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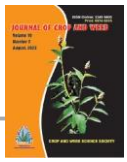

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Response of varieties and planting dates on postharvest performance ofgladiolus under the ecological conditions of Punjab

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ABSTRACT

Variation in temperature due to different planting time is considered as important attribute influencing performance of Gladiolus. An experiment was conducted to evaluate five gladiolus cultivars (Punjab Glad 3, Punjab Lemon Delight, CPG, Punjab Glance and White Prosperity) under four planting dates (28th September, 28th October, 28th November and 28th December) for their postharvest performance. The planting dates and cultivars significantly affected the postharvest quality of spikes. Among different dates of planting, September planting exhibited most favorable responses with minimum days taken to open basal floret in vase (1.27 days), maximum floret size (7.84 cm), maximum number of florets open at one time (5.66), maximum per cent opening of florets (73.07%), maximum vase life (8.65 days), minimum change in pH of vase solution (0.26), maximum total water absorbed per spike (73.06 ml) and minimum loss in weight at termination of vase life (33.07%). Vase life of gladiolus spikes gets affected with variation in planting time, because low temperature during reproductive growth stages aided in extending it.

***Keywords*:** Gladiolus, planting dates, temperature, vase life

Cut flowers are valuable products of horticulture. The market acceptability of flowers is determined by its postharvest quality and vase life (Gogoi *et al.*, 2021) are influenced by preharvest and postharvest factors. The prime preharvest factors in postharvest management include genetic make-up and environmental factors. The environmental factors like temperature, light, humidity etc. have dramatic impacts on postharvest quality of flowers.

Planting time influences quality flower production because different planting dates exposes plants to different temperature, photoperiod, light intensity, humidity, etc. that affect its growth and development (Muhammad *et al.*, 2013). Appropriate photoperiod and temperature enhance photosynthesis, leading to increased photosynthates production and hence better vegetative plant growth (Sudhakar and Kumar, 2012). In gladiolus, accumulating photosynthates such as sucrose prolongs vase life (Nasar and Qasim, 2018). Because sucrose acts as a food source; delayed protein degradation and improved water balance of cut flowers and hence increases their vase life (Kumari *et al.*, 2018).

Low temperature is beneficial as low temperature declines the respiration rate that slows down the utilization of sugars, which improves the net accumulation of carbohydrates in the petals and prolongs the vase life. On the other hand, high temperature increases the rate of respiration that decreases carbohydrate reserves and hence, postharvest life. Too low temperature may also causes freezing injury to buds (Halevy and Mayak, 1979). In this way, change in temperature due to different planting dates can have impact on quality and vase life of different cut flowers (Dhatt and Jhanji, 2021).

Gladiolus, the leading bulbous cut flower crop, has great demand in flower market because of its beautiful long spikes of different colors and good vase life (Nasar and Qasim, 2018). It occupies fourth position in global cut flower market after rose, carnation and chrysanthemum (Rashid *et al.*, 2022). It has gained recognition in the world due to its unrivaled beauty and economic value. It is frequently used as a cut flower in flower arrangements and attractive bouquets in different social and religious ceremonies (Ferdousi *et al.*, 2018). Therefore, the present investigation was planned to assess the influence of planting dates on postharvest quality and life of gladiolus spikes.

MATERIALS AND METHODS

The study was conducted in the Field Area and Laboratories of Department of Floriculture and Landscaping, Punjab Agricultural University, Ludhiana.

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Gladiolus cultivars, viz. Punjab Glad 3, Punjab Lemon Delight, CPG, Punjab Glance and White Prosperity were planted at four different planting dates at one month interval, viz. 28th Sep., 28th Oct., 28th Nov. and 28th Dec. The experimental design of trial was split plot with planting dates in main plots and cultivars in sub-plots. Each treatment had 3 replications. Before sowing, Bavistin 0.1% was used to treat the corms for half an hour as a protective measure against fungus. The treated corms were dried in shade and de-husked before planting in the field. The soil used to raise the crop had sandy loam texture and alkaline nature with pH 8.3. All recommended cultural practices (weeding, irrigation and fertilization) were followed to raise the healthy crop.

Spikes from each replication were harvested at tight bud/color break stage, when lower florets started showing color. The spikes were placed immediately in labeled flasks containing distilled water until the termination of vase life. Following observations pertaining to postharvest keeping quality of spikes were recorded: number of days to open basal floret in vase, size of 2nd -floret from base, maximum number of simultaneously opened florets and per cent opening of florets. The per cent opening of florets was calculated by following formula:

$$\text{Per cent opening of florets} = \frac{\text{Max. no. of florets open at one time}}{\text{Total no. of florets}} \times 100$$

Vase life was measured from the day of opening of basal floret till when there were five open florets on the spike and it was expressed in days. In case of spikes where less than five florets showed opening, wilting of the basal floret was taken as criterion for the termination/ end of vase life. The pH change of vase solution was measured in terms of difference in pH of distilled water before keeping the spikes in it (initial) and pH of distilled water containing spikes at the end of vase life (final) i.e., change in pH = final pH - initial pH. Total amount of water absorbed by the spike till the end of vase life was recorded in ml and physiological weight loss (%) at the end of vase life was calculated by following formula:

$$\text{Physiological loss in weight (\%)} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100$$

The data was statistically analyzed using Statistix 10 software and ANOVA (analysis of variance) technique was used to test the overall significance of the data. Mean comparison to calculate significant difference between treatments was performed using CD at 0.05 level of probability.

RESULTS AND DISCUSSION

The commercially important part of gladiolus is its magnificent and elegant spikes. The acceptability of spike depends upon its postharvest attributes. Temperature, the main abiotic factor affects growth and development of gladiolus and thus affects the quality of spikes. So, five gladiolus cultivars were planted at four planting dates each at 30 days interval from 28 September to 28 December to find the response of gladiolus to varying temperature to statistically compare the dates of planting for quality spike production.

Number of days taken to open basal floret in vase varied significantly with different planting dates and cultivars (Table 1). Delayed planting increased the days taken to open basal floret as September planting recorded minimum (1.27 days) days to open basal floret in vase followed by October (1.68 days) and November (2.02 days) plantings. Spikes obtained from December planting took maximum (2.22 days) days to open basal floret in vase. Delay in basal floret opening in vase by means of delay in planting date may be due to comparatively high temperature during reproductive growth under late plantings. High temperature during reproductive phase can lead to burning of petals and sepals and restrict opening of florets on the spike (Uhlmann *et al.,* 2017). Among the varieties evaluated, significantly least days were recorded for White Prosperity (1.53 days) followed by CPG (1.58 days). Maximum number of days for the parameter was recorded by Punjab Glad 3 (2.04 days) (Table 1). The difference among the varieties for days taken to open basal floret in vase could be attributed to the varietal variation (Kumari *et al.,* 2001).

Size of fully expanded floret in different varieties varied significantly under different dates of planting (Table 2). With delay in planting, the size of floret decreased in all the varieties. September planting recorded significantly maximum size of fully expanded floret (7.84 cm) followed by October (7.54 cm) and November (6.93 cm) plantings. Minimum size of fully expanded floret i.e. 6.50 cm was recorded in December

Table 1: Influence of date of planting on days to opening of basal floret of different varieties

Planting date (D)	Varieties (V)					Mean
	Punjab Glad 3	Punjab Lemon Delight	CPG	Punjab Glance	White Prosperity	
D_1(28 Sep.)	1.60^{g}	1.03^{k}	1.03^{k}	1.40^{i}	1.30^{j}	1.27^{D}
D_2(28 Oct.)	1.80^{e}	1.60^{g}	1.50^{h}	1.80^{e}	1.70^{f}	1.68^{C}
D_3(28 Nov.)	2.23^{b}	2.00^{d}	1.80^{e}	2.10^{c}	2.00^{d}	2.02^{B}
D_4(28 Dec.)	2.53^{a}	2.10^{c}	2.00^{d}	2.23^{b}	2.23^{b}	2.22^{A}
Mean	2.04^{A}	1.88^{B}	1.58^{D}	1.68^{C}	1.53^{E}	
LSD(0.05)	**D = 0.04;**		**V = 0.02;**		**D × V = 0.04**	

Table 2: Influence of date of planting on size of fully expanded floret of different varieties

Planting date (D)	Varieties (V)					Mean
	Punjab Glad 3	Punjab Lemon Delight	CPG	Punjab Glance	White Prosperity	
D_1(28 Sep.)	8.50^{a}	8.13^{b}	7.50^{f}	7.60^{e}	7.50^{f}	7.84^{A}
D_2(28 Oct.)	8.06^{c}	7.80^{d}	7.33^{h}	7.40^{g}	7.10^{i}	7.54^{B}
D_3(28 Nov.)	7.76^{d}	7.00^{j}	6.90^{k}	6.20^{o}	6.80^{l}	6.93^{C}
D_4(28 Dec.)	7.10^{i}	6.70^{m}	6.50^{n}	6.00^{p}	6.20^{o}	6.50^{D}
Mean	7.85^{A}	6.90^{D}	6.80^{E}	7.05^{C}	7.40^{B}	
LSD(0.05)	**D = 0.02;**		**V = 0.02;**		**D × V = 0.05**	

Table 3: Influence of date of planting on maximum florets open at one time of different varieties

Planting date (D)	Varieties (V)					Mean
	Punjab Glad 3	Punjab Lemon Delight	CPG	Punjab Glance	White Prosperity	
D_1(28 Sep.)	6.33^{a}	5.33^{bcd}	5.00^{cde}	5.66^{abc}	6.00^{ab}	5.66^{A}
D_2(28 Oct.)	6.00^{ab}	5.00^{cde}	4.66^{def}	5.66^{abc}	5.66^{abc}	5.40^{AB}
D_3(28 Nov.)	5.33^{bcd}	4.66^{def}	4.33^{ef}	5.00^{cde}	5.66^{abc}	5.00^{BC}
D_4(28 Dec.)	5.33^{bcd}	4.33^{ef}	4.33^{ef}	5.00^{cde}	4.00^{f}	4.60^{C}
Mean	5.75^{A}	4.83^{B}	4.58^{B}	5.33^{A}	5.33^{A}	
LSD(0.05)	**D= 0.50;**		**V = 0.45;**		**D× V = 0.91**	

Table 4: Influence of date of planting on per cent floret opening of different varieties

Planting date (D)	Varieties (V)					Mean
	Punjab Glad 3	Punjab Lemon Delight	CPG	Punjab Glance	White Prosperity	
D_1 (28 Sep.)	79.50^{a}	72.50^{abc}	69.27^{abcdef}	74.27^{ab}	69.80^{abcde}	73.07^{A}
D_2 (28 Oct.)	77.60^{a}	$68.33^{abcdefg}$	62.23^{cdefgh}	71.03^{abcd}	$63.43^{bcdefgh}$	68.53^{A}
D_3 (28 Nov.)	70.57^{abcde}	58.90^{efghi}	55.57^{hi}	59.73^{defghi}	57.50^{fghi}	60.45^{B}
D_4 (28 Dec.)	69.63^{abcde}	49.50^{i}	48.53^{i}	57.07^{ghi}	53.33^{hi}	55.61^{B}
Mean	74.32^{A}	62.30^{BC}	58.90^{C}	65.52^{B}	61.01^{BC}	
LSD(0.05)	**D = 4.92;**		**V = 6.00;**		**D × V = 12.00**	

Table 5: Influence of date of planting on vase life of different varieties

Planting date (D)	Varieties (V)					Mean
	Punjab Glad 3	Punjab Lemon Delight	CPG	Punjab Glance	White Prosperity	
D_1(28 Sep.)	9.06^{a}	8.56^{d}	8.03^{f}	8.86^{b}	8.73^{c}	8.65^{A}
D_2(28 Oct.)	8.56^{d}	8.03^{f}	7.36^{h}	8.36^{e}	8.03^{f}	8.07^{B}
D_3(28 Nov.)	7.56^{g}	6.73^{j}	6.63^{k}	7.26^{h}	6.96^{i}	7.03^{C}
D_4(28 Dec.)	7.06^{i}	6.33^{m}	6.03^{n}	6.53^{k}	6.43^{l}	6.48^{D}
Mean	8.06^{A}	7.41^{D}	7.01^{E}	7.75^{B}	7.54^{C}	
LSD(0.05)	D = 0.13;		V = 0.02;		D × V = 0.05	

Table 6: Influence of date of planting on water absorbed per spike of different varieties

Planting date (D)	Varieties (V)					Mean
	Punjab Glad 3	Punjab Lemon Delight	CPG	Punjab Glance	White Prosperity	
D_1 (28 Sep.)	79.50^{a}	72.50^{abc}	69.26^{abcdef}	74.26^{ab}	69.80^{abcde}	73.06^{A}
D_2 (28 Oct.)	77.60^{a}	$68.33^{abcdefg}$	62.23^{cdefgh}	71.03^{abcd}	$63.43^{bcdefgh}$	68.52^{A}
D_3 (28 Nov.)	70.56^{abcde}	58.90^{efghi}	55.56^{hi}	59.73^{defghi}	57.50^{fghi}	60.45^{B}
D_4 (28 Dec.)	69.63^{abcde}	49.50^{i}	48.53^{i}	57.06^{ghi}	53.33^{hi}	55.61^{B}
Mean	74.32^{A}	62.30^{BC}	58.90^{C}	65.52^{B}	61.01^{BC}	
LSD(0.05)	D = 4.92;		V = 6.00;		D× V = 12.00	

Table 7: Influence of date of planting on change in pH of vase solution of different varieties

Planting date (D)	Varieties (V)					Mean
	Punjab Glad 3	Punjab Lemon Delight	CPG	Punjab Glance	White Prosperity	
D_1(28 Sep.)	0.10^{h}	0.31^{f}	0.41^{e}	0.20^{g}	0.31^{f}	0.26^{D}
D_2(28 Oct.)	0.20^{g}	0.42^{e}	0.51^{d}	0.31^{f}	0.41^{e}	0.37^{C}
D_3(28 Nov.)	0.31^{f}	0.51^{d}	0.71^{b}	0.51^{d}	0.61^{c}	0.53^{B}
D_4(28 Dec.)	0.51^{d}	0.81^{a}	0.81^{a}	0.71^{b}	0.71^{b}	0.71^{A}
Mean	0.28^{D}	0.51^{B}	0.61^{A}	0.43^{C}	0.51^{B}	
C.D. (5%)	D = 5.69 ×10^{-3};		V = 2.63 ×10^{-3};		D × V = 5.26 ×10^{-3}	

Table 8: Influence of date of planting on physiological loss in weight of different varieties

Planting Date (D)	Varieties (V)					Mean
	Punjab Glad 3	Punjab Lemon Delight	CPG	Punjab Glance	White Prosperity	
D_1(28 Sep.)	26.73^{n}	35.63^{j}	36.63^{i}	31.70^{l}	34.66^{k}	33.07^{D}
D_2(28 Oct.)	29.70^{m}	37.60^{h}	38.63^{f}	35.03^{k}	38.20^{g}	35.83^{C}
D_3(28 Nov.)	34.66^{k}	40.56^{d}	42.06^{bc}	38.63^{fg}	39.90^{e}	39.16^{B}
D_4(28 Dec.)	38.63^{fg}	42.56^{b}	44.56^{a}	40.56^{d}	41.96^{c}	41.66^{A}
Mean	32.43^{E}	39.09^{B}	40.47^{A}	36.48^{D}	38.68^{C}	
C.D. (5%)	D = 0.42;		V = 0.15;		D × V = 0.30	

planting. Favorable growing conditions prevailing during the crop development accounted for bigger size of fully expanded floret in September and October plantings. Thakur *et al.,* (2015) also reported decrease in floret size with delay (10th December) in planting. Among the varieties, significantly large sized fully expanded floret was recorded in Punjab Glad 3 (7.85 cm) followed by White Prosperity (7.40 cm), Punjab Glance (7.05 cm) and Punjab Lemon Delight (6.90 cm), whereas smallest size of fully expanded floret was recorded in CPG i.e. 6.8 cm.

September planting recorded maximum number of florets opened at one time (5.66) followed by October (5.40) and November (5.00) planting (Table 3). Minimum number of florets (4.60) opened at one time in December planting. Punjab Glad 3 recorded significantly maximum florets opened at a time (5.75) which was at par with Punjab Glance and White Prosperity. Minimum number of florets opened at a time (4.58) was recorded in CPG which was at par with Punjab Lemon Delight (4.83). Maximum florets remained open at one time in early plantings could be attributed to favorable environmental conditions that resulted in accumulation of more amount of carbohydrates during vegetative growth. Carbohydrates might have contributed to floret freshness, leading to more florets being open. The results are in conformity with Kumari *et al.,* (2018) as sucrose improved floret opening and vase life of cut tuberose. Sucrose acts as a food source or respiratory substrate, thereby delayed protein degradation and improved water balance of cut flowers. Hence, flowers remain open and fresh for more days.

Per cent opening of florets showed significant differences for planting dates and varieties (Table 4). There was decrease in per cent opening of florets with delay in planting dates in all the varieties. September planting recorded significantly maximum per cent opening of florets (73.06%) which was at par with October (68.52%) planting. Minimum per cent opening of florets i.e. 55.61 % was recorded in December planting which was at par with November (60.45%) planting. Among the varieties, significantly maximum per cent opening of florets was recorded in Punjab Glad 3 (74.32%) followed by Punjab Glance (65.52%). Per cent opening of florets in Punjab Lemon Delight (62.30%) was at par with White Prosperity (61.01%). Whereas, minimum was recorded in CPG (58.90%). Decrease in per cent opening of florets might be due to reduced accumulation of carbohydrates under late plantings because of unfavorable environmental conditions which leads to decreased water absorption and hence loss of turgidity. Floret opening on the spike is also determined by genetics, and there are significant variations between varieties (Bhattacharjee and De, 2006).

Decreased vase life was recorded with delayed planting (Table 5). September planting recorded significantly maximum vase life (8.65 days) followed by October (8.07 days) and November (7.03 days) planting. Minimum vase life i.e. 6.48 days was recorded in December planting. Among the varieties, significantly maximum vase life was recorded in Punjab Glad 3 (8.06 days) followed by Punjab Glance (7.75 days), White Prosperity (7.54 days) and Punjab Lemon Delight (7.41 days). Minimum was recorded in CPG (7.01 days). It is possible that the reduction in vase life from September to December in all varieties is due to the fact that in late planted plants, flower initiation and development were exposed to high temperatures in April. Gladiolus growth quality and vase life drastically declined as a result of extreme heat and longer daylight hours (Pavani, 2009). Temperature affects the metabolism of flowers which regulates their senescence, thus determining the vase life of flowers (Dhatt and Jhanji, 2021). Low temperature slows down the rate of metabolism of cells, which delays respiration, ethylene activity, attack of pathogens and in the end senescence (Faraji *et al.,* 2011). Variations in vase life among the varieties may be attributed to differential carbohydrates accumulation due to variation in leaf production (Pavani, 2009).

Planting dates and varieties had significant influence on absorption of water by spikes of gladiolus (Table 6). September planting recorded maximum water absorption (73.06 ml) which was at par with October (68.52 ml) planting. Spikes obtained from December planting absorbed minimum amount of water per spike (55.61 ml) and it was at par with November planting (60.45 ml). Among the varieties evaluated, Punjab Glad 3 absorbed maximum water per spike (74.32 ml) followed by Punjab Glance (65.52 ml). Punjab Lemon Delight and White Prosperity were at par with each other for the parameter. CPG absorbed minimum i.e. 58.90 ml of water per spike. Maximum water absorbed per spike in early plantings might be due to increased floret opening. Increased floret opening could be attributed to accumulation of more amount of carbohydrates during vegetative growth period due to favorable environmental conditions. Further, sugar accumulation in the cells reduced petal water potential and promoted water uptake (Mittal and Jhanji, 2021).

Change in pH showed significant increase in pH of vase solution with delay in planting dates (Table 7). December planting recorded significantly maximum

change in pH (0.71) whereas significantly minimum change in pH i.e. 0.26 was recorded in September planting. Among the varieties, significantly maximum change in pH was recorded in CPG (0.61). Punjab Lemon Delight and White Prosperity were at par to each other for change in pH. Minimum change in pH was recorded in Punjab Glad 3 (0.28). Change in pH increases (acidic to basic) whereas water absorbed per spike decreases with delay in planting. Spikes of September planting absorbed maximum amount of water and there was minimum change in pH of distilled water which may be due to less bacterial growth. Growth of bacteria lead to blockage of xylem in stem causing wilting of petals and leaves, bent neck or other similar water stress related symptoms that reduces vase life (Carlson, 2014). Lower i.e. acidic pH prevents and slowed down the bacterial growth which ensured the proper uptake of water and delayed the senescence (Hussen and Yassin, 2013).

Among the four planting dates, December planting resulted in significantly maximum (41.66%) loss in physiological weight followed by November (39.16%) and October (35.83%) planting (Table 8). Minimum loss in physiological weight (33.07%) was recorded in September planting. Data regarding effect of varieties showed that CPG recorded significantly maximum (40.47%) loss in physiological weight whereas minimum loss in physiological weight (32.43%) was recorded in Punjab Glad 3. Physiological loss in weight increased with delay in planting which might be due to decreased or retarded growth because in the plants of late plantings, high temperature along with longer day periods reduced the postharvest quality and life of gladiolus.

CONCLUSION

The spikes of different cultivars respond differently to planting dates which could be accounted to environmental variation as spikes obtained from September planting of all the cultivars were of better quality. The spikes from September planting had higher vase life along with other postharvest quality attributes while spikes from December/late planting had significantly lower postharvest quality and life. Thus, higher temperature during flowering phase and vase life make late planting of gladiolus unfit in Punjab plains as compared to normal planting in September. Out of all the varieties tested, Punjab Glad 3 and Punjab Glance exhibited superior post-harvest quality traits, including the maximum size of fully opened florets, the number of florets opened at one time, the percentage of open florets and longer vase life compared to the other three varieties. This could be attributed to the higher levels of carbohydrate reserves in these varieties. Since flowering requires a significant amount of energy, having more reserves could potentially prolong the vase life of these varieties compared to those with lower reserves.

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