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Response of planting time and growing conditions on flowering behaviour and spike yield of gladiolus (*Gladiolus x hybrid* L.)

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Abstract
The present investigation was carried out at Agri-Tourism Centre, CCS Haryana Agricultural University, Hisar. This experiment was laid out in Factorial Randomised Block Design (RBD) with four replications. It consists of four planting dates viz. 10th October, 2018, 17th October, 2018, 24th October, 2018 and 1st November, 2018 with three growing conditions viz. open condition, polyhouse and shade net. With the possible combination of planting time and growing conditions maximum number of florets per spike (11.10) was observed with 10th October in open condition. The planting on 10th October recorded significantly maximum spike length (75.80 cm), floret diameter(8.94 cm), number of spikes per plant (1.75), number of spikes per plot (21.6), number of estimated spikes (000) per hectare (150) and significantly lowest days taken to slipping stage(75.97), days taken to full emergence of spike (83.72), days taken to first floret to show colour (89.50) and days taken to opening of first floret (92.50) in comparison to four planting dates in all growing conditions. Maximum flowering duration (8.22 days) was recorded on 1st November planting. Among the various growing conditions, all flowering and spike characters were recorded better in plants grown under polyhouse condition as compared to open and shade net. Numbers of florets per spike and yield characters were superior in open condition.

Keywords: Planting time and growing conditions, flowering behaviour, yield, *Gladiolus x hybrid* L.

1. Introduction
Gladiolus (*Gladiolus x hybrida*) is a commercial bulbous plant native to South Africa that belongs to the Iridaceae family. Gladiolus was named after the Latin word "gladius" and is also known as 'Sword Lily' because of its leaf shapes. Gladiolus is commercially grown via corms and cormlets, which are specialised subterranean stems coated with dried leaf base. It has a spike-like inflorescence with up to 15-20 florets placed alternately on the axis. The outermost three parts are known as the calyx, while the inner three segments are known as the corolla. Sepals (calyx) and petals (corolla) are joined at the base to produce tepals, which are tube-like structures. Three stamens and a tricarpelled pistil are surrounded by the perianth. Capsule is the name given to the fruit. Bees and insects pollinate gladiolus flowers. It required an open and bright environment with an ideal temperature of 16-30oC for growth and development.

Gladiolus is cultivated all over the world. The major producing countries are United States (Florida and California), Holland, Italy, France, Bulgaria, India, and Israel (Riaz *et al.*, 2007) [11].

Gladiolus growing is well suited to India's agro-climatic conditions. Gladiolus area in India was 11.77 thousand hectares in 2021-2022, with a production of 14.51 thousand metric tonne loose flower and 245.01 thousand metric tonne cut flower (Anonymous, 2022) [2]. Gladiolus came in third place among cut flowers in terms of both area and yield. The leading gladiolus producing states in the country include Uttar Pradesh, West Bengal, Karnataka, Punjab, Haryana and Maharashtra. From 2019 to 2020, the gladiolus area in Haryana was 0.07 thousand hectares, with a yield of 0.80 thousand metric tonne cut flower. (Anonymous, 2020) [1].

Gladiolus is grown mostly for its beautiful spikes in a variety of colours. The spikes have lovely and delicate flowers. These florets open sequentially over a prolonged period of time. As a result, it has a longer shelf life. The spikes are utilised in floral arrangements, interior design and bouquets. It also improves the overall appearance of the garden. It may be cultivated as a border plant as well as a specimen plant for exhibitions.

The planting date is important in managing gladiolus spike growth and quality. Different flowering parameters in gladiolus are influenced by day length and temperature. These considerations also limit the number of planting dates available. Furthermore, diverse planting schedules make gladiolus available on the market all year and satisfying customer preferences. During important events such as New Year's, Memorial Day, weddings and several other religious functions, the demand for cut flowers such as gladiolus is often extremely high. As a result, it helps in getting higher price.

Apart from determining the best planting time for gladiolus, the current study was conducted to determine the best environmental conditions for gladiolus production. A healthy flowering can only be obtained when the plant is grown under optimal climatic and cultural environments, which result in the greatest quantity of carbohydrates being produced. Gladiolus necessitates a bright location, which has a significant impact on flowering growth.

Keeping these facts in mind, the current experiment was designed to investigate the influence of planting time and different growing conditions on gladiolus flowering and spike yield (*Gladiolus x hybrid*).

2. Materials and Methods

The experiment entitled "Response of planting time on flowering behaviour and spike yield of gladiolus under different growing conditions" cv. Eurovision was carried out at Agri Tourism Centre, CCS Haryana Agricultural University, Hisar during 2019. The experimental material was uniform sized corms of gladiolus cv. Eurovision. Each plot was 1.2 m × 1.2 m in size and 30 x 30 cm in spacing, with 16 plants. The experiment was carried out in Factorial RBD with 12 treatment combinations of four planting dates, viz. 10th October, 2018, 17th October, 2018, 24th October, 2018, and 1st November, 2018, under three growing conditions, viz. open condition, polyhouse and shadenet, each with four replications. The outer protective covering of corms was first removed and then treated with bavistin (0.2%) solution for 30 minutes to avoid the attack of fusarium wilt and other fungal diseases. The treated corms were allowed to dry in shade to remove the excess moisture of corm surface and sown in field. Five plants were tagged from each plot. Number of days taken from planting of corms to slipping stage in each tagged plant of each plot was counted and average was calculated. Number of days taken from planting of corms to full emergence of spike from leaves was recorded in each tagged plant of each plot and average was calculated. Number of days taken from planting of corms to the colour showing stage of first floret in each spike was recorded and average was calculated. Number of days taken from planting of corms to the opening of first floret in each spike was recorded and average was calculated. Spike length was measured from second node from the ground to the tip of spike in each tagged plant of each plot in centimeter. Diameter of second floret of the spike in each tagged plant was measured by digital verniercaliper. Total number of florets per spike in each tagged plant of each plot was recorded. The total number of days taken from opening of first floret of spike to the opening of last floret was recorded on each tagged plant and average was worked out. The total numbers of spikes produced from each planted corm were counted and average number of spikes was calculated. The estimated numbers of spikes produced per hectare were calculated. The data observed were subjected to statistical analysis. The data were transferred from where ever required before suitability of ANOVA analyzed in statistical package SAS version 7.0.

3. Results and Discussion

The data presented in table 1 showed that days taken to slipping stage are significantly influenced by different planting time and growing conditions. The data on different planting time revealed that days taken to slipping stage increased significantly with the delay in planting time, however, minimum number of days to slipping stage (75.97) were recorded on 10th October planting and 1st November planting took maximum number of days to slipping stage (80.61). Among the growing conditions, minimum number of days to slipping stage (74.28) was recorded under polyhouse followed by shadenet (78.50) and maximum number of days to slipping stage (81.93) was recorded under open field condition. No significant interaction effect was observed between planting dates and growing conditions. Early planted corms were exposed to higher temperature which resulted in early sprouting whereas, late planted corms being exposed to lower temperature resulted in late sprouting and ultimately delayed the plants to come into reproductive phase. The possible reason behind superior flower characters during early planting might be that there was better growth and early completion of vegetative stage and therefore photosynthates were available in large amount for the production of quality spikes. Similar results were reported by Tirkey *et al.* (2018) [15].

Table 1: Effect of planting time and growing conditions on days taken to slipping stage in gladiolus cv. Eurovision

Planting Time	Growing conditions			
	Open condition	**Shadenet**	**Polyhouse**	**Mean**
10th October	79.30	75.85	72.75	75.97
17th October	80.80	77.45	73.80	77.35
24th October	82.75	79.20	75.05	79.00
1st November	84.85	81.50	75.50	80.61
Mean	81.93	78.50	74.28	
C.D. (P = .05)	Planting Time	Growing Conditions	Planting Time x Growing conditions	
	1.30	1.12	NS	

It is evident from the data presented in table 2 that number of days taken to full emergence of spike is significantly influenced by different planting time and growing conditions. The data on different planting time revealed that minimum number of days to full emergence of spike (83.72) recorded on 10th October planting. 1st November planting took maximum number of days to full emergence of spike (88.46). Number of days taken to full emergence of spike increased

significantly with late planting. Among the growing conditions, minimum number of days to full emergence of spike (81.30) were recorded under polyhouse followed by shadenet (84.99) and maximum (92.09) were recorded in open field condition. This might be due to better, early and fast growth in polyhouse which results into availability of more photosynthates for reproductive stage. Similar results were reported by Saaie *et al.* (2011) [12]. No significant interaction effect was observed between planting time and growing conditions.

Table 2: Effect of planting time and growing conditions on days taken to full emergence of spike in gladiolus cv. Eurovision

Planting Time	Growing Conditions			
	Open condition	Shadenet	Polyhouse	Mean
10th October	89.05	82.40	79.70	83.72
17th October	90.80	83.90	80.65	85.12
24th October	93.55	86.00	82.05	87.20
1st November	94.95	87.65	82.80	88.46
Mean	92.09	84.99	81.30	
C.D. (P = .05)	Planting Time	Growing Conditions	Planting Time x Growing conditions	
	0.96	0.83	NS	

The data presented in table 3 showed that the days taken to first floret to show colour were significantly differed with planting time and growing conditions. The data on different planting time revealed that the days taken to first floret to show colour increased significantly with the delay in planting time, however, minimum number of days taken to first floret to show colour (89.50) were recorded in 10th October planting and maximum number of days (94.43) were recorded in 1st November planting. Among the growing conditions, minimum number of days taken to first floret to show colour (85.21) were recorded in plants grown under polyhouse followed by shadenet (91.48) and maximum were observed (99.31) under open field condition. Interaction was observed non-significant in influencing days to first floret to show colour. Similar results were reported by Saaie *et al*. (2011) [12], Islam *et al*. (2011) [4].

Table 3: Effect of planting time and growing conditions on days taken to first floret to show colour in gladiolus cv. Eurovision

Planting Time	Growing Conditions			
	Open condition	Shadenet	Polyhouse	Mean
10th October	96.25	88.90	83.35	89.50
17th October	98.05	90.30	84.65	91.00
24th October	100.70	92.55	85.95	93.07
1st November	102.25	94.15	86.9	94.43
Mean	99.31	91.48	85.21	
C.D. (P = .05)	Planting Time	Growing Conditions	Planting Time x Growing conditions	
	0.90	0.78	NS	

The data presented in table 4 showed that the days taken to opening of first floret were significantly differed with planting time and growing conditions. The number of days taken to opening of first floret increased significantly with late planting. The minimum number of days taken to opening of first floret (92.50) was recorded in 10th October planting and maximum number of days (97.18) was recorded in 1st November planting. Among the growing conditions, minimum number of days taken to opening of first floret (87.52) were recorded in plants grown under polyhouse followed by shadenet (94.66) and maximum number of days taken to opening of first floret were observed (102.60 days) under open field condition. Interaction between planting time and growing conditions was observed non-significant in influencing days to opening of first floret. Laurie *et al.* (1979) [6] suggested that earliness in flowering in the greenhouse might be due to rise in soil temperature.

Table 4: Effect of planting time and growing conditions on days taken to opening of first floret in gladiolus cv. Eurovision

Planting Time	Growing Conditions			
	Open condition	Shadenet	Polyhouse	Mean
10th October	99.90	91.90	85.70	92.50
17th October	101.75	93.45	86.60	93.93
24th October	103.90	96.00	88.40	96.10
1st November	104.85	97.30	89.40	97.18
Mean	102.60	94.66	87.52	
C.D. (P = .05)	Planting Time	Growing Conditions	Planting Time x Growing conditions	
	0.82	0.71	NS	

The data presented in table 5 regarding length of spike had shown significant differences for different planting time and growing conditions. The spike length decreased significantly with the delay in planting time. The dates of sowing showed that 10th October planting produced more spike length (75.80 cm) and 1st November planting recorded least spike length (74.56 cm). Among the different growing conditions, maximum spike length (83.56 cm) was produced by plants grown under polyhouse followed by shadenet (73.55 cm) and minimum spike length (65.64 cm) was recorded under open

condition. Interaction between planting time and growing conditions was observed non-significant in influencing spike length of gladiolus. This might be due to better, early and fast growth in polyhouse which results into availability of more photosynthates for reproductive stage which ultimately gives more spike length.

Table 5: Effect of planting time and growing conditions on spike length (cm) in gladiolus cv. Eurovision

Planting Time	Growing Conditions			
	Open condition	Shadenet	Polyhouse	Mean
10th October	69.75	73.15	84.50	75.80
17th October	65.30	71.85	83.90	73.68
24th October	64.60	70.75	83.45	72.93
1st November	62.85	68.45	82.40	71.23
Mean	65.63	71.05	83.56	
C.D. (P = .05)	Planting Time	Growing Conditions	Planting Time x Growing conditions	
	1.50	1.31	NS	

The perusal of data presented in table 6 regarding effects of planting time and growing conditions on floret diameter indicated that floret size was influenced significantly by both the factors. The floret diameter decreased significantly with the delay in planting time. Maximum floret diameter (8.94 cm) was recorded by corms planted on 10th October and 1st November planting recorded minimum diameter of floret (8.13 cm). Among the growing conditions, maximum floret diameter (9.17 cm) was observed in plants grown under polyhouse followed by open condition (8.60 cm) whereas minimum floret diameter (7.69 cm) was recorded in shadenet. Interaction effect between planting time and growing conditions was observed non-significant in influencing floret diameter. This might be due to better, early and fast growth in polyhouse which results into availability of more photosynthates for reproductive stage which ultimately gives floret diameter. Similar results were reported by Saaie *et al.* (2011) [12] and Islam *et al.* (2011) [4].

Table 6: Effect of planting time and growing conditions on floret diameter (cm) in gladiolus cv. Eurovision

Planting Time	Growing Conditions			
	Open condition	Shadenet	Polyhouse	Mean
10th October	9.18	8.39	9.26	8.94
17th October	8.66	7.91	9.23	8.60
24th October	8.37	7.35	9.11	8.28
1st November	8.19	7.12	9.09	8.13
Mean	8.60	7.69	9.17	
C.D. (P = .05)	Planting time	Growing Conditions	Planting Time x Growing conditions	
	0.13	0.11	NS	

The perusal of data regarding the number of florets per spike of gladiolus is presented in table 7 and observed that planting time had significant effect on number of florets per spike. The number of florets per spike decreased significantly with the delay in planting time. Maximum number of florets were observed in plants grown on 10th October (9.57) and minimum number of florets were recorded on 1st November planting (8.33). Growing conditions also had significant effect on number of florets per spike. Maximum number of florets (10.00) was observed in plants grown under open field condition followed by polyhouse (9.05) and minimum (7.69) in plants grown under shadenet. Interaction between planting time and growing conditions was observed significant in influencing number of florets per spike. The maximum number of florets per spike (11.10) were observed in 10th October planting under open condition, whereas, minimum number of florets per spike (7.10) were recorded in corms plantedon1stNovemberinshadenet.The number of florets per spike is a genitival character but it is also influenced to a large extent by the environmental factors particularly light. This parameter also depends on the corms size used and also on the growing conditions. Mckay *et al.* (1981) [7] also reported significance of light during growing period for gladiolus.

Table 7: Effect of planting time and growing conditions on number of florets per spike in gladiolus cv. Eurovision

Planting Time	Growing Conditions			
	Open condition	Shadenet	Polyhouse	Mean
10th October	11.10	8.30	9.30	9.57
17th October	10.20	7.80	9.10	9.03
24th October	9.65	7.55	8.95	8.72
1st November	9.05	7.10	8.85	8.33
Mean	10.00	7.69	9.05	
C.D. (P = .05)	Planting Time	Growing Conditions	Planting time x Growing conditions	
	0.25	0.21	0.44	

The data presented in table 8 regarding flowering duration had shown significant differences for different planting time and growing conditions. Planting time had a significant effect on flowering duration and observed that 1st November planting had maximum flowering duration (8.22 days) and 10th October planting recorded least flowering duration (7.18d

ays). The flowering duration increased significantly with late planting. Reduction in flowering duration at early planting may be due to early exposure to amiable climatic conditions as compared to delay planting during which temperature is low. Similar results were reported by Dod *et al*. (1989) [3]. Among the different growing conditions, maximum flowering duration (9.24 days) was observed in plants grown under open field condition followed by shadenet (7.25 days) whereas minimum flowering duration (6.70 days) was recorded under polyhouse. Interaction between planting time and growing conditions was observed non-significant in influencing flowering duration. Maximum flowering duration under open field condition might be due to more number of florets per spike, therefore, late opening of last floret as evident from the present investigation.

Table 8: Effect of planting time and growing conditions on flowering duration (days) in gladiolus cv. Eurovision

Planting Time	Growing Conditions			
	Open condition	Shadenet	Polyhouse	Mean
10th October	8.40	6.80	6.35	7.18
17th October	9.00	7.20	6.70	7.63
24th October	9.45	7.40	6.80	7.88
1st November	10.10	7.60	6.95	8.22
Mean	9.24	7.25	6.70	
C.D. (P = .05)	Planting Time	Growing Conditions	Planting Time x Growing conditions	
	0.38	0.33	NS	

It is revealed from the data presented in table 9 that number of spikes per plant influenced significantly by different planting time and growing conditions. Planting time had significant effect on number of spikes per plant and observed that number of spikes/plant decreased significantly with delay in planting time. Maximum number of spikes (1.75) was observed in plants grown on 10th October and minimum number of spikes (1.30) was recorded on 1st November planting. Similar results were also reported by Nagar *et al.* (2017) [9]. Growing conditions also had significant effect on number of spikes per plant. Maximum number of spikes (1.66) was observed in plants grown in open field condition which is statistically at par with polyhouse (1.59) and minimum number of spikes per plant (1.30) was recorded in shadenet condition. It might be due to occurrence of congenial temperature range and optimum availability of moisture resulting into fast and better growth and ultimately led to production of more spikes during early planting and in open field condition observed that delaying the planting time significantly decreased the number of spikes on a plant. Similar results were reported by Nagar *et al.* (2017) [9] and Kour (2009) [5]. Interaction between planting time and growing conditions was observed non-significant in affecting number of spikes per plant.

Table 9: Effect of planting time and growing conditions on number of spikes/plant in gladiolus cv. Eurovision

Planting Time	Growing Conditions			
	Open condition	Shadenet	Polyhouse	Mean
10th October	1.90	1.55	1.80	1.75
17th October	1.70	1.35	1.65	1.57
24th October	1.65	1.20	1.50	1.45
1st November	1.40	1.10	1.40	1.30
Mean	1.66	1.30	1.59	
C.D. (P =.05)	Planting Time	Growing Conditions	Planting Time x Growing conditions	
	0.13	0.12	NS	

It is evident from the data presented in table 10 that number of estimated spikes (000)/ha influenced significantly by different planting time and growing conditions. Planting time had significant effect on number of estimated spikes (000)/ha and observed that number of estimated spikes (000)/ha decreased significantly with delay in planting time. Maximum number of estimated spikes per ha (150.00) were observed in 10th October planting and minimum number of estimated spikes per ha (102.50) were recorded on 1st November planting.

Table 10: Effect of planting time and growing conditions on number of estimated spikes (000)/ha in gladiolus cv. Eurovision

Planting Time	Growing Conditions			
	Open condition	Shadenet	Polyhouse	Mean
10thOctober	170.00	130.00	150.00	150.00
17thOctober	160.00	120.00	135.00	138.33
24thOctober	142.50	105.00	120.00	122.50
1st November	112.50	92.50	102.50	102.50
Mean	146.25	111.88	126.88	
C.D. (P =.05)	Planting Time	Growing Conditions	Planting Time x Growing conditions	
	8.06	6.98	NS	

Growing conditions also had significant effect on number of estimated spikes per ha (000). Maximum number of estimated spikes per ha (146.25) were observed in open field followed by polyhouse (126.88) and minimum number of estimated

spikes per ha (111.88) were recorded in shadenet. Interaction between planting time and growing conditions was observed non-significant in influencing number of estimated spikes (000)/hectare.

4. Conclusion

The present investigation indicates that planting time and growing conditions affects the flowering and yield parameters of gladiolus. The study revealed that the various flowering parameters in gladiolus viz. days taken to slipping stage, days to full emergence of spike, days to first floret to show colour, days to opening of first floret and flowering duration significantly increased with delay in planting time. The flowering parameters viz. spike length, floret diameter and number of florets per spike significantly decreased with delay in planting time. Minimum number of days taken to slipping stage, days to full emergence of spike, days to first floret to show colour and days to opening of first floret were recorded under polyhouse. Maximum spike length and floret diameter were observed in plants grown under polyhouse. Maximum number of florets per spike and flowering duration was shown by plants grown in open field condition. The maximum numbers of florets per spike were observed in 10th October planting in open condition. The different yield parameters i.e., number of spikes per plant and number of estimated spikes per hectare significantly decreased with delay in planting. Maximum numbers of spikes per plant were recorded in open field. Maximum number of estimated spikes (000) per hectare was observed in open field condition.

5. Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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