Journal of Horticultural Science and Technology 1(1): 21-27 (2018)
ISSN (Print) 2617-3220
http://www.pshsciences.org

Original Research

Optimizing Planting Time for Some Selected Commercial Gladiolus Cultivars under Agro-Climatic Conditions of Faisalabad, Pakistan

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ABSTRACT

A field experiment was conducted at Commercial Floriculture Research Area, Institute of Horticultural Sciences, University of Agriculture, Faisalabad, during 2017-18 to evaluate different planting times for quality production of selected gladiolus cultivars. Six commercial gladiolus cultivars, viz., Advance, Amsterdam, Essential, Grand Prix, Rose Supreme and White Prosperity were compared by planting at five different planting times from September to November at 15 days interval. Data regarding vegetative growth, flowering and quality parameters were collected. Early sprouting, best vegetative growth and higher quality gladiolus stems were produced when planted in September for all tested cultivars, while among cultivars, 'Rose Supreme' proved best for all planting times in the agro-climatic conditions of Faisalabad. Early planting of gladiolus crop in the season with favourably high temperature and longer photoperiod produced strong growth response as compared to late plantings when temperature dropped below 20 °C with photoperiods became shorter. The minimum time to 50% sprouting (7.0 days) along with the highest sprouting percentage (95%), number of leaves per plant (9.6), leaf area (67.6 cm^2), plant height (96.4 cm), spike length (73.0 cm), the longest vase life (11.9 d), the best spike quality (8.3) and the greatest number of cormels per clump (30.5) were recorded for September plantation, which gradually decreased with delayed planting. In summary, the best time of planting gladiolus under agro-climatic conditions of Faisalabad, Punjab (Pakistan) is September, which may be adopted by growers for quality stem production.

Keywords: *Cultivar evaluation, geophytes, sowing dates, spike quality, temperature, vase life.*

Article History: *Received 18 September 2018; Revised 06 December 2018; Accepted 12 December 2018; Published 28 December 2018.*

INTRODUCTION

Gladiolus (*Gladiolus* L. hybrids), one of the leading bulbous cut flowers, has high demand in local and global floral markets on account of its elegant long double row spikes of variable colours having acceptable vase life. It is the 2nd most demanded cut flower after rose in local cut flower trade and is cultivated on more than 200 ha in different parts of Pakistan (Ali, 2017). Its major share comes from Punjab; however, northern hilly areas of Azad Kashmir, Khyber Pakhtunkhwa and Gilgit Baltistan are getting popularity for its summer production. Gladiolus is commercially grown as cut flower, border plant or potted plant, in various tropical and subtropical regions of the world. Major issues in quality gladiolus production include unavailability of new cultivars and inadequate knowledge about commercial cultivation, optimal planting time, production practices and postharvest handling (Usman and Ashfaq, 2013; Ahmad et al., 2014). Pakistan has diverse agro-climatic zones, which make it possible to grow gladiolus throughout the year. However, there is a need to explore the suitable cultivars and their optimum planting times for each region.

Planting time determines the quality of the gladiolus stems as environmental conditions have great influence on producing better quality spikes (Saleem et al., 2013). Different planting times ensure extended supply of gladiolus spikes to the market, which may lower the risks of less profitability and fulfill consumer demands for longer period. Flowering in gladiolus can be extended by planting corms at weekly or biweekly intervals to produce an array of blooms for a longer period (Younis et al., 2018). Arora and Sandhu (1987) explained that early sprouting in late plantation was because of rise in temperature, which ultimately encouraged sprouting of corms, as high temperature has positive influence on the corms sprout. Talia and Traversa (1986) stated that healthier corms of gladiolus were produced by the early plantation in September and October.

Climatic conditions in Punjab plains ranging from 25-30 °C are suitable for gladiolus production on commercial scale. However, suitable planting time of gladiolus needs to be optimized for each cultivar in different zones. Therefore, this study was conducted to optimize the planting time of different gladiolus cultivars for their commercial production in agro-climatic zone of Faisalabad.

MATERIALS AND METHODS

A field experiment was conducted at Commercial Floriculture Research Area, Institute of Horticultural Sciences, University of Agriculture, Faisalabad, during 2017-18. Six commercial

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Table 1: Meteorological data of Faisalabad, Pakistan during the study period (September 2017 – April 2018).

	Temperature (°C)			Photoperiod (h)			Relative humidity (%)		
Months	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
September	36.5	25.5	31.0	11:25	2:00	7:08	72	46	53.5
October	34.4	19.5	26.5	10:00	3:00	7:50	66	41	51.3
November	27.6	12.1	20.1	8:50	2:00	6:04	77	39	60.1
December	23.6	9.2	16.4	9:25	2:00	6:04	85	43	68.6
January	17.6	8.2	12.9	9:00	1:15	5:25	85	45	72.0
February	23.4	10.2	16.8	9:00	00:50	6:06	84	40	51.0
March	27.3	14.2	20.0	10:00	00:45	7:20	74	31	49.5
April	37.7	20.9	29.3	11:00	4:00	9:20	56	17	30.6

gladiolus cultivars, viz. Advance, Amsterdam, Essential, Grand Prix, Rose Supreme and White Prosperity were selected for the experiment. Gladiolus corms were acquired from Greenworks, Lahore (Pakistan) shipped to the laboratory in an air-conditioned vehicle and acclimatized at room temperature for a week before plantation. There were five different planting times at 15 days interval, viz. Sep. 15, Sep. 30, Oct. 15, Oct. 30, and Nov. 15. The experiment was laid out in randomized complete block design with split plot arrangement having three replications and 20 corms were planted in each experimental unit. The cultivars were in main plots, while sowing times in sub-plots. Topsin M (fungicide) @ 2 g L^{-1} was used for the treatment of corms before sowing for 8-10 minute followed by drying under shade. Soil was thoroughly prepared and and sowing was done on ridges prepared 60 cm apart keeping 15 cm corm to corm distance at a depth of 5-8 cm in each experimental unit. All cultural practices, viz., weeding, irrigation, fertilization, staking and IPM were similar for all treatments during entire study period. Meteorological data during study period were collected from Agro-meteorology Cell, Department of Agronomy, University of Agriculture, Faisalabad and is presented in Table 1. The data on different parameters were recorded using standard procedures as described below

Time to 50% Sprouting (days)

After sowing, sprouting of corms was observed daily and numbers of days were counted until 50% corms had sprouted in each treatment and average was computed.

Sprouting Percentage

Number of sprouted corms was recorded when all possible corms had emerged from soil and percentage was calculated by the following formula.

$$Sprouting\ percentage\ (\%) = \frac{Total\ numbers\ of\ corms\ sprouted}{Total\ number\ of\ corms\ sown} X\ 100$$

Leaf Area (cm²)

Fully matured leaves preferably lower most from ten randomly selected plants in each treatment per replication were selected. Their length was measured with the help of measuring rod and maximum width was measured with digital Vernier caliper and area was calculated by multiplying maximum length, maximum width and contact factor (0.68) as described by Carleton and Foote (1965).

Plant Height (cm)

Plant height was measured with the help of measuring rod at harvesting time. Ten plants from each treatment per replication were selected randomly and their average was computed.

Days to Spike Emergence (days)

Days to spike emergence of ten randomly tagged plants from each treatment per replication were recorded from time of sowing to emergence of spike and average was calculated.

Number of Leaves per Plant

The number of leaves produced on each of the three tagged plants in each treatment per replication was counted after emergence of flower spike and then mean was worked out.

Spike Length (cm)

Spike length of ten stems from each treatment per replication was recorded with the help of measuring rod. Spike length was measured from the base of lower most floret to the tip of upper floret and average was calculated.

Spike Quality

Spike quality is a display of various characteristics including development of bud, shape of flower, form of flower, diameter of flower, leaf quality and colour development. Flower quality was measured by visual assessment using a scale ranging from 1 to 9 (Dest and Guillard, 1987; Cooper and Spokas, 1991). 1-3 = poor quality, 4-6 = medium quality, and 7-9 = excellent quality.

Vase Life (days)

Stems from each replicate were harvested at commercial stage, when lower most floret started showing color. The cataphyll (lower two oldest leaves) were retained with coms for their better development. The stems were placed immediately in buckets containing distilled water, leaves were removed and graded, recut to uniform length of 60 cm, labelled and put in glass vases containing distilled water until termination. Ten stems in each treatment per replication were selected. For vase life evaluation, a stem was considered ready to terminate when 50% of the florets were wilted, necrotic or desiccated.

Table 2: Time to 50% sprouting of six cultivars of gladiolus as affected by various sowing times.

	Cultivars						
Planting times	Advance	Amsterdam	Essential	Grand Prix	Rose Supreme	White Prosperity	Means
Sep. 15	12.0 ef	12.6 de	10.3 ijk	10.6 hij	9.3 lm	11.0 ghi	10.5 B
Sep. 30	11.0 ghi	13.6 bc	11.6 fg	10.6 hij	11.3 fgh	10.0 jkl	8.5 C
Oct. 15	10.0 jkl	13.3 cd	10.6 hij	9.3 lm	10.0 jkl	10.0 jkl	10.5 B
Oct. 30	7.0 n	14.3 b	7.0 n	7.0 n	7.0 n	9.0 m	11.3 A
Nov. 15	9.6 klm	15.7 a	9.3 lm	10.0 jkl	9.3lm	9.3 lm	11.0 AB
Means	9.9 B	13.9 A	9.8 BC	9.5 CD	9.4 D	9.8 BC	

Means sharing similar letter(s) in a group a statistically non-significant at $p \leq 0.05$ (LSD test).

Table 3: Sprouting percentage of six cultivars of gladiolus as affected by various sowing times.

	Cultivars						
Planting times	Advance	Amsterdam	Essential	Grand Prix	Rose Supreme	White Prosperity	Means
Sep. 15	96.0 abc	95.3 abcd	96.3 ab	94.0 abcd	94.6 abcd	94.6 abcd	95.1 A
Sep. 30	92.0 de	93.3 abcde	96.6 a	92.6 cde	96.6 a	93.0 bcde	94.0 A
Oct. 15	86.3 gh	92.0 de	92.6 cde	90.0 ef	92.6 cde	92.3 de	91.0 B
Oct. 30	83.3 hij	90.0 ef	87.0 fg	87.0 fg	90.0 ef	85.0 ghij	87.0 C
Nov. 15	82.0 j	85.6 ghi	82.6 ij	83.3 hij	85.6 ghi	81.6 j	83.5 D
Means	87.9 B	91.2 A	91.0 A	89.4 B	91.9 A	89.3 B	

Means sharing similar letter(s) in a group a statistically non-significant at $p \leq 0.05$ (LSD test).

Corm Diameter (cm)

Diameter of ten average sized corms in each treatment per replication was measured with the help of digital caliper (LF-07) and average was calculated.

Weight of Cormels per Clump (g)

Cormels produced on one clump of ten randomly selected plants from each treatment per replication were weighed on an electric balance and average was calculated.

Statistical Analysis

The data were statistically analyzed using Statistix® 10.0 and analysis of variance technique was used to test the overall significance of the data, while the Least Significant Difference (LSD) test at $p \leq 0.05$ was used to compare the differences among treatment means (Steel et al., 1997).

RESULTS

Among planting times, September 30 planting took the minimum time to 50% sprouting with 8.5 days for most of the cultivars (Table 2), while late planting on October 30 and November 15 took longest time for 50% sprouting (11.3 and 11.0 days, respectively). Among cultivars, 'Rose Supreme' proved early cultivar than others tested in the study. The maximum sprouting percentage (95%) was recorded in corms planted on September 15 followed by corms planted on September 30 and October 15 (94% and 91%, respectively). However, the lowest sprouting percentage (83.5%) was recorded when corms were planted on November 15. Among cultivars, 'Rose Supreme' had highest sprouting percentage compared to rest of tested cultivars (Table 3).

The maximum number of leaves per plant (9.1) were recorded in corms planted on September 15 followed by corms planted on September 30, while the least number of leaves (7.6) was recorded when corms were planted on November 15. Among cultivars, 'Rose Supreme' and 'Amsterdam' produced the highest number of leaves per plant than other tested cultivars (Table 4). The maximum leaf area (67.6 cm^2) was recorded in corms planted on September 30 followed by September 15 planting, while the lowest leaf area (56.9 cm^2) was recorded for November 15 planting. Among cultivars 'Essential' has broader leaves (73.5 cm^2), while 'Advance' ha narrow leaves (53.8 cm^2) (Table 5).

Among planting times, the maximum plant height (88.6 cm) was recorded in corms planted on September 30 followed by corms planted on September 15, while the least plant height (68.6 cm) was recorded when corms were planted on November 15. Among cultivars, 'Rose Supreme' was the tallest cultivar and 'Grand Prix' the shortest cultivar (Table 6). For time to spike emergence, the earliest spike emergence (82.7 days) was recorded in plants with planting date of September 15, followed by those planted on September 30, while the maximum time to spike emergence was recorded when corms were planted on November 15. 'Grand Prix' took minimum time for to spike emergence (84.1 days), while 'Amsterdam' took longer time (95.9 days) to spike emergence compared with other cultivars (Table 7).

For spike length, longest spikes were recorded in corms planted on September 30 (78.1 cm) and September 15 (77.3 cm), while smallest spikes (58.3 cm) were found in corms planted on November 15. Among cultivars, the maximum spike length was recorded in 'Rose Supreme' (73.0 cm), 'Advance' (72.5 cm) and 'White Prosperity' (71.8 cm); while the minimum spike length (64.1 cm) was recorded in 'Grand Prix' (Table 8). The longest vase life (11.9 days) was recorded in corms planted on September 30, while shortest vase life was recorded in corms planted on November 15 (8.7 days). Among cultivars, the maximum vase life was recorded in 'Amsterdam' (11.5 days) followed by 'Advance' (11.0 days), while minimum vase life was

Table 4: Number of leaves per plant of six cultivars of gladiolus as affected by various sowing times.

Planting times	Cultivars						Means
	Advance	Amsterdam	Essential	Grand Prix	Rose Supreme	White Prosperity	
Sep. 15	8.2 ghi	9.5 ab	9.0 bcdef	9.3 abcd	9.4 abc	8.8 def	9.1 A
Sep. 30	9.1 abcdef	9.3 abcd	9.0 cdef	8.2 hi	9.6 a	8.9 cdef	9.0 A
Oct. 15	7.9 ijkl	9.2 abcde	8.7 efgh	7.8 ijklm	9.2 abcde	8.0 ijk	8.5 B
Oct. 30	7.4 lm	9.0 bcdef	8.1 ij	7.3 mn	9.0 bcdef	7.5 klm	8.1 C
Nov. 15	6.7 o	8.7 efg	7.6 jklm	7.4 lm	8.6 fgh	6.8 no	7.6 D
Means	7.9 C	9.2 A	8.5 B	8.0 C	9.2 A	8.0 C	

Means sharing similar letter(s) in a group a statistically non-significant at $p \leq 0.05$ (LSD test).

Table 5: Leaf area (cm^2) of six cultivars of gladiolus as affected by various sowing times.

Planting times	Cultivars						Means
	Advance	Amsterdam	Essential	Grand Prix	Rose Supreme	White Prosperity	
Sep. 15	58.4 gh	71.5 abc	74.7 a	70.7 bcd	72.0 ab	58.0 gh	67.5 A
Sep. 30	60.8 fg	70.4 bcd	75.3 a	72.2 ab	67.9 cde	59.1 gh	67.6 A
Oct. 15	53.9 ijk	67.0 de	74.1 ab	67.3 de	64.4 ef	55.5 hi	63.7 B
Oct. 30	50.2 k	67.2 de	72.8 ab	65.3 e	56.2 hi	54.1 ij	61.0 C
Nov. 15	45.9 l	55.7 hi	70.3 bcd	64.2 ef	53.8 ijk	51.4 jk	56.9 D
Means	53.8 E	66.4 B	73.5 A	67.9 B	62.9 C	55.6 D	

Means sharing similar letter(s) in a group a statistically non-significant at $p \leq 0.05$ (LSD test).

Table 6: Plant height (cm) of six cultivars of gladiolus as affected by various sowing times.

Planting times	Cultivars						Means
	Advance	Amsterdam	Essential	Grand Prix	Rose Supreme	White Prosperity	
Sep. 15	93.7 a	88.8 b	82.2 defgh	82.1 efgh	93.8 a	86.8 bcd	87.9 A
Sep. 30	97.1 a	94.1 a	79.0 ghi	77.4 ij	96.4 a	87.4 bc	88.6 A
Oct. 15	86.2 bcde	82.3 defg	84.1 cde	74.8 ijk	85.8 bcde	83.4 cdef	82.8 B
Oct. 30	77.2 ij	78.8 ghi	75.3 ijk	70.8 klm	77.9 ghij	77.7 hij	76.3 C
Nov. 15	67.5 mn	68.8 m	68.4 m	63.2 n	74.0 jkl	69.8 lm	68.6 D
Means	84.3 AB	82.6 BC	77.8 D	73.7 E	85.5 A	81.0 C	

Means sharing similar letter(s) in a group a statistically non-significant at $p \leq 0.05$ (LSD test).

recorded in 'Grand Prix' (7.7 days) (Table 9). The highest spike quality (8.3) was recorded in corms planted on September 30 followed by corms planted on September 15 (8.2). Gladiolus cultivars planted on October 30 and November 15 exhibited the minimum spike quality (6.8 and 6.0, respectively). Among cultivars, 'Amsterdam' exhibited the best spike quality than other tested cultivars (Fig. 1A).

The maximum number of cormels per clump (30.5) was recorded in corms planted on September 30, while the minimum number of cormels per clump (16.6) was recorded in corms planted on November 15. Among cultivars, 'Amsterdam' had the maximum number of cormels per clump (32.6) followed by 'Advance' (31.2), while the minimum number of cormels per plant (16.9) were recorded in 'Essential' (Fig. 1B). The greatest weight of a cormels per clump (0.54 g) was obtained in corms planted on September 15, while the lowest weight of a cormel (0.44 g) was recorded in corms planted on November 15 (Fig. 1C). Among cultivars, the maximum weight of a cormel was recorded in 'Rose Supreme' (0.56 g), while the minimum in 'Grand Prix' (0.43 g).

DISCUSSION

Variable planting times, genetically different cultivars and geographical locations led plants to grow under variable environmental conditions (Saleem *et al*., 2013). Gladiolus grows well in areas with moderately high temperatures and plenty of sunlight. In plain areas, the best suited planting time is when temperatures ranges between 15 and 25 °C and sunlight is available for more than 8 hours, while late sowing in November delayed sprouting, that was possibly due to low temperature and shorter photoperiod (Adil et al., 2013). Younis et al. (2018) reported that genetic variation and climatic conditions mainly light and temperature are responsible for variable sprouting percentage in gladiolus. Similar findings have also been reported by Adil et al. (2013) that temperature had significant effect on sprouting of corms. Early sowing of gladiolus crop in the season with favorable temperature (25-27 °C) and longer photoperiod produced strong growth response as compared to late sowing when temperature dropped below 20 °C with shorter photoperiod. Planting at different environmental conditions results in variation in sprouting percentage and flower quality of gladiolus (Dilta et al., 2004). Planting time plays very crucial role in growth, yield and quality of gladiolus (Khan *et al*., 2008).

In gladiolus, temperature affects all aspects of plant growth including shoot emergence, leaf area and flower development (Adil *et al*., 2013). Genetic makeup of different cultivars may also influence number of leaves (Sheikh and Jhon, 2005). The maximum leaf area was recorded in early season plantations and possible cause of increase in leaf area was sought to be increased

Table 7: Days to spike emergence (days) of six cultivars of gladiolus as affected by various sowing times.

	Cultivars						
Planting times	Advance	Amsterdam	Essential	Grand Prix	Rose Supreme	White Prosperity	Means
Sep. 15	83.4 hij	86.0 efghij	87.2 efghij	75.8 kl	81.4 jk	82.4 ij	82.7 D
Sep. 30	86.8 efghij	84.8 ghij	85.1 fghij	75.2 l	89.4 efg	81.9 ij	83.8 D
Oct. 15	89.2 efg	99.3 bc	88.9 efgh	81.6 ij	97.1 cd	91.7 de	91.3 C
Oct. 30	97.1 cd	104.0 ab	86.6 efghij	90.8 ef	101.3 abc	101.0 abc	96.8 B
Nov. 15	106.4 a	105.5 a	91.4 de	97.3 cd	87.3 efghi	106.3 a	99.1 A
Means	92.6 B	95.9A	87.8C	84.1 D	91.3B	92.6 B	

Means sharing similar letter(s) in a group a statistically non-significant at $p \leq 0.05$ (LSD test).

Table 8: Spike length (cm) of six cultivars of gladiolus as affected by various sowing times.

	Cultivars						
Planting times	Advance	Amsterdam	Essential	Grand Prix	Rose Supreme	White Prosperity	Means
Sep. 15	82.0 bcd	74.2 fg	74.5 fg	73.1 g	83.0 abc	77.2 ef	77.3 A
Sep. 30	83.8 ab	78.3 de	73.1 g	67.4 ij	86.7 a	79.3 cde	78.1 A
Oct. 15	74.2 fg	65.9 ijkl	78.6 de	65.3 jklm	72.2 gh	73.3 g	71.6 B
Oct. 30	66.0 ijk	61.1 nop	69.3 hi	61.6 mno	63.3 klmn	67.7 ij	64.8 C
Nov. 15	56.3 qr	57.7 pq	62.1 lmno	53.3 r	59.3 opq	61.2nop	58.3 D
Means	72.5 A	67.5 B	71.5 A	64.1 C	72.9 A	71.8 A	

Means sharing similar letter(s) in a group a statistically non-significant at $p \leq 0.05$ (LSD test).

Table 9: Vase life (days) of six cultivars of gladiolus as affected by various sowing times.

	Cultivars						
Planting times	Advance	Amsterdam	Essential	Grand Prix	Rose Supreme	White Prosperity	Means
Sep. 15	12.5 bc	12.8 b	12.3 c	10.7 gh	11.1 fgh	10.7 gh	11.7 B
Sep. 30	13.4 a	12.6 bc	11.0 fgh	12.0 cd	11.3 ef	11.1 efg	11.9 A
Oct. 15	11.4 ef	11.6 de	9.7 i	9.0 k	9.7 i	10.6 h	10.3 C
Oct. 30	9.6 i	10.7 gh	8.8 kl	8.7 kl	9.7 i	9.5 ij	9.5 D
Nov. 15	7.9 m	9.6 i	8.4 lm	8.4 lm	8.9 kl	9.0 jk	8.7 E
Means	11.0 B	11.5 A	10.0 C	9.7 D	10.1 C	10.2 C	

Means sharing similar letter(s) in a group a statistically non-significant at $p \leq 0.05$ (LSD test).

photosynthesis due to excessive chlorophyll production. Environmental conditions such as sunlight and temperature are responsible for the growth and development of gladiolus (Zubair *et al*., 2006; Yadav *et al*., 2016).

Among all planting times, September plantings produced better results regarding spike emergence, spike quality, vase life, and cormel production, which might be due to enhanced photosynthesis resulting in increased production of photosynthates and better plant growth (Usha Bala et al., 2002; Sudhakar and Kumar, 2012). Higher photosynthesis rate causes more sucrose production and ultimately has positive effect on vase life (Usman and Ashfaq, 2013). Gupta et al. (2002) reported longest vase life for gladiolus corms sown earlier in the planting season. They also reported that at high temperature, greater accumulation of photosynthates in gladiolus extended its vase life.

Environmental conditions prevailed during gladiolus development stage mobilized photosynthates towards sink (corms and cormels), which also affected cormel production (Ahmad et al., 2011). Gladiolus production might be governed by genotypic makeup of the cultivars while early sowing of gladiolus crop in the season with favorable temperature may also affect cormel production (Khan et al., 2008). Saleem et al. (2013) concluded that among cultivars, 'Rose Supreme' performed the best followed by "Grand Prix', 'Essential' and White Prosperity', which varied at different planting times, however, behaved similarly based on their genetic variability.

CONCLUSION

The present study confirmed the environmental requirements of the gladiolus production in plains of Punjab, Pakistan as best quality stems with early production resulted when corms were planted during September. Among tested cultivars, the maximum response was recorded in 'Rose Supreme' when sown early in September for growth, quality and spike production of gladiolus, while late sowing in November proved unsuitable for planting gladiolus in Punjab plains, which was possibly due to lower temperature and shorter photoperiods. Therefore, growers may plant 'Grand Prix', 'Essential' or 'Rose Supreme' during September for higher quality spike production. Different cultivars respond differently to variable climatic and soil conditions and need to be evaluated in different agro-climatic zones before recommending for commercial cultivation.

ACKNOWLEDGEMENTS

Authors gratefully acknowledge Higher Education Commission of Pakistan for financial assistance under the project entitled 'Establishing production protocol for potential bulbous crops for

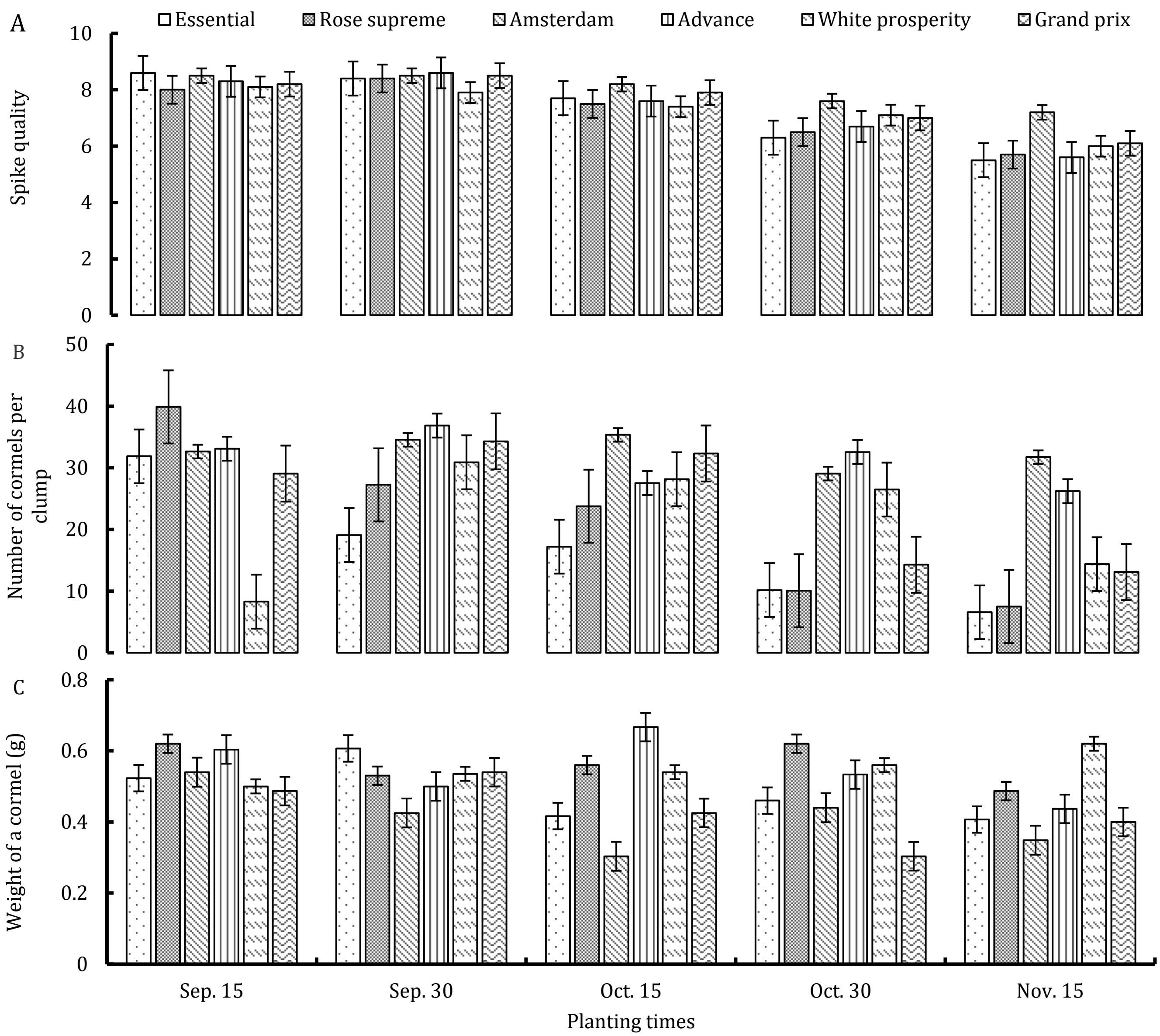

Figure 1: Spike quality (A), number of cormels per clump (B), and weight of a cormel (C) of gladiolus cultivars as influenced by various planting times. Bars represent means ± S.E.

cut flowers.

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