (3.09) were recorded in cvs. Red balance followed by Amsterdam (0.63), Essential (0.36) and White prosperity (0.35).

**Flavonoids (mg 100 g$^{-1}$)**

The study revealed that flavonoids contents were found significant in different gladiolus cultivars. The study indicated that more flavonoids contents (61.76) and (51.78) were yielded in Amsterdam and White prosperity gladiolus cultivars. However, flavonoids contents calculated in Essential and Red Balance were 41.38 and 38.10 respectively.

**Total phenolic compounds (mg GAEg$^{-1}$ FM)**

Total phenolic compounds were observed highest (158.78) and (151.96) in cvs. Amsterdam and White prosperity. Similarly, Red Balance and Essential cultivars produced lowest total phenolic compounds with mean values of 141.05 and 138.90 respectively.

**Total antioxidant activity (TAA %)**

It was depicted from the results of study that total antioxidant activity was greatly differed among gladiolus cultivars. The maximum total antioxidant activity was noticed in Amsterdam (92.46) which was statistically at par with Essential (91.56). The average total antioxidant activity was documented in White prosperity (84.51) and minimum was recorded in Red Balance (82.61).

**Chlorophyll a (mg/g)**

It is evident from the study that chlorophyll "a" contents were significantly changed in gladiolus cultivars. The chlorophyll a was recorded highest (1.79) in Amsterdam which was statistically insignificant with White prosperity (1.41) and Essential (1.40) followed by Red Balance (1.24).

**Chlorophyll b ((mg/g)**

The results exhibited that chlorophyll b contents were found remarkably increased in different gladiolus cultivars. The greater chlorophyll b contents (2.33) were observed in Amsterdam followed by White prosperity (1.73) which was statistically similar with Essential and Red Balance with 1.81 and 1.59 chlorophyll b contents respectively.

## Discussion

The findings of the study explained that different gladiolus cultivars significantly indicated variations in their physical and floral traits under agroclimatic conditions of Multan. Corm sprouting in term of days depends on different factors like corms size, planting time, genetic characters of varieties and environmental factors but genetic factor is mostly prominent. Corm sprouting is governed by the production of specific plant growth regulars which break the dormancy and induce initiation of sprouting. The different gladiolus cultivars exhibited significant number of days for sprouting of corms. Our results are in line with the investigation of (Swaroop et al., 2017; Mushtaq et al. 2018; Bharti et al., 2021). The deviation of plant height in different cultivars of gladiolus is attributed due to the collective response of growing conditions of environment and inherited character of the plant. In different gladiolus cultivars similar results were observed by (Kumari & Kumar, 2015; Verty et al., 2017; Fatihullah et al., 2018; Azimi, 2020; Parmanand Sen & Ramshankar Pawak, 2021) and (Swaroop et al., 2022) Variation in number of leaves per plant in different genotypes of gladiolus has also been reported. The genetic make-up of plants and environmental conditions determine the differences in number of leaves/plant. However, hereditary traits of different gladiolus cultivars and environments are responsible for variation in number of leaves per plant. Our findings are in conformity with the results of (Zubair et al., 2013; Bhujbal et al., 2013; Prasad, 2019). The differences in leaf length and width of plant might be due to genotypic and phenotypic characteristics of plant species.

Certain climatic conditions also influence physical & flowering parameters of gladiolus (Saleem et al., 2013; Swaroop et al., 2016; Singh et al., 2020; Swaroop et al., 2022). Number of days for spike emergence was significantly influenced in gladiolus cultivars. The variation for the emergence of spike might be due to environmental and genetic factors of plants. Moreover, the spike initiation depends on the growth and accumulation of sugar reserves in plant body during growth period of plant. The results of study are in accordance with the findings of (Sudhakar and Kumar, 2012; Chourasia et al., 2015; Singh et al., 2020). Some gladiolus varieties show early blooming as compared to other varieties. A specific variety of gladiolus required a certain period for appearance of flowering. The induction of early flowering may be inherited behavior of different varieties with respect to flowering over other varieties. Furthermore, the possible reason for blooming is associated with the accumulation of food reserves in plant body. Our findings are in conformity with the study of (Shaukat et al., 2012; Chourasia et al., 2015; Singh et al., 2020). It is reported that spike length is a crucial part of plant which is preferable over other floral characters of gladiolus. Varieties with longer inflorescence length are highly demanded in the market. Modifications in the spike length may be due to genetic composition of various genotypes of gladiolus. Similar investigations were recorded by (Swaroop et al., 2017; Bharti et al., 2021; Swaroop et al., 2022).

Our findings demonstrated that rachis length was found significant in different gladiolus cultivars. Rachis length is

inherited character of plants which is variable in different varieties of gladiolus. Environmental conditions may also contribute for diversification of rachis length (cm) among gladiolus germplasms. These results were found in conformity with the outcome of (Mushtaq et al., 2018; Azimi, 2020; Singh et al., 2020). The numbers of florets per spike were affected with highly visible variations among different gladiolus cultivars. The variations in number of floret/spike are determined by genetic transformation of plant species and it is inherited characters which differ in plant genotypes. Similar observations were reported by (Singh et al., 2020; Swaroop et al., 2021; Goyanka & Singh, 2021). Floret diameter was slightly influenced in gladiolus cultivars. Diameter of floret is associated with genetic character of plant. The nutritional status of soil and other cultural practices determine the floret diameter (cm) of gladiolus. (Maurya et al., 2017; Safeena and Thangam, 2019; Gautam and Sarvanan, 2020). Corm diameter was greatly different in gladiolus cultivars. It might be due genetic and climatic factors of plants. Favorable environmental conditions, preferably light and temperature might be the main reasons for the production of bigger corms. Our results are in accordance with the work of (Churasia et al., 2015; Naresh et al., 2015; Azimi, 2020) who studied that corm diameter may vary in different gladiolus verities. Significant results were observed for corm weight production in different gladiolus cultivars. The variation in corms weight is attributed due to genetic and environmental factors. Variation in corm weight (g) were explained by (Chopde et al., 2012; Safeena and Thangam, 2019; Azimi, 2020). Similar findings were studied by (Swetha et al., 2019; Kumar et al., 2019; Swaroop et al., 2022). The number cormels production/ plant were significantly different in gladiolus varieties. It might be due different genetic factor which is responsible for the multiplication of cormels per plant under suitable climatic conditions. It was studied that high temperature accelerates the formation of cormels. (Thakur et al., 2015). The present results are in conformity with the reports of (Safeena and Thangam, 2019; Goyanka & Singh, 2021). It was observed that no significant variations in vase life were noticed. The variation in vase life of spike may be due to genetic attributes of plant which may vary in different genotypes of gladiolus. Production of ethylene level in plant body after harvesting influences the vase life of the plant. Environmental conditions and post-harvest operations determine the vase life of flower (Azimi and Banijamali, 2019; Goyanka & Singh, 2021).

Physiological characteristics play a crucial role in influencing the growth and development of gladiolus plants. These parameters comprise a range of biological processes that are fundamental for the overall health, strength and productivity of the plants. The physiological parameters of various gladiolus cultivars revealed significant differences under agro-climatic conditions of Multan. The variations in different physiological traits such as anthocyanin contents, flavonoids contents, total phenolic compounds, total antioxidant activity and chlorophyll contents in different gladiolus genotypes might be due to various factors such as genetic traits, environmental conditions, nutrition, and developmental stages of plant. Different plant species constitute dissimilarities in physiological components of plants due to environment and genetic makeup. Additionally, the analysis of plant morphology and physiology in relation to various environmental conditions is dependent upon the specific genotypes present and their interaction with the surrounding environment. Similar results were reported by findings of previous studies (Fanourakis et al., 2012; Islam, 2016; Kim et al., 2016; Souza et al., 2021). Various cultivars exhibit diverse response to environmental conditions for growth as evidenced by the markedly significant variations in biochemical pigments in gladiolus (Akhtar et al., 2023). Similarly, deviations in physiological analysis were also confirmed in gladiolus. It has also been reported from earlier studies that genotypes of gladiolus exhibit the outstanding genetic diversity mainly attributed to its wide range of species tendency to crossbreed and high level of heterozygosity for physiological attributes. Moreover, a significant level of variability was found in 35 morpho-physiological traits within its gladiolus germplasm. (Singh et al., 2017; Hiremath et al., 2023; Nazir et al., 2023).

## Conclusion

It is explored from findings of study that significant variations were observed among gladiolus cultivars for growth, flowering and corms propagation attributes under agro-climatic conditions of Multan. It was found that Amsterdam presented outstanding performance for different traits such the highest plant height, longer spike, wide corm diameter and prolonged vase life. While white prosperity displayed heavier corm weight and more shelf life. Moreover, physiological parameters like flavonoids, total phenolic, total antioxidant, chlorophyll a and chlorophyll b were documented maximum in Amsterdam. It is suggested that both cultivars: Amsterdam and White Prosperity are the most suitable for commercial cultivation and cut flower production in this region. The study findings will lead to enhance quality production of cut flower on commercial scale and will establish a supply chain of gladiolus production for floral market in the region.

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