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RESEARCH ARTICLE

Evaluation of Various Exotic Gladiolus Cultivars Through Staggered Planting in Subtropics

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ABSTRACT

Gladiolus (Gladiolus L. hybrids), a member of the family of Iridaceae, is also known as the "queen of bulbous flowers" in floral markets worldwide. It has high demand and potential due to its exceptional color, size, and reasonably long vase life. There is a dire need to standardize its early, mid-season, and late-season cultivars to achieve sustainable production throughout the season with high-quality stems. Therefore, a study was conducted to optimize planting time for different exotic cultivars through staggered planting at Institute of Horticultural Sciences, University of Agriculture, Faisalabad, Pakistan. Results demonstrated that the longest vase life was recorded in 'Manhattan' (10.9 d), 'Mix' (10.8 d), 'Comedy' (10.6 d), and 'Amsterdam' (10.5 d), followed by 'Almerim' (9.8 d), 'Adrenalin' (9.4 d), and 'Advance red' (9.0 d). Whereas, the shortest vase life was recorded in 'Merry' (7.5 d). The shortest production time was recorded in 'Merry' (96.6 d), followed by 'Advance Red' (97.3 d), 'Adrenalin' (98.3 d), and 'Almerim' (100.6 d). Longest days to flower were recorded in 'Rosie Bee' (115.1 d). The least time to 50% sprouting was recorded in 'Merry (9.0 d), followed by 'Almerim' (11.3 d), 'Rosie Bee' (14.1 d), and 'Mix' (14.0 d). The greatest plant height was recorded in 'Kir Royal' (82.9 cm), 'Advance Red' (82.3 cm), 'Almerim' (81.7 cm), followed by 'Nova Zambla' (80.1 cm). The shortest plant height was recorded in 'Merry' (35.5 cm). The highest sprouting percentage was recorded in 'Merry' (90.8%), 'Bangladesh' (90.2%), 'Adrenalin (89.2%), and 'Manhattan' (89.1%), whereas the least sprouting percentage was recorded in 'Chanson' (66.2%), 'Magma' (67.9%) and 'Cassis' (69.1%). The greatest number of cormels were produced in 'Adrenalin' (10.1), 'Comedy' (9.2), 'Manhattan' (8.8), 'Almerim' (8.5), 'Mix' (8.4) and 'Amsterdam' (7.1). Cormel diameter was recorded highest in 'Adrenalin' (47.8 mm), 'Bangladesh' (41.2 mm), 'Chanson' (40.0 mm), and 'Cayyene' (39.6 mm). In summary, early planting of all tested cultivars in September and October performed best regarding growth attributes and vase life of cut stems; however, late planting in November and December failed to produce marketable cut stems for over 2/3rd of the crop and exhibited weak response in all growth attributes. Among all tested gladiolus cultivars, 'Kir Royal', 'Manhattan', 'Almerim', 'Adrenalin', and 'Advance Red' exhibited good quality stems with longer vase life. 'Merry' and 'Mix' were early cultivars, while 'Rosie Bee', 'Lemon Drop', and 'Nova Zambla' were late cultivars. Therefore, the gladiolus corms may be planted in early September till the end of October to get the best quality stems with longer vase life for commercial production and marketing in subtropics.

Key words: Cut flowers, Cormels, Floral traits, Vegetative attributes, Vase life, Spike quality.

INTRODUCTION

Floriculture is a highly competitive and rapidly growing business worldwide. The cut flower production industry has shifted to a favorable climatic region where production inputs are lower compared to traditional flower grower regions (Hussain et al., 2025). Cut flowers contribute around 45% share of the total global trade in

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floricultural commodities. According to the ITC report, there is around 9% annual increase in global floriculture trade, along with a 17% increase in trade share of growing countries (Augiar et al., 2022). Commercial Cut flower production in Pakistan is currently restricted to limited regions, and not much importance has been given to this lucrative business in the past.

Gladiolus, commonly known as sword lily, or queen of ornamental bulbous crops, is an important cut flower with classic spikes having glamorous florets of varying sizes and colors, propagated through corms and cormlets asexually (Moradi and Azimi, 2017). Commercially, gladiolus is used for cut flower, while occasionally it is used for various landscape purposes as well (Poon et al., 2012). Gladiolus production is mostly done in tropical and subtropical countries around the world, having great economic value as a cut flower and for decor (Anonymous, 2015). Gladiolus had been cultivated around the world since the late 16th century. The most important producers of gladiolus are the United States of America, the Netherlands, France, Portugal, Italy, Belgium, Brazil, Australia, Pakistan, and India (Azimi, 2020).

Flower production is a lucrative enterprise that ensures remarkable profit in contrast to other horticultural crops (Hussain et al., 2024). Production of cut flowers in Pakistan is found to be almost ten to twelve thousand tons annually (Khan et al., 2011). Cut flower demand and production showed a reasonable increase during the last decade and are expected to increase further in the countryside (Ahmad et al., 2025). Fertile soils and conducive environmental conditions favor commercial flower production in Pakistan, which should be wisely utilized (Ahmad et al., 2008). Cut gladiolus production in Pakistan is less than its demand due to a lack of proper knowledge about its production technology and knowledge of suitable planting time for various cultivars. An experiment was conducted to evaluate the best planting times for various exotic cultivars through staggered plantings. Mostly, growers are unaware of the growth response of different cultivars with respect to the planting time in different regions, there is prime importance to identify the accurate and most suitable planting time for gladiolus to get the best quality cut stems production.

In Pakistan, the climatic conditions of Faisalabad are considered favorable for the commercial production of gladiolus, because temperature, humidity, rainfall, and photoperiod are conducive to gladiolus cultivars. However, present research was conducted to evaluate various exotic cultivars of gladiolus and to explore the best planting time for commercial production of gladiolus in Faisalabad. This experiment may assist commercial growers by providing them with proper information regarding the diversification of cultivars and cultural requirements, for the quality production of cut stems with longer vase life, which will be a leading step towards flourishing the cut flower industry in Pakistan. It was hypothesized that the provision of favorable growth conditions through optimal planting time would improve quality, vegetative and floral growth, and yield of cut gladiolus cultivars.

MATERIALS AND METHODS

Experimental Site

An experiment was conducted at Floriculture Research Area, Institute of Horticultural Sciences, University of Agriculture, Faisalabad, Pakistan, to assess the best planting time for the evaluation of thirty exotic cultivars of gladiolus through staggered plantings on morphological, yield, and quality attributes for commercial recommendation.

Planting Times and Exotic Cultivars

Plantings were carried out on 20th September, 20th October, 20th November, and 20th December, 2021. Corms of thirty exotic cultivars, viz., 'Adrenalin', 'Advance Red', 'Almerim', 'Amsterdam', 'Bangladesh', 'Beach Party', 'Cantate', 'Cartago', 'Cassis', 'Chanson', 'Chapel Hill', 'Comedy', 'Cayenne', 'Essential', 'Grand Prix', 'Hunting Song', 'Kir Royal', 'Lemon Drop', 'Magma', 'Manhattan', 'Merry', 'Milka', 'Mix', 'Nova Zambla', 'Polar Bear', 'Red Balance', 'Rose Supreme', 'Rosie Bee', 'Violata' and 'White Prosperity' were obtained from a local supplier of Stoop Flowers Bulbs Company of Holland in Lahore, Pakistan. Corms were shipped from the cold store in Lahore, after import from the Netherlands in a reefer truck. On arrival, all corms were grouped into four groups for staggered planting, and each group was kept in the lab at ambient conditions for one week before planting to acclimatization. The rest of the corms were kept in a cold store at 1± 4°C.

Land Preparation Intercultural Practices

Soil preparation and all cultural practices like IPM, fertilization, irrigation, staking, and weeding were similar for all treatments during the entire experiment period. Soil and water analysis and meteorological data during the course of the experiment were also collected. Before planting, all corms were dipped in a fungicide, Rodomel Gold solution, @ 2 g per liter of water for five minutes, and after treatment dried under shade before planting. There were twenty corms planted in each replication of all thirty cultivars. In this experiment, planting distance was maintained at 15 cm between corms, and the planting depth of the corms was kept at 5-8 cm. Corms were planted on ridges, spaced at 60 cm. The experiment was executed according to a factorial design, and four planting times were laid out in main plots, which are listed below, while cultivars were randomized in subplots, as depicted in (Fig. 1). Planting times included: 1 = Sep. 20, 2021, 2 = Oct. 20, 2021, 3 = Nov. 20, 2021, 4 = Dec. 20, 2021.

Soil and irrigational water analysis

Before the start of the experiment, trial, soil samples were collected randomly from different blocks

Fig. 1: Pictorial representation of fungicidal treatment of corms and layout preparation.

Fig. 2: Pictorial representation of corms sprouting, flower initiation in gladiolus.

of the field to check physico-chemical characteristics (EC, organic matter, pH, texture, saturation %age, and N, P, K, Zn, B, Mn, and Fe contents) of the experimental soil. The results regarding soil characteristics were pH (8.1), organic matter (0.88%), EC (0.67 dS m^{-1}), nitrogen (0.04%), phosphorus (4.2 mg kg^{-1}), potassium (300 mg kg^{-1}), zinc (0.5 mg kg^{-1}), iron (2.8 mg kg^{-1}), boron (0.1 mg kg^{-1}), manganese (1.2 mg kg^{-1}), saturation (36%), sand (45%), silt (27.5%), clay (27.5%) with loamy texture. Water samples from canal used to irrigate the experiment were collected to estimate physico-chemical characteristics, viz., pH (6.4), EC (0.2 dS cm^{-1}), TSS (142 ppm), calcium (1.2 me/L), sodium (0.2 me/L), bi-carbonate (1.6 me/L), chloride (0.2 me/L), sodium absorption ratio (0.2 SAR), magnesium (0.8 me/L), total hardness (99.8 ppm), potassium (0.07 me/L) which was considered fit quality for irrigation.

STATISTICAL ANALYSIS

The experiment had three replications with four planting times and thirty exotic cultivars of gladiolus, which were laid out in a Randomized Complete Block Design (RCBD) with factorial arrangements. Data were analyzed using the analysis of variance (ANOVA) technique, followed by Tukey's test with the least significant difference test at P≤0.05. (Steel et al.,1997).

RESULTS

Results depicted significant differences among the recorded vase life of the tested gladiolus cultivars. Some early, mid-season, and late varieties of gladiolus exhibited the longest vase life: 'Manhattan' (10.9 d), 'Mix' (10.8 d), 'Comedy' (10.6 d), 'Amsterdam' (10.5 d), 'Nova Zambla' (10.0 d), and were statistically at par. Whereas, 'Almerim' (9.8 d), 'Lemon drop' (9.6 d), 'Adrenalin' (9.4 d), 'Advance Red' (9.0 d), and 'Rosie bee' (8.7 d) also exhibited longer vase life. A mid-season variety 'Merry' (7.5 d) exhibited the shortest vase life, as exhibited in Fig. 3 (a).

Fig. 3: Vase life evaluation of gladiolus cultivars.

Planting times remarkably influenced the time to 50% sprouting of gladiolus. Among tested treatments, the shortest time to 50% sprouting was recorded in the last planting time, viz., 20 Dec 2021 (11.9 d), followed by the third sowing time, viz., 20 Nov. 2021 (12.3 d). Shortest days to 50% sprouting were taken by 'Merry' (9.0 d) and 'Almerim' (11.3 d), whereas the longest time to 50% sprouting was taken by 'Rosie Bee' (14.1 d) and 'Mix' (14.0 d). The highest sprouting (%) was recorded in the first planting time, viz., 20 Sept 2021(89.1%), followed by the 2nd planting time (85.3%).

The least sprouting percentage (67.3%) was recorded during the last planting time on 20 December 2021. Among cultivars, 'Merry' (90.8%), 'Bangladesh' (90.2%), 'Adrenalin' (89.2%), and 'Manhattan' (89.8.1%) exhibited the greatest sprouting (%) in all the cultivars. The least sprouting (%) was recorded in 'Chanson' (66.2%), 'Magma' (67.9%), and 'cassis' (69.1%). Cultivars planted early in September-October exhibited the highest sprouting percentage.

The least production time was recorded in 'Merry' (96.6 d), 'Advance red' (97.3 d), 'Adrenalin' (98.3 d), and 'Almerim' (100.6 d). Whereas the longest production time was recorded in 'Rosie bee' (115.1 d), 'Lemon drop' (104.6 d), and 'Nova zambla' (103.0 d).

Planting times significantly influence the plant height of gladiolus. Among the various cultivars and treatments, the highest plant height was recorded in the first planting (76.6 cm) (20, Sep 2021), followed by the second planting (73.6cm) (20, Oct 2021), and the fourth planting (67.7cm) (20, Dec 2018) occupied the bottom position in all the treatments that were studied. The environmental conditions during September were around 36°C temperature with 61% R.H. and around 12 h of photoperiod. Among cultivars, 'Kir Royal' (82.9cm), 'Advance Red' (82.3cm), 'Cartago' (82.0cm), and 'Amerim' (81.7cm) exhibited maximum plant height in all the cultivars. Among all tested cultivars, 'Merry', (35.5cm), 'Rosie Bee' (46.7cm), 'Hunting Song' (46.1cm), and 'Violata' (65.7cm) exhibited the shortest plant height.

The greatest leaf area (cm2) was recorded in the first planting (55.6 cm2) (20, Sep 2021), followed by second planting (53.1 cm2) (20, Oct 2021) and the fourth planting (47.2 cm2) (20, Dec 2021) occupied the bottom position in all the treatments that were studied. Among cultivars, 'Comedy' (70.4 cm2), 'Adrenalin' (69.5 cm2), 'Mix' (60.2 cm2), and 'Red Balance' (58.1 cm2) exhibited the greatest leaf area (cm2) in all the cultivars. Among all tested cultivars, 'Merry' (39.1 cm2), 'Rosie Bee' (41.5 cm2), 'Grand prix' (44.4 cm2), and 'Hunting Song' (44.6 cm2) exhibited the shortest leaf area (cm2).

The greatest leaf total chlorophyll contents (SPAD) were recorded in the first planting (59.2 SPAD) (20, Sep 2021), followed by the second planting (56.7 SPAD) (20, Oct 2021) and the fourth planting (53.8 SPAD) (20, Dec 2021), which occupied the bottom position in all the treatments that were studied.

Among cultivars, 'Amsterdam' (69.1 SPAD), 'Bangladesh' (62.7 SPAD), 'Polar Bear' (62.5 SPAD), and 'Violata' (59.2 SPAD) exhibited the greatest leaf total chlorophyll contents in all the cultivars. Among all tested cultivars, 'Magma' (48.3 SPAD), 'Red Balance' (50.4 SPAD), 'Cassis' (50.5 SPAD), and 'Beach Party' (51.3 SPAD) exhibited the shortest leaf total chlorophyll contents. The highest number of florets per spike was recorded in the first planting (12.3) (20, Sep 2021), followed by the second planting (11.5) (20, Oct 2021) and the fourth planting (10.7) (20, Dec 2021), which occupied the bottom position in all the treatments that were studied.

Among cultivars, 'Comedy' (13.6), 'Essential' (13.4), 'Mix' (13.4), and 'Kir Royal' (13.2) exhibited the highest number of florets per spike in all tested cultivars. 'Hunting Song' (6.5), 'Red Balance' (8.6), 'Rosie Bee' (8.1), and 'Chapel Hill' (9.7) exhibited the shortest number of florets per spike. Among cultivars, 'Adrenalin' (50.9cm), 'Beach Party' (44.6cm), 'Mix' (40.8cm), and 'Kir Royal' (40.7cm) exhibited the longest length of spike in all the cultivars. Among all tested cultivars, 'Merry', (20.1cm), 'Hunting Song' (24.1cm), and 'Rosie Bee' (22.9cm) exhibited the shortest length of spike. Among cultivars, 'Cassis' (8.8), 'Hunting Song' (8.7), 'Nova Zambla' (8.6), and 'Cayyene' (8.6) exhibited excellent spike quality in all the cultivars. Among all tested cultivars, 'Milka', (7.3), 'Merry' (7.5), and 'Grand Prix' (7.3) exhibited medium spike quality.

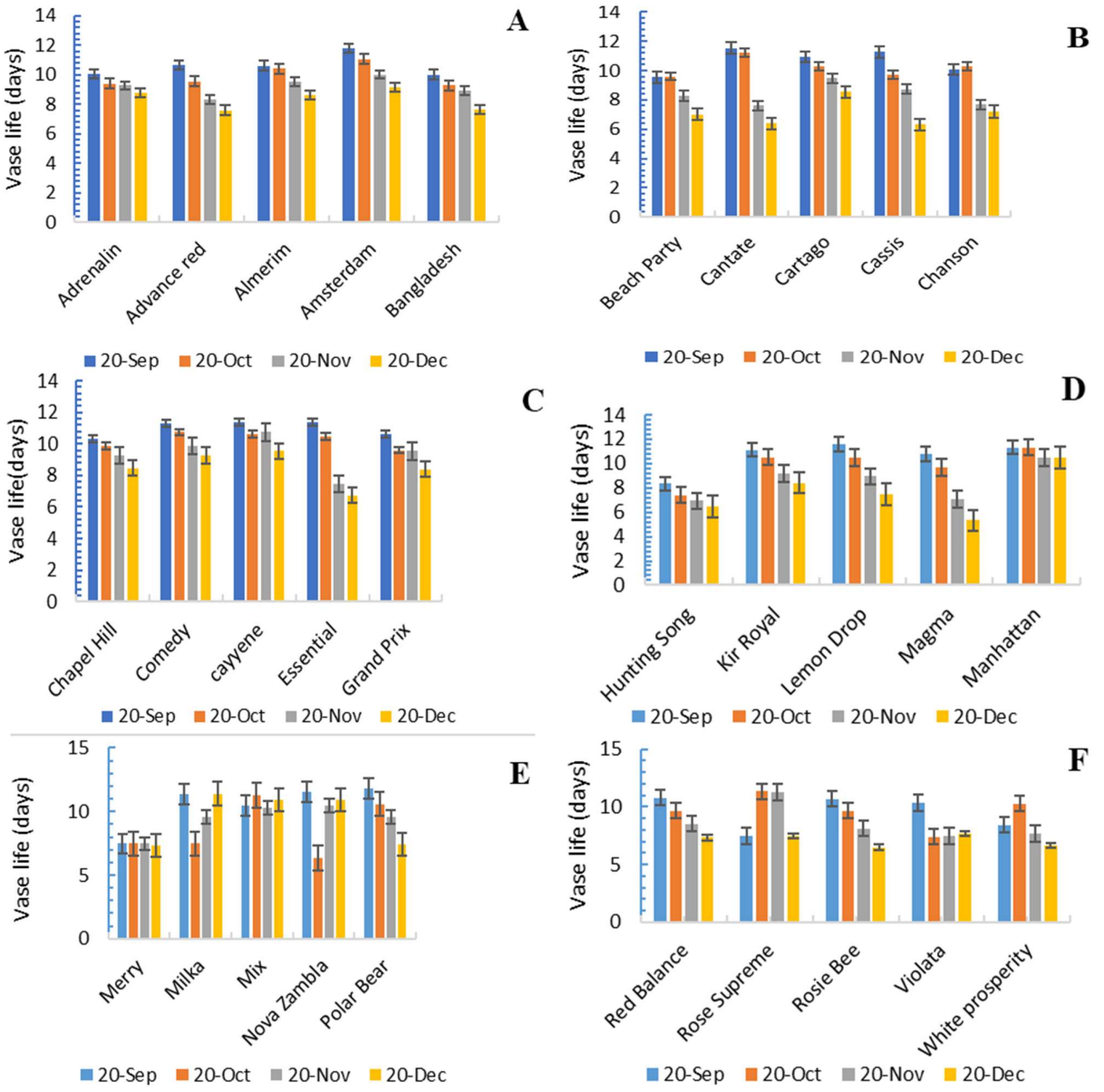

Fig 3 (a). Effect of various planting times on vase life (days) of thirty exotic gladiolus cultivars. Bars represent means of 30 stems ± S.E.

Among cultivars, 'Cartago' (8.9 mm), 'Almerim' (7.9 mm), 'Cantate' (7.9 mm), and 'Nova zambla' (7.7 mm) exhibited the highest spike diameter in all the cultivars. Among all tested cultivars, 'Merry', (4.9 mm), 'Chapel Hill' (5.9 mm), and 'Rosie Bee' (5.2 mm) exhibited the smallest spike diameter. 'Adrenalin' (70.6 mm), 'Almerim' (70.6 mm), 'Bangladesh' (65.5 mm), and 'Polar Bear' (64.4 mm) exhibited the highest floret diameter in all the cultivars.

Among all tested cultivars, 'Merry' (41.1mm), 'Advance Red' (41.3 mm), and 'Rosie Bee' (46.1mm) exhibited the shortest floret diameter. Among cultivars, 'Chapel Hill' (90.9 g), 'Adrenalin' (70.1g), 'Cayenne' (77.1 g), and 'Almerim' (56.2g) exhibited the maximum fresh weight of a flower stem in all the cultivars. Among all tested cultivars, 'Merry' (30.7 g), 'Hunting Song' (26.7 g), and 'Rosie Bee' (32.9 g) exhibited shorter fresh weight of a flower stem. Kir Royal' (5.4g), 'Adrenalin' (5.9 g), 'Chapel Hill' (5.3 g), and 'Cartago' (5.2 g) exhibited the maximum dry weight of a flower stem in all the cultivars. Among all tested cultivars, 'Merry' (3.1 g), 'Hunting Song' (3.8g), and 'Lemon Drop' (3.7 g) exhibited the dry weight of a flower stem. Among cultivars, 'Adrenalin' (10.1), 'Bangladesh' (10.0), 'Comedy' (9.2), and 'Lemon Drop' (9.1) exhibited the highest number of cormels per clump in all the cultivars. Among all tested cultivars, 'Kir Royal' (5.6), 'Magma' (5.8), and 'Essential' (7.0) exhibited the smallest number of cormels per clump. 'Adrenalin' (47.8mm), 'Bangladesh' (41.2mm), 'Chanson' (40.0mm) and 'Cayyene' (39.6mm) exhibited the greatest diameter of a cormel in all the cultivars. Among all tested cultivars, 'Hunting Song' (32.2mm), 'Merry' (27.2mm), and 'Magma' (31.3mm) exhibited the smallest diameter of a cormel.

Table 1: Effect of various staggered planting times on 50% sprouting, production time, sprouting (%), plant height, leaf area, chlorophyll contents, and number of florets of thirty exotic gladiolus cultivars. (n=30)

Treatments	50% sprouting (days)	Production time(days)	Sprouting (%age)	Plant Height (cm)	Leaf area (cm^2)	Chlorophyll contents (SPAD)	Number of florets/Spike
			Planting times				
Sep.,20	13.1 a[z]	103.2 a	89.1 a	76.6 a	55.6 a	59.2 a	12.3 a
Oct., 20	12.7 b	101.8 c	85.3 b	73.6 b	53 b	56.7 b	11.5 b
Nov., 20	12.3 c	100.8 d	75.8 c	70.9 c	51.6 c	56.3 b	11.3 c
Dec., 20	11.9 d	102.6 b	67.3 d	67.68 d	49.2 d	53.8 c	10.7 d
			Cultivars				
'Adrenalin'	12.8 defg[z]	98.3 kl	89.2 ab	75.6 fghi	69.5 a	60.6 bcde	12.5 cd
'Advance Red'	12.9 defg	97.1 lm	88.4 abc	82.3 a	57.6 bcd	54.9 fghij	10.2 k
'Almerim'	11.3 lmn	100.6 ij	79.5 fg	81.7 ab	54.7 def	61.2 bcd	12.1 def
'Amsterdam'	12.6 efgh	101.3 hij	75.3 hijklm	74.3 hijk	55.2 cde	69.1 a	12.1 def
'Bangladesh'	11.9 ijkl	97.4 lm	90.3 a	78.5 cdef	52 fghij	62.7 b	12.2 cde
'Beach Party'	11.6 klm	109 c	77.9 gh	74.8 ghij	51.2 ijkl	51.3 ijk	11.9 efg
'Cantate'	12.1 hijk	97.4 lm	75.4 hijk	74.1 hijk	45.1 n	58.6 bcdefg	11.5 hi
'Cartago'	12.5 fghi	111.4 b	77.4 ghi	82.0 ab	55.1 de	55.9 defghij	13.1 b
'Cassis'	11.1 mn	97.2 lm	69.1 nop	76.4 efghi	51.7 ghij	50.5 jk	11.6 gh
'Chanson'	11.7 jklm	101.4 hij	66.2 p	74.8 ghij	54.3 efgh	58.1 bcdefg	12.0 def
'Chapel Hill'	13.4 bcd	104.4 ef	87.4 abcd	71.9 jkl	54.6 efg	53.6 ghijk	9.7 lm
'Comedy'	12.6 efgh	101.6 hij	71.5 lmno	77.1 efgh	70.4 a	53.4 ghijk	13.6 a
'Cayyene'	12.5 efghi	106.9 d	73.5 jklm	75.5 fghi	49.8 jkl	55.3 efghij	12.2 cde
'Essential'	13.8 bc	99.9 jk	81.8 ef	79.1 bcde	52.1 fghij	58.7 bcdefg	13.4 ab
'Grand Prix'	13.0 def	89.1 o	75.4 hijkl	75.3 ghi	44.4 n	57.4 bcdefgh	11.9 efg
'Hunting Song'	12.3 ghijk	102.8 fgh	84.2 de	46.0 p	44.8 n	56.1 defghi	6.5 p
'Kir Royal'	12.1 hijk	112.5 b	85.4 bcde	82.9 a	52.7 efghij	58.4 bcdefg	13.1 b
'Lemon Drop'	12.8 defg	104.6 ef	77.0 ghij	73.6 ijkl	46.4 mn	55.4 efghij	12.0 def
'Magma'	10.7 n	97.9 lm	67.9 op	70.9 lm	52.3	48.3 k	11.5 hi
'Manhattan'	14.0 b	102.1 ghi	89.8 a	74.5 hijk	51.7 ghijk	55.7 efghij	11.1 ij
'Merry'	9.8 o	96.m	90.8 a	35.5 q	39.1 o	53.3 ghijk	10.0 kl
'Milka'	13.9 b	101.4 hij	79.5 fg	77.7 defg	51.5 hijk	58.1 bcdefg	12.6 c
'Mix'	14.8 a	106 de	73.6 ijklm	81.5 abc	60.2 b	55.9 defghi	13.4 ab
'Nova Zambla'	12.4 fghij	103.9 fg	72.9 klmn	80.1 abcd	50.6 jkl	55.2 efghij	13.2 ab
'Polar Bear'	11.9 hijkl	92.7 n	84.6 cde	71.6 klm	52.5 efghij	62.5 bc	11.0 j
'Red Balance'	12.0 hijk	103.1 fgh	87.3 abcd	66.7 n	58.1 bc	50.4 jk	8.6 n
'Rose Supreme'	14.0 b	104.2 ef	76.8 ghij	68.6 mn	54.1 efghi	56.0 defghi	11.7 fgh
'Rosie Bee'	14.1 b	115 a	75.2 hijklm	46.7 p	41.5 o	52.2 hijk	8.0 o
'Violata'	13.2 cde	103.9 fg	71.5 lmno	60.7 o	48.4 lm	59.2 bcdef	9.4 m
'White Prosperity'	11.3 lmn	104.2 ef	85.6 abcd	75.2 ghi	48.8 klm	57.2 cdefgh	11.5 gh
Significance							
Cultivars (CV)	<0.0001	0.0001	0.0003	<0.0001	<0.0001	0.0012	0.0001
Planting times (PT)	<0.0001	0.0023	0.0024	<0.0001	0.0033	<0.0001	0.0001
CV × PT	<0.0001	<0.0001	0.0036	0.0022	0.040	0.0034	0.0002

[y]Means separation within columns by Fisher's LSD P≤0.05. [x]P values were obtained using general linear models (GLM) procedures of Statistix (version 8.1, analytical software) for significant effects of staggered planting times on cut gladiolus exotic cultivars.

DISCUSSION

The planting time plays a pivotal role in producing high-quality cut stems. The timing of planting significantly influences plant developmental processes (Lweis et al., 2022). Vase life of various cultivars varies from each other due to differences in genetic makeup and adaptability of a cultivar to a specific environment (Hussain et al., 2025). The vase life of a gladiolus depends on the growth of the plant and the quality of production. Healthy stems have the highest water-holding capacity as compared to weak stems (Ahmad et al., 2025). The presented findings are closely related to the findings of Adil et al. (2021), who reported a significant effect of planting time on vase life of freesia when planted early with gibberellic acid treatment, exhibiting longer vase life compared to late planting. The quality production of gladiolus can be obtained by early plantings (Sept-Oct) in longer days to get started metabolic activities in plants. Early sowing with the least planting distance positively affected the quality attributes and yield of cut stems. These results are in line with the findings of Singh et al. (2019), who concluded that the differences in time to 50% sprouting were due to genetic combinations of cultivars and corms of gladiolus planted in early October. Planting time plays an important role in regulating the growth and quality of gladiolus. Vegetative growth and quality of gladiolus are improved by optimal planting times, which also satisfy the consumer's demands (Ahmad et al., 2011). Every

Table 2: Effect of various staggered planting times on spike length, spike quality, spike diameter, floret diameter, stem fresh weight, stem dry weight, and number of cormels per clump of thirty exotic gladiolus cultivars. (n=30).

Treatments	Spike Length(cm)	Spike quality	Spike Diameter(mm)	Floret Diameter (mm)	Fresh weight(g)	Dry weight(g)	No of Cormels/clump
Planting times							
Sep.,20	39.1 a	8.3 a	7.2 a	62.13 a	48.2 a	4.8 a	8.5 a
Oct., 20	36.4 b	8.2 a	6.9 b	58.66 b	45.3 a	4.6 b	8.4 ab
Nov., 20	35.3 c	8.1 a	6.7 c	56.17 c	51.9 a	4.5 c	8.3 b
Dec., 20	34.1 d[z]	8.0 a	6.6 d	53.84 d	47.6 a	4.4 d	7.7 c
Cultivars							
'Adrenalin'	50.9 a	8.5 abcde	7.6 bcd	70.60 a	70.0 ab	5.9 a	10.1 a
'Advance Red'	35.0 fghij	8.6 abc	6.2 klmn	41.32 m	40.2 ab	4.5 fghij	6.9 i
'Almerim'	41.3 c	8.3 abcd	7.9 b	70.60 a	56.2 ab	4.7 efgh	8.5 bcdef
'Amsterdam'	36.9 defg	8.4 abcd	6.2 lmn	55.97 hij	48.0 ab	4.1 klm	7.1 hi
'Bangladesh'	37.9 d	8.3 abcde	7.3 de	65.56 b	53.9 ab	4.9 de	10.0 a
'Beach Party'	44.6 b	8.0 bcdef	6.9 gh	57.61 ghi	41.3 ab	5.1 cd	7.8 fgh
'Cantate'	38.0 d	8.5 abcde	7.9 b	59.90 cdefgh	44.4 ab	3.9 mn	8.0 efg
'Cartago'	46.3 b	8.4 abcd	8.9 a	58.21 ghi	55.1 ab	5.2 bcd	8.4 cdefg
'Cassis'	37.2 def	8.8 a	7.3 cde	62.80 bcdef	47.1 ab	3.9 lmn	8.5 bcdef
'Chanson'	40.6 c	8.2 abcdef	7.3 de	63.21 bcd	53.6 ab	4.8 ef	9.0 bcd
'Chapel Hill'	34.0 hijk	8.7 abc	5.9 n	59.63 cdefgh	90.9 a	5.3 bc	8.5 bcdef
'Comedy'	37.0 defg	8.0 cdef	6.8 hij	58.48 fgh	51.4 ab	5.1 cd	9.2 b
'Cayyene'	40.7 c	8.2 abcdef	7.2 efg	58.68 efgh	77.1 ab	5.2 bc	8.2 efg
'Essential'	38.2 d	7.8 efg	6.8 hi	61.90 bcdefg	46.5 ab	4.7 efgh	7.0 i
'Grand Prix'	32.8 jkl	7.8 efg	7.2 ef	52.47 jk	46.1 ab	4.5 fghij	8.3 cdef
'Hunting Song'	24.4 n[z]	8.7 ab	6.0 mn	58.74 efgh	26.7 b	3.8 mn	8.2 efg
'Kir Royal'	40.7 c	8.2 abcdef	6.9 gh	59.19 defgh	43.7 ab	5.4 b	5.6 j
'Lemon Drop'	34.9 ghij	8.5 abcd	6.8 hi	49.85 kl	41.7 ab	3.7 n	9.1 bc
'Magma'	33.1 ijkl	8.5 abcde	6.3 klm	50.22 kl	37.5 b	3.9 mn	5.8 j
'Manhattan'	35.3 fghi	8.4 abcd	6.5 ijk	57.01 hi	41.2 ab	5.3 bc	8.8 bcde
'Merry'	20.1 o	7.5 fg	4.9 p	41.06 m	30.7 b	3.1 o	8.0 efg
'Milka'	37.8 de	7.3 g	7.2 efg	59.89 cdefgh	45.9 ab	4.5 fghij	8.0 efg
'Mix'	40.8 c	8.5 abcde	7.3 e	63.67 bc	54.2 ab	5.2 bc	8.4 bcdef
'Nova Zambla'	40.6 c	8.6 abc	7.7 bc	62.92 bcde	48.7 ab	4.5 fghij	7.6 ghi
'Polar Bear'	35.5 efgh	8.4 abcd	7.2 efg	64.60 b	46.3 ab	4.3 ijk	8.3 defg
'Red Balance'	31.1 lm	8.3 abcde	6.5 jk	54.06 ijk	41.9 ab	4.4 hijk	9.0 bcd
'Rose Supreme'	32.5 kl	8.0 cdef	6.4 kl	51.89 jk	41.8 ab	4.4 ghijk	7.9 fg
'Rosie Bee'	22.9 n	8.2 abcde	5.2 o	46.08 l	32.9 b	4.7 efg	8.5 bcdef
'Violata'	29.3 m	8.1 abcdef	6.1 mn	55.78 hij	40.1 ab	4.3 jkl	9.0 bcd
'White Prosperity'	37.1 defg	7.8 defg	7.0 fgh	59.05 defgh	46.6 ab	4.6 efghi	8.4 cdef
Significance							
Cultivars (CV)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Planting times (PT)	<0.0001	<0.0001	0.0011	<0.0001	<0.0001	<0.0001	<0.0001
CV × PT	<0.0001	<0.0001	0.00015	0.0040	<0.0001	<0.0001	<0.0001

[y]Means separation within columns by Fisher's LSD P≤0.05. [x]P values were obtained using general linear models (GLM) procedures of Statistix (version 8.1, analytical software) for significant effects of staggered planting times on cut gladiolus exotic cultivars.

plant species has a specific range of temperatures that are tolerable and allow plant growth, but extreme temperatures may reduce inflorescence quality by increasing production time and reducing stem quality (Kalinowski et al., 2021). Presented results on gladiolus are also aligned with research findings on stock, snapdragon, and China aster, where delayed sowing resulted in reduced crop time; however, with poor quality stems having shorter vase life (Abdullah et al., 2020).

Plant development and selection of a suitable genotype are important factors for the successful cultivation of gladiolus in various Agro-climatic conditions. Thakur et al. (2015) reported that gladiolus corms planted in early October exhibited taller stems with the greatest leaf area and vase life. Photosynthetic activity and chlorophyll contents directly affect leaf area. Gladiolus cultivars depicted different growth behavior regarding quality production. Various gladiolus cultivars have variation in growth due to their different genetic makeup, and these shows significantly different responses under different climatic conditions (Balaram et al., 2009; Ganjali et al., 2010). Optimal temperature and day length regulate both plant growth and flowering. Reduction in day length and increase in temperature drastically affect vegetative growth and reproductive growth of plants, causing weaker stems with poor quality leaves (Puangkrit et al., 2018). Light intensity and day length have a strong relationship with the development of leaves and plant photosynthetic activity. When a plant goes under vegetative growth, the maximum light intensity required to develop optimal growth is not given to the plant; it may become stunted with reduced stem quality, which ultimately affects bulb production. The presented study is in accordance with

Fig. 4: (a) Pictorial representation of tested gladiolus cultivars at the flower initiation stage.

the findings of Hussain et al. (2025), who investigated various exotic cultivars of chrysanthemum. early planted stems exhibited greater leaf area with the highest chlorophyll contents. Chlorophyll content was recorded as highest in variety 'White Prosperity' when planted in October (Javaid et al., 2025).

Date of planting plays an important role in regulating the growth and quality of plants. Earlier planting is beneficial as it allows plants to mature and increases the probability of harvesting prior to inclement fall weather. Probably the planting schedule varies due to differences in photoperiods, temperatures, and light intensity (Alkurdi et al., 2015). The growth parameters (plant height, plant diameter, number of branches, as well as fresh and dry matter yield of plant herb) were significantly influenced by the planting date in *Tagetes lucida* L. (Ismail et al., 2013).

Sowing of corms at a suitable time not only regulates a steady supply of the crops to the market but also enhances the flower display time in the landscape. Initial growth of gladiolus was accelerated by the high early two-month mean diurnal temperature (30.75°C) received by corms planted in September. High temperature enhanced the vegetative developmental phase, and in response plant height, leaf numbers, leaf area, and stalk length was increased. Flower induction is believed to be a function of temperature, photoperiod and/or gibberellin hormone. Gladiolus corms, when planted in early Sept-Oct, exhibited good quality stems with the greatest flower diameter as depicted in presented study (Alhajhoj, 2017).

Delay of sowing and shortening of the growing cycle decreased the amount of radiation intercepted during the growing season and thus plant dry matter contents. Earlier planting in longer days increases total light interception to develop a greater plant crop canopy, which increases total plant fresh and dry matter (Mirzaei et al., 2016). Low temperature and short photoperiod significantly influence the length of the stem (g), which depends on the quality of the stem harvested, the thickness of the spike, and the number of florets that spike; it varies from cultivar to cultivar. Those cultivars that have a larger spike diameter and a greater number of florets will have more weight in the

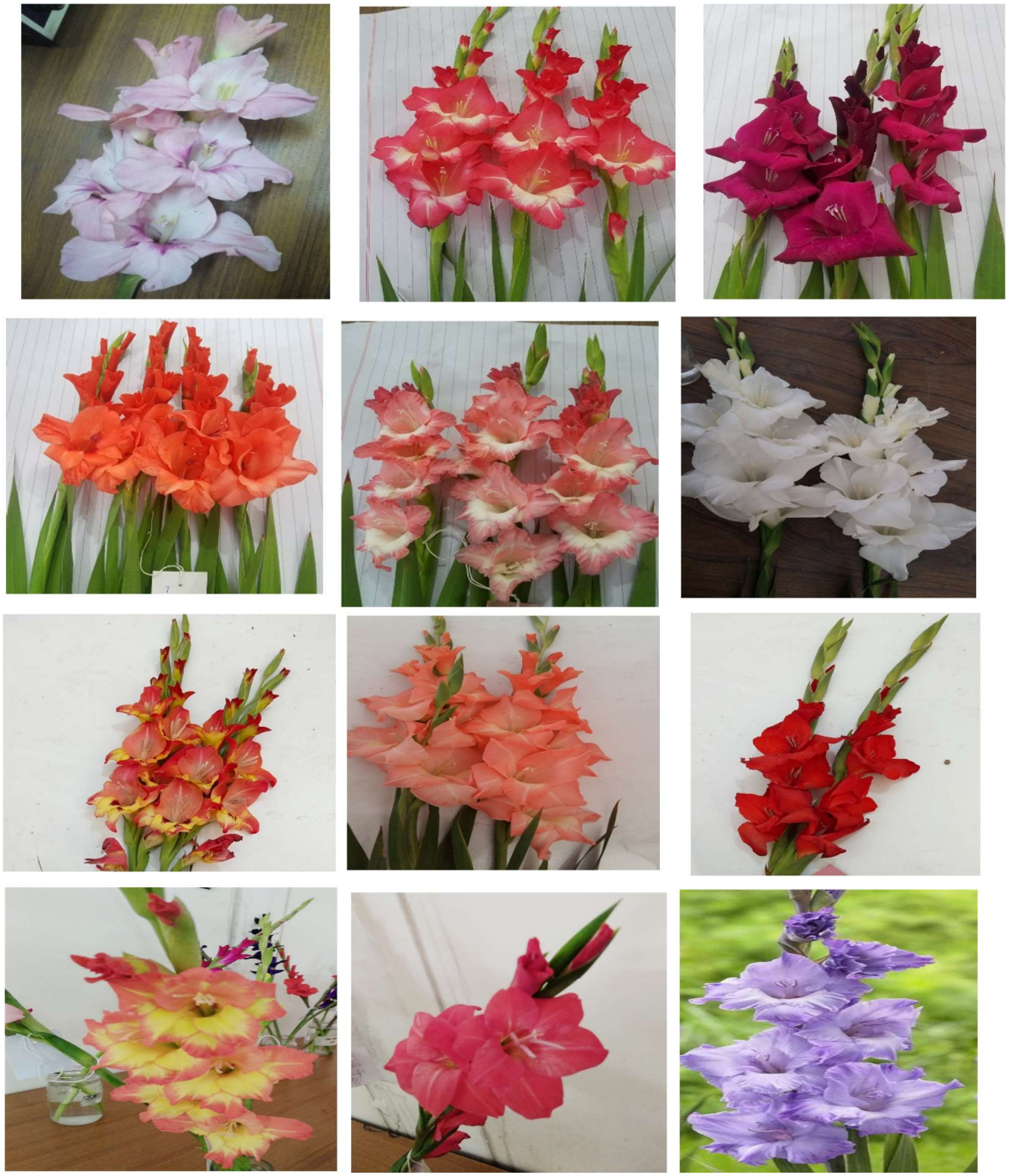

Fig. 4: (b) Pictorial representation of tested gladiolus cultivars at full bloom stage.

flower stem. Similar findings were reported by Abdullah et al. (2020); staggered planting of Matthiolas produced high-quality stems with the greatest fresh and dry weight of stems. Early planting on October 15 significantly improved vegetative traits, with the variety 'Oscar' showing superior performance as the number of florets per spike (15.22), spike length (93.44 cm), and spike weight. Oscar variety planted in October gave the tallest plant, the highest leaf number, and corm yield (Javaid et al., 2025). Gladiolus corms planted early in the season in a lath house containing various substrate compositions and plantings exhibited a greater number of corms and cormels production. Early planting at suitable growth temperatures and light intensity may assist in regulating plant metabolic processes, which had a positive impact on growth attributes, stem quality, vase life, and healthy cormel production of cut gladiolus cultivars (Siddiqui et al., 2025).

Conclusions

It is concluded that among all tested exotic cultivars, the best response was recorded in early plantings in September and October regarding all growth parameters, while late plantings in November and December, 70% of plants failed to attain flowering and production of marketable stems and showed weak response in all growth attributes as well. Results depicted that 'Kir Royal', 'Chapel Hill', 'Comedy', 'Manhattan', 'Almerim' Adrenalin', and 'Advance Red' exhibited good quality stems with the longest vase life (days). 'Merry' and 'Mix' proved early cultivars, while 'Rosie Bee', 'Lemon Drop', and 'Nova Zambla' were late cultivars, which took the longest time to produce stems. Therefore, new cultivars may be grown commercially by planting in September - October by the growers for the best quality stems.

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