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EVALUATION OF GLADIOLUS (*GLADIOLUS GRANDIFLORUS* L.) GERMPLASM FOR VEGETATIVE, FLORAL AND CORM YIELDING CHARACTERS UNDER TEMPERATE REGION OF UTTARAKHAND, INDIA

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ABSTRACT

The objective of this research was to evaluate the suitability of gladiolus (*Gladiolus grandiflorus* L.) germplasm for cultivation in the temperate region of Uttarakhand in terms of vegetative, flowering and corm yielding characters from March to October, 2019. The field experiment was laid out using Randomized complete block design which replicated thrice at each plot size (150 cm × 100 cm) and a spacing of 30 cm × 20 cm. There were significant results obtained among the genotype in terms of vegetative, flowering and yield characteristics on gladiolus. The genotype Punjab Dawn performed the best in terms of minimum days required for sprouting of corms (16.41 days), days to first floret to show colour (91.16 days), days taken to first floret opening (95.33 days) and days to full bloom (106.50 days). Furthermore, it was also found that genotype Palmpur Pink performed best in terms of maximum plant height (113.70 cm), spike length (97.49 cm), rachis length (53.75 cm), number of floret per spike (18.04), spike weight (77.36 g), diameter of corm (5.73 cm) and weight of corm (53.72 g). In contrast, genotype Arka Amar on gladiolus had the longest vase life (14.20 days) for post-harvest quality. The experiment conclude that among 15 genotypes the Punjab Dawn and Palmpur Pink genotype are most suited for cut flower and corm production under temperate conditions of Bharsar, Pauri Garhwal (Uttarakhand), India.

Key words : Gladiolus, Genotypes, Corm, Randomized complete block design, Temperate region, Uttarakhand.

Introduction

Gladiolus (*Gladiolus grandiflorus* L.) is one of the most popular ornamental bulbous plants, belonging to the family Iridaceae and is commercially cultivated as cut flower for its fascinating flowers in many parts of the word (Arora, 1999). In the year 2020-21, gladiolus was cultivated in an area of about 11.77 tha in India (Anonymous, 2022). It has majestic flower spikes with florets of varying shapes, sizes, colours and patterns and also due to its prolonged vase-life and high economic value makes it very popular for floral arrangement (Negi *et al*., 1986). The genus *Gladiolus* having approximately 260 species (Singh, 2014) with a chromosomes number (n=15) and is originated from South Africa and then it wide spread to central Europe, Mediterranean region and Western Asia and Asia Minor (Bose *et al*., 2003). The generic name gladiolus derived from the Latin word '*gladius*' meaning 'a sword' which describes the shape of the leaves and commonly known as Sword lily or "Queen of bulbous flowers" (Kaicker and Naurial, 1964). It is an herbaceous bulbous perennial plant used for landscaping and for cut flower production (Alam *et al*., 2013). It is grown in open field conditions during the summers in temperate to subtemperate areas and winters in tropical to sub-tropical areas in India (Sarkar *et al*., 2014 and Proietti *et al*., 2022). This makes Gladiolus a versatile crop that is produced throughout India for cut flower production. Although, there are many cultivars of

exotic and indigenous origin in gladiolus, which ability to improve the different traits of cultivars using breeding techniques requires knowledge of the performance of particular cultivars. As a result, for the production of new varieties, interbreeding of individuals related closely or distantly with desirable traits can be utilized (Cantor and Tolety, 2011).

Gladiolus cultivation has been exploited in Uttarakhand high hills, but it is becomes challenging for farmers to gather appropriate information to evaluate the performance of different germplasm and their suitability to grow successfully in different climatic conditions. A comparative varietal evaluation of new and existing cultivars needs to be performed to establish their consumers' value. Previous research has also found significant physical genetic variability in all gladiolus genotypes (Swaroop *et al*., 2019 and Gurung *et al*., 2021). Genetic variability has been noticed in different gladiolus cultivars grown under Delhi conditions in India (Kadam *et al*., 2014 and Sindhu *et al*., 2016). Variations in morphological traits throughout different genotypes under climatic conditions of Uttarakhand have not been reported before. Under the climatic conditions of Bharsar, this crop is one of the best options for production of cut flowers during winter season. However, no research work has been conducted on the performance of gladiolus varieties and expression of their genetic variability under temperate region of Bharsar. Keeping all of these considerations in view, the current study was conducted to evaluation of 15 gladiolus germplasms for growth, flowering and corm yielding under temperate region of Uttarakhand.

Materials and Methods

The present investigation was conducted during March to October, 2019 at Floriculture and Landscaping block, College of Horticulture, Veer Chandra Singh Garhwali, Uttarakhand University of Horticulture and Forestry, Bharsar, Pauri Garhwal, Uttarakhand, which is situated at the hills of Himalayas at 29^0 20'-29^0 75' N Latitude and 78^0 10'-78^0 80' E Longitude at an altitude of 1900 meters above the mean sea level. The experiment was designed in Randomized Complete Block Design (RCBD) with three replicates. The experiment comprised of 15 germplasm, 6 germplasm of gladiolus i.e. Punjab Dawn, Peter Pears, Nova Lux, Black Star, White Prosperity and Punjab Gold was procured from Model Floriculture Centre at GBPUAT, Pantnagar, 6 germplasm of gladiolus i.e. Amsterdam, Arka Amar, Bharsar Local-1, Bharsar Local-2, Bharsar Local-3, Bharsar Local-4 from COH, VCSG, UUHF Bharsar and 3 germplasm of gladiolus *i.e*. Palampur Delight, Palampur Pride, Palampur Pink was procured from CSIR IHBT Palampur, Himachal Pradesh. The soil was medium sandy loam with a pH of 6.1. The field was prepared with the help of rope and the whole area was divided into different plots having plot size 1.5 m × 1 m. The required numbers of corms per plot was treated with bavistein (0.2%) for 45 minutes and were kept under shade for drying. Corms were planted at a spacing of 30 cm × 20 cm in each row along the ridge sides at a depth of 5-6 cm to accommodate twenty five corms per plot. The recommended dose of phosphorus (20 g/m^2) and potassium (20 g/m^2) were applied in each plot before the planting of corms. Nitrogen was applied in two split doses using CAN at three leave stage (20 g/m^2) and six leaves stage (10 g/m^2). Uniform cultural practices were followed to all the treatment, to grow successful crop. Observations on various vegetative and flowering parameters were recorded at peak flowering, whereas corm yielding parameters were recorded after crop harvesting. The data were analysed using 'OPSTAT' or 'Excel sheet' according to the procedure proposed by Gomez and Gomez (1984).

Results and Discussion

Vegetative parameters

The results in Table 1 revealed that there was a significant variation in all the growth parameters examined throughout the experiment among the 15 genotypes of gladiolus. The genotype Punjab Dawn showed the earliest corm sprouting (16.41 days), which was statistically at par with genotype Palampur Pride (19.50 days). In contrast, genotype Bharsar Local-4 showed delayed corm sprouting (31.14 days). The results indicate that the wide variation in gladiolus genotypes which may be due to the presence of different dormancy periods in gladiolus genotypes as well as the influence of the prevailing environment conditions in Bharsar (Uttarakhand). Similar results were reported by Kadam *et al*. (2014) and Kumar (2019) in gladiolus. Likewise, genotype Palampur Pink achieved the tallest plant height (113.70 cm), which was at par with genotype Arka Amar (112.72 cm). Conversely, genotype Punjab Dawn achieved the shortest (75.32 cm). The difference in plant height attributed to difference in their genetic make-up, which differ from genotype to genotype and influence of prevailing environmental conditions of the growing location. These findings were in line with Hossain *et al*. (2011), Pandey *et al*. (2012), Islam *et al*. (2017), Patra and Mohanty (2014) in gladiolus. Furthermore, genotype Arka Amar produced more number of leaves (10.05) and found at par with Black Star (9.79). While, genotype Punjab Dawn (7.46) produced less number of leaves per plant (7.46). The variation in number of leaves per plant might be attributes

Table 1 : Mean performance of gladiolus genotypes on different vegetative parameters under temperate region of Uttarakhand.

Genotypes		Number of days required for sprouting of corms ± S.E.(m)	Plant height (cm)± S.E. (m)	Number of leaves per plant ± S.E.(m)
Punjab Dawn		16.41±1.73	75.32±1.18	7.46±0.11
Peter Pears		26.62±1.34	96.52±1.38	7.92±0.22
Nova Lux		21.12±1.89	98.12±1.15	8.25±0.19
Black Star		25.16±1.36	82.74±6.11	9.79±0.18
White Prosperity		30.71±1.53	101.63±1.26	9.17±0.26
Punjab Gold		25.75±1.30	102.77±1.44	8.79±0.11
Amsterdam		25.50±2.67	108.52±0.47	7.96±0.29
Arka Amar		21.21±0.11	112.72±1.04	10.05±0.33
Bharsar Local-1		26.16±2.24	103.37±1.10	7.88±0.07
Bharsar Local-2		29.83±1.28	83.45±1.01	7.79±0.11
Bharsar Local-3		29.96±2.64	78.26±0.25	7.59±0.23
Bharsar Local-4		31.14±1.12	77.95±3.66	7.71±0.08
Palampur Delight		30.37±0.99	86.03±0.76	8.50±0.13
Palampur Pride		19.50±1.09	78.73±3.27	9.63±0.19
Palamapur Pink		27.29±2.69	113.70±1.38	9.59±0.11
Range	**Min.**	16.41	75.32	7.46
	Max.	31.14	113.70	10.05
Mean		25.78	93.32	8.54
SE(d)		2.55	3.04	0.28
$CD_{(0.05)}$		5.24	6.26	0.57
CV		12.10	3.99	3.99

due to the difference in the amount of store food material in mother corm and other probable reason might be the prevailing environmental condition of growing location. Similar findings have also been reported by Mushtaq *et al*. (2018) and Singh *et al*. (2017) in gladiolus.

Flowering parameters

Table 2a summarise that all the flowering characteristics recorded throughout the experiment had a significant influence on the 15 gladiolus genotypes. The results suggest that early visible spike appearance (82.62 days) was shown by genotype Peter Pears, which was statistically at par with genotype Punjab Dawn (82.66 days) while it was delay resulted in genotype Amsterdam (92.37 days). Spike appearance may have been primarily based on plant food reserves, which might be related to growth rate of plants which regulating accumulation of the requisite level of carbohydrates for slipping. In gladiolus, similar outcomes were previously noted by Kumar *et al*. (2011), Rao and Sushma (2015) in gladiolus. Moreover, first floret to show colour and first floret opening (91.16 and 95.33 days, respectively) was observed to be early in genotype Punjab Dawn which was statistically at par with genotype Palmapur Pink (93.75 and 95.37 days, respectively). In contrast, delayed to first floret to show colour and first floret opening was recorded in genotype Bharsar Local-3 (105.12 and 104.95 days, respectively). The significant variation might be attributed due to the genetic constituents of gladiolus genotypes and morphological adaptation to the environment conditions. Similar results were observed earlier by Thakur *et al.* (2017), Ishwarraddy *et al*. (2017), Singh *et al*. (2017), Swaroop *et al*. (2018) in gladiolus. It is also apparent that, genotype Punjab Dawn had the shorter days to full bloom and blooming duration (106.50 days and 11.16 days, respectively), followed by genotype Palmapur Pink (108.37 days and 12.75 days, respectively). In contrast, longer days to full bloom were noticed in genotype Bharsar Local-3 (125.16 days). In case of blooming duration it was noticed prolonged in genotype

Table 2a : Mean performance of gladiolus genotypes for floral parameters under temperate region of Uttarakhand.

Genotypes		Days to visible spike appearance ± S.E.(m)	Days taken for first floret to show colour ± S.E.(m)	Days taken to first floret opening ± S.E.(m)	Days to full bloom ± S.E.(m)	Blooming duration ± S.E.(m)
Punjab Dawn		82.66±1.35	91.16±1.50	95.33±1.48	106.50±1.57	11.17±0.11
Peter Pears		82.62±0.45	94.87±0.83	98.79±0.89	112.00±0.73	13.05±0.17
Nova Lux		92.04±1.65	99.41±1.56	103.83±1.65	118.04±1.47	14.21±0.23
Black Star		90.00±2.35	104.95±2.30	109.37±2.02	124.21±1.49	14.84±0.53
White Prosperity		86.96±1.16	97.75±1.20	101.75±1.35	115.16±1.24	13.58±0.33
Punjab Gold		88.62±0.76	100.46±0.76	104.91±0.80	118.33±0.40	13.38±0.47
Amsterdam		92.37±1.20	102.00±2.17	106.33±1.96	120.25±2.15	13.92±0.23
Arka Amar		89.25±1.45	99.67±1.17	103.50±1.21	116.79±1.19	13.17±0.26
Bharsar Local-1		83.17±1.52	94.50±1.47	99.00±1.37	113.87±1.32	14.88±0.07
Bharsar Local-2		86.92±1.34	99.17±1.36	104.00±1.13	120.33±1.68	16.00±0.57
Bharsar Local-3		92.00±2.25	105.12±2.32	110.12±2.27	125.16±2.23	14.66±0.18
Bharsar Local-4		87.41±0.11	97.25±0.38	102.67±0.65	118.50±0.76	15.62±0.40
Palampur Delight		87.46±0.69	97.29±3.55	103.20±2.82	117.16±2.71	13.96±0.15
Palampur Pride		90.00±0.66	99.12±0.98	103.75±1.45	119.62±1.64	15.84±0.27
Pink		83.12±0.76	93.75±0.96	95.37±1.18	108.37±1.05	12.75±0.07
Range	**Min.**	82.62	91.16	95.33	106.50	11.17
	Max.	92.37	105.12	110.12	125.16	16.00
Mean		87.64	98.43	102.79	116.95	14.07
SE(d)		1.94	2.35	2.19	2.13	0.45
$CD_{(0.05)}$		3.99	4.83	4.52	4.38	0.92
CV		2.71	2.92	2.61	2.23	3.88

Bharsar Local-2 (16.00 days). Variations in full bloom and blooming duration seem indicate the varietal characteristics, environmental conditions and genetic traits of genotypes. These results are in conformity with the work of Shaukat *et al*. (2013), Naresh *et al*. (2015), Bhaskar and Reddy (2017) in gladiolous.

The findings in Table 2b reveal that genotype Palampur Pink had the longest spike and rachis length (97.49 and 53.75 cm, respectively), while genotype Punjab Dawn had the shortest (54.33 cm and 25.48 cm, respectively). This variance in spike and rachis length might be attributed to the inherent genetic characters associated with the genotypes as well as environmental condition prevailed during growth stage of spike. Similar, results were reported earlier by Bhujbal *et al*. (2013), Jana and Das (2013) and Swaroop *et al*. (2018) in gladiolus. Likewise, genotype Palampur Pink produced more number of floret per spike (18.04) and found statistically at par with genotype Arka Amar (17.87). In contrast, genotype Bharsar Local-2 produced less (10.41). The variability in florets per spike among gladiolus cultivars may be due to their genotypic differences in phenotypic expressions. Similar results were observed by Mushtaq *et al*. (2018) and Ishwarraddy *et al*. (2018) in gladiolus. Moreover, genotype Peter Pears had the highest floret length (9.11cm), which was statistically equivalent to genotype Palampur Pink (9.04 cm). In contrast, lowest floret length (6.16 cm) was resulted in genotype Bharsar Local-2. This might be due to their genetic composition, which reacts differently to soil and weather circumstances. These results are corroborated with the findings of Naresh *et al*. (2015) and Ramzan *et al*. (2016) in gladiolus. In spike weight, genotype Palampur Pink obtained the highest value (77.36 g) and was equivalent to genotype Amsterdam (76.85 g). The lowest spike weight was obtained in genotype Punjab Dawn (36.37 g). The variation among varieties may be caused by genetic inheritance as well as the effect of prevailing environmental conditions. Similar results were reported by Hossain *et al*. (2011) and Jana and Das (2015) in

Table 2b : Mean performance of gladiolus genotypes for floral parameters under temperate region of Uttarakhand.

Genotypes		Spike length (cm)±SE (m)	Rachis length (cm)±SE (m)	Number of florets per spike±SE (m)	Floret length (cm)±SE (m)	Spike weight (g)± SE (m)	Vase life (days)± S.E. (m)
Punjab Dawn		54.33±2.47	25.48±0.13	13.58±0.32	6.77±0.08	36.37±2.36	13.58±0.32
Peter Pears		67.64±3.39	43.09±1.37	12.83±0.36	9.11±0.05	50.16±1.25	13.25±0.07
Nova Lux		75.43±0.35	29.43±0.12	12.04±0.11	6.51±0.02	51.28±2.25	12.46±0.04
Black Star		66.93±3.44	36.37±0.87	14.83±0.17	7.39±0.15	58.21±0.12	8.54±0.04
White Prosperity		64.69±1.12	46.35±0.22	15.41±0.18	6.89±0.04	48.51±1.46	12.87±0.13
Punjab Gold		65.36±0.60	46.73±1.38	14.45±0.22	7.37±0.06	56.48±0.29	12.33±0.30
Amsterdam		79.68±0.02	48.61±1.16	17.50±0.07	7.36±0.14	76.85±1.14	11.50±0.19
Arka Amar		90.67±2.67	48.54±0.87	17.87±0.48	8.83±0.10	70.51±1.20	14.20±0.08
Bharsar Local-1		67.46±0.12	42.91±0.35	15.50±0.07	7.25±0.04	63.64±0.57	11.12±0.07
Bharsar Local-2		69.51±0.97	28.08±0.49	10.41±0.11	6.16±0.05	49.72±1.26	10.58±0.30
Bharsar Local-3		58.81±0.93	28.43±0.04	11.04±0.17	7.48±0.04	40.69±3.32	10.29±0.15
Bharsar Local-4		55.29±1.18	30.69±0.47	11.50±0.13	6.82±0.06	45.76±3.12	10.25±0.19
Palampur Delight		72.44±1.13	36.67±2.15	14.50±0.31	7.74±0.03	68.23±0.28	8.54±0.08
Palampur Pride		64.20±0.84	33.78±0.60	10.62±0.13	6.28±0.04	41.98±3.37	9.04±0.23
Pink		97.49±1.49	53.75±0.47	18.04±0.51	9.04±0.09	77.36±8.37	12.29±0.23
Range	**Min.**	54.33	25.48	10.41	6.16	36.37	8.54
	Max.	97.49	53.75	18.04	9.11	77.36	14.20
Mean		70.00	38.59	14.01	7.40	55.72	11.39
SE(d)		2.48	1.23	0.37	0.10	4.13	0.27
$CD_{(0.05)}$		5.10	2.52	0.76	0.21	8.50	0.56
CV		4.33	3.89	3.25	1.68	9.07	2.92

gladiolus. Furthermore, maximum vase life (14.20 days) was resulted in genotype Arka Amar while, it was resulted minimum (8.54 and 8.54 days, respectively) in genotype Palampur Delight and Black Star during the experiment. This variance might be attributed to different genetic makeup of genotypes and prevailing environmental conditions that might have influenced the flower physiological such as cell turgidity, water loss through evapotranspiration and break down of the reserve food. Similar results were noted by Naresh *et al*. (2015), Bhaskar and Reddy (2017) and Singh and Singh (2018).

Corm yielding parameters

Based on the corm yielding parameters evaluated, the finding revealed significant variation among the fifteen genotypes of gladiolus (Table 3). The results showed that genotype Punjab Dawn produced more corms per plant (2.62) and genotype Amsterdam produced less (1.12). It might be because different genotypes, depending on their genetic composition, responded differently to the soil and climatic conditions that prevailed in the area. Similar results were observed earlier by Joshi *et al*. (2011) and Swaroop *et al*. (2018) in gladilous. In corm diameter and weight, genotype Palampur Pink obtained the highest value (5.73 cm and 53.72 g, respectively) and was found statistically at par with genotype Arka Amar (5.30 cm and 51.01 g, respectively) and genotype Bharsar Local-1 (5.23 cm and 46.92 g, respectively). The lowest value was obtained by genotype Palampur Delight (3.69 cm and 28.63 g, respectively). Corms diameter and weight in gladiolus genotypes may be closely associated with the genetic variation of the cultivars. These findings are also in accordance with Geeta *et al*. (2014) and Rao and Sushma (2015) in gladiolus. Furthermore, genotype Palampur Pride produced more cormels per plant (37.16) followed by genotype Arka Amar (29.00). In contrast, less number of cormels per plant was produced by genotype Black Star (11.12). Production of cormels per plant was mainly due to the presence of greater amount of stored food materials which promoted vegetative

Table 3 : Mean performance of gladiolus genotypes for corm yielding parameters under temperate region of Uttarakhand.

Genotypes		Number of corms per plant ± S.E.(m)	Diameter of corm (cm) ± S.E.(m)	Weight of corm (g) ± S.E.(m)	Number of cormels per plant ± S.E.(m)
Punjab Dawn		2.62±0.19	4.19±0.05	32.30±1.18	16.37±.62
Peter Pears		2.04±0.04	3.86±0.13	29.40±1.88	14.66±0.66
Nova Lux		1.33±0.04	4.37±0.10	36.22±3.33	20.42±0.30
Black Star		1.45±0.08	3.84±0.13	29.21±3.36	11.12±0.88
White Prosperity		1.62±0.12	3.97±0.26	31.19±2.08	17.12±0.83
Punjab Gold		1.46±0.11	4.28±0.40	32.97±1.33	14.12±0.25
Amsterdam		1.12±0.12	4.09±0.20	31.60±0.35	23.79±2.80
Arka Amar		1.83±0.11	5.30±0.19	51.01±1.89	29.00±1.77
Bharsar Local-1		1.66±0.11	5.23±0.04	46.92±2.84	22.91±0.33
Bharsar Local-2		1.54±0.18	4.57±0.46	40.04±5.27	11.70±0.58
Bharsar Local-3		1.54±0.04	3.95±0.34	30.74±1.25	14.96±0.52
Bharsar Local-4		1.33±0.11	4.68±0.71	41.08±7.73	19.71±0.40
Palampur Delight		1.46±0.11	3.69±0.34	28.63±4.25	18.21±0.18
Palampur Pride		2.29±0.11	3.81±0.35	29.05±4.11	37.16±3.18
Palampur Pink		2.12±0.13	5.73±0.42	53.72±6.81	19.17±1.08
Range	**Min.**	1.12	3.69	28.63	11.12
	Max.	2.62	5.73	53.72	37.16
Mean		1.69	4.37	36.27	19.36
SE(d)		0.16	0.38	5.07	1.89
$CD_{(0.05)}$		0.32	0.79	10.44	3.89
CV		11.37	10.69	17.12	11.94

growth and ultimately reflected on cormels production. Similar variation was observed by Joshi *et al*. (2011) and Swaroop *et al*. (2018) in gladiolus.

Conclusion

The study's findings demonstrated the potential for selecting and breeding gladiolus genotypes with superior vegetative, floral and corm yielding characteristics suitable for the temperate conditions of Uttarakhand. Genotypes such as Palampur Pink, Arka Amar and Punjab Dawn exhibit promising characteristics for commercial cultivation, including early sprouting, robust vegetative growth, superior floral attributes and high corm yield. These genotypes can significantly enhance the economic viability and ornamental value of gladiolus cultivation in the temperate region of Uttarakhand.

Future recommendations

Continued research and breeding programs focusing on these superior genotypes can further optimize gladiolus cultivation. Integrating these findings with advanced agronomic practices and environmental management can lead to improved productivity, quality and marketability of gladiolus in Uttarakhand. Sustainable cultivation practices and genetic improvement efforts will be crucial for the long-term success and profitability of the gladiolus industry in the region.

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