



Genetic Variability, Heritability, Genetic Advance and Genetic Divergence for Yield and its Contributing Traits in Gladiolus (*Gladiolus grandiflorus* L.)

Anupama Bharti, D Ram and Abhinav Kumar*

Department of Horticulture, College of Horticulture & Forestry
Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya -224 229
(Uttar Pradesh)

ABSTRACT

The experiment on 12 genotypes of gladiolus (*Gladiolus grandiflorus* L.) was conducted to work out the genetic variability, heritability, genetic advance and genetic divergence effects of their various attributes on spike yield. The analysis of variance revealed that mean squares due to treatments were highly significant for all characters. The magnitude of phenotypic coefficient of variation was higher than corresponding genotypic coefficient of variation for all the characters. Expected genetic advance expressed as per cent of mean ranged between 4.90 to 38.63 per cent. The highest of genetic advance was recorded for number of cormels per plant (38.63%) and lowest for number of spikes per plant and number of spikes per hectare (4.90%). High genetic advance coupled with high heritability was recorded for the characters of number of cormels per plant, number of sprouts per corm, number of leaves per plant, vase life (days), plant height (cm), days taken for complete sprouting, number of spikes per plant, length of spike (cm), number of spikes per ha (lac), duration of flowering (days) and corms yield per ha (q) provide greater scope for further improvement of these traits in advance generations. Phenotypic and genotypic coefficient variations were highest for number of cormels per plant (26.95 and 22.48) and lowest for duration of flowering (days) (11.01 and 9.99). Heritability and genetic advance indicate that the additive nature of gene action and reliability of those characters for selection and emerged as ideal traits for improvement through selection.

Key Words: Gladiolus, Genetic Variability, Heritability, Genetic Advance, Genetic Divergence, Spike, Yield.

INTRODUCTION

Gladiolus (*Gladiolus grandiflorus* L.) is sword lily because of its sword shaped leaves. India has suitable agroclimatic conditions and commercially cultivated in West Bengal, Himachal Pradesh, Sikkim, Karnataka, Uttar Pradesh, Tamil Nadu, Punjab and Delhi. In the eastern states like Tripura, Assam, Manipur, Meghalaya and Nagaland, this flower has established itself as a commercial proposition. There is a sizeable area under gladiolus in Jammu-Kashmir, Andhra Pradesh and Gujarat also. There are over 180 known species of the gladiolus today, but only a few of them are

found in most gardens. The orchids like flowers of the Butterfly gladiolus and recently a strain of miniatures have also been introduced. The flowers open from the bottom to up. The flowers may be frilly, ruffled or plain, solid colored or multicolored and they come in every shade and color combination imaginable.

Gladiolus plants are unbranched leafy, leaves basal and cauline, sword shaped, less frequently linear or cylindrical. Flowers showy in one sided spike, irregular, borne in two spathe valves, perianth segments six, united basically into curved, funnel form tube, the upper three segments larger than lower

Corresponding Author' Email: abhinavkumar188@gmail.com

Table 1. Analysis of variance (mean square) for twelve characters in gladiolus.

Sr. No.	Character	Replication	Treatment	Error
	d.f.	2	11	22
1	Days taken for complete sprouting	5.03	55.81**	1.12
2	Number of leaves per plant	0.02	4.09**	0.02
3	Number of sprouts per corm	0.01	0.44**	0.02
4	Plant height (cm) 9	1.34	131.61**	1.09
5	Duration of flowering (days)	0.83	21.06**	1.41
6	Length of spike (cm)	0.30	45.35**	1.55
7	Number of spikes per plant	0.09	0.30**	0.06
8	Number of florets per spike	0.32	9.52**	1.36
9	Number of spikes per ha (lac) 9	0.13	0.45**	0.10
10	Number of corms per plant	0.07	0.63**	0.08
11	Vase life (Days)	0.29	4.62**	0.29
12	Corms yield per ha (q)	30.01**	11.12**	4.13

**Significant at 1 % probability level, Here Mean Sum of Squares of Treatments was significant for all characters.

three, stamens 3, filaments not united, borne below the throat, style branches three entire, fruit, a three valved capsule and the winged seeds are arranged in two rows in each locule. Gladiolus produce flowers with their beautiful spikes, from October to March in plains and from June to September in hills in India. Improvement of any crop is a continuous process and in gladiolus also there is scope to improve the existing cultivars or genotypes. Since the gladiolus is highly heterozygous, it becomes more essential to evaluate. Though many genotypes of Gladiolus can be grown in particular agroclimatic region but all are not suitable for cut flower purpose, garden display or exhibition purposes. Hence, there is a need to evaluate some of the promising varieties of gladiolus with extended vase life in this area

so that suitable variety could be recommended for commercial cultivation under Eastern Plain Zone of Uttar Pradesh. Therefore, an investigation was undertaken to study the performance of elite gladiolus varieties identified under Eastern tract of Uttar Pradesh.

MATERIALS AND METHODS

The study was undertaken to work out the status of genetic variability, heritability and genetic advance effects of their various attributes on yield per plant among 12 gladiolus genotypes namely Pafefica, Regency, Tiger Flame, Yellow stone, Praha, Shagun, Pink Friendship, Novalux (check), Promise, True love, Spic & span and Wind song at field experiment under present investigation

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was conducted during *Rabi* 2018-19 at the Main Experimental Station, Floriculture, A.N.D.U.A.& T., Kumarganj, Ayodhya (U.P.). Geographically, it is situated in typical saline alkali belt of Indo-gangetic plains of eastern U.P. at 26.47-0 N latitude, 88.120 E longitudes and at an altitude of 113 meter from mean sea level. The region enjoys sub humid and subtropical climate receiving a mean annual rainfall of about 1215 mm out of which about 85 per cent is concentrated from mid June to end of September. The winter months are cold and dry and occasional frost occurs during this period. Westerly hot wind starts from the month of March and continues up to onset of monsoon.

The experiment was laid out in Randomized Block Design. The observation was recorded on 17 different traits *viz.*, days taken for complete sprouting, number of leaves per plant, number of sprouts per corm, plant height (cm), duration of flowering (days), length of spike (cm), number of spikes per plant, number of florets per spikes, number of spikes per hectare, number of corms/plant, vase life (days), corms yield per hectare (q), variability for different characters and heritability in broad sense (h^2) was calculated using the formula suggested by Burton and de Vane (1953). Expected genetic advance (aG) was estimated by the method suggested by Johnson *et al* (1955). The genetic divergence among ten genotypes of gladiolus was worked out using Mahalanobis's (1936) D^2 statistics.

RESULTS AND DISCUSSION

Analysis of variance revealed highly significant difference among the genotypes for all the characters presented in Table 1. Days taken for complete sprouting varied from 19.00 to 31.33. Maximum days taken for complete sprouting was noticed in variety Promise (31.33) followed by Tiger flame (31.00) and Yellow Stone (28.33), while minimum in variety Pacea (19.00) and the mean for this character was 24.94. Number of leaves per plant varied from 5.63 to 8.90. The maximum number of leaves per plant was observed in variety

(8.90) followed by Wind Song (7.95) and Promise (7.64), while minimum in variety Pacea (5.63). Number of sprouts per corm varied from 1.20 to 2.45. The maximum number of sprouts per corm was observed in variety Novalux (2.45) followed by Pink Friendship (2.35) and Praha (2.26), while minimum in variety Spic and span (1.20). The height of plant ranged from 30.40 cm to 50.26 cm. Height was higher in variety Yellow stone (50.26 cm) followed by Novalux (48.12 cm) and Tiger flame (45.40 cm) while Shagun (30.40 cm) was shortest one and the mean for such character was 58.64. The results were in agreement to Sidhu and Arora (2000), Rai *et al* (2000) and Basavaraddy (2004). The longest duration of flowering was observed for the variety Praha (29.48 days) followed by Spic and span (29.16 d) and Promise (28.63 d) and shortest for the variety Shagun (21.26 d). The length of spike ranged from 20.00 cm to 35.33 cm. The longest spike was observed for the variety Tiger flame (35.3 cm) followed by Novalux (35.0 cm) and Pacea (33.0 cm) and shortest for the variety Shagun (20.0 cm). The number of spikes per plant varied from 1.20 to 2.1. The number of spikes per plant was maximum in case of variety Pink Friendship (2.13) followed by True love (2.06) and Yellow stone (1.93), while minimum number of spikes per plant in case of variety Spic and span (1.20). The number of florets per spikes varied from 10.20 to 15.63. The number of spikes per plant was maximum in case of variety Pacea (15.63) followed by True love (15.43) and Promise (15.30), while minimum number of spikes per plant in case of variety Shagun (10.20). The number of spikes per hectare varied from 1.49 to 2.66 lakh. The maximum number of spikes was observed variety Pink Friendship (2.66 lakh) followed by True love (2.58 lakh) and Tiger flame (2.41 lakh) and minimum number of spike variety Spic and span (1.49 lakh). For the character spike yield per hectare and number of spikes per hectare results are in accordance with Nair and Shiva (2003). Total number of corms produced per plant was recorded highest in variety Pink friendship (2.53) followed

Table 2. Mean performances of quantitative characters of gladiolus varieties.

Varieties	Days taken for complete sprouting	No. of leaves per plant	No. of sprouts per corm	Plant height (Cm)	Duration of flowering (Days)	Length of spike (Cm)	No. of spike per plant	No. of florets per spike	No. of spikes per ha (lac)	No. of corms per plant	Vase life (Days)	Corms yield per ha (qt)
Pacefica	19.0000	5.6300	2.1267	34.5667	24.2000	33.0000	1.6333	15.6333	2.0400	1.4667	6.6500	34.7900
Regency	19.3333	7.2900	1.6867	44.6333	26.2000	30.2667	1.8333	14.1333	2.2900	1.6000	7.1833	39.9533
Tiger flame	31.0000	5.9000	2.0467	45.4000	21.6800	35.3333	1.9333	12.0000	2.4133	2.4333	7.3000	37.3733
Yellow stone	28.3333	7.2867	2.0100	50.2667	26.7333	31.0000	1.9000	13.6333	2.3733	2.3000	6.6667	37.2133
Praha	19.0000	5.1000	2.2667	36.4667	29.4867	29.1667	1.5333	13.3667	1.9167	1.4000	5.5000	37.4967
Shagun	26.3333	5.6200	2.0667	30.4000	21.2667	20.0000	1.3000	10.2000	1.6200	1.4667	5.2333	40.9067
Pink friendship	25.3333	7.6833	2.3500	45.2000	25.9000	28.6667	2.1333	12.2667	2.6633	2.5333	8.0000	37.2500
Novalux (check)	24.0000	7.1167	2.4567	48.1333	24.7300	35.0000	1.6333	14.6000	2.0400	1.4000	8.1667	41.4467
Promise	31.3333	7.6400	1.9333	35.4333	28.6300	30.6667	1.8333	15.3000	2.2900	2.3000	4.7500	39.2900
True love	27.0000	8.9000	2.2500	35.5667	25.0633	29.6667	2.0667	15.4333	2.5800	2.4333	5.5000	38.2900
Spic and span	22.6667	5.9467	1.2000	32.3333	29.1667	29.8333	1.2000	11.8667	1.4967	1.8000	6.0000	40.5367
Wind song	26.0000	7.9567	1.3667	39.4667	24.4500	30.8333	1.2667	11.3000	1.6233	1.7000	8.5000	38.1233
Mean	24.9444	6.8392	1.9800	39.8222	25.6256	30.2861	1.6889	13.3111	2.1122	1.9028	6.6208	38.5558
C.V.	5.2649	2.0380	7.4890	2.6235	4.6267	4.1107	14.8086	8.7746	14.7403	14.9466	8.1599	5.2716
F ratio	32.3572	210.3153	20.1725	120.5810	14.9790	29.2585	4.7315	6.9803	4.6519	7.7736	15.8163	2.6912
F Prob.	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0010	0.0001	0.0011	0.0000	0.0000	0.0231
S.E.	0.7582	0.0805	0.0856	0.6032	0.6845	0.7188	0.1444	0.6743	0.1798	0.1642	0.3119	1.1735
C.D. 5%	2.2238	0.2360	0.2511	1.7691	2.0076	2.1081	0.4235	1.9778	0.5272	0.4816	0.9148	3.4417
C.D.1%	3.0225	0.3208	0.3413	2.4045	2.7287	2.8653	0.5756	2.6881	0.7166	0.6545	1.2434	4.6778

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by Tiger flame (2.43) and True love (2.43) while variety Praha (1.40) had produced lowest number of corms produced per plant. The vase life of spike varied from 4.75 days to 8.50d. The variety Wind song (8.50 d) had maximum vase life in the laboratory when kept in vases with 4 % sucrose solution followed by Novalux (check) (8.16 d) and Pink friendship (8.00 d). The variety Promise (4.75 d) had minimum vase life. Similar results were observed by Singh *et al* (2000) and Nagaraju and Parthasarathy (2001). The corm yield per hectare ranged from 89.61 to 228.87q. The highest spike yield was observed variety Novalux (check) (41.44 q) followed by Shagun (40.90 q) and Spic and span (40.53q) and lowest spike yield variety Pacefica (34.79q).

Heritability

The estimates of heritability varied from 54.13 to 98.55 per cent. The highest heritability estimates in broad sense were observed for the characters number of leaves per plant (98.55%) followed by plant height (cm) (97.56%), days taken for complete sprouting (91.29%), length of spike (cm) (90.40%), number of sprouts per corm (87.58%), vase life (days) (83.26%), duration of flowering (d) (82.29%), number of corms per plant (69.58%), number of florets per spike (66.66%) and number of spikes per plant (56.52%). The lowest estimate of heritability in broad sense was noticed for number of spikes per ha (lac) (54.13%). Burton (1953) pointed out that heritability in combination with intensity of selection and amount of variability present in the population influences the genes to be obtained from the selection.

Genetic advance

The high range of genetic advance was recorded for plant height (cm) (13.42), days taken for complete sprouting (8.36) and length of spike (cm) (7.48). The medium range of genetic advance was observed for duration of flowering (days) (4.78), number of leaves per plant (2.38), vase life (d) (2.26) and corms yield per ha (q) (1.89). Rest of characters showed low to very low genetic advance

i.e., number of corms per plant (0.74), number of sprouts per corm (0.72), number of spikes per ha (lac) (0.52) and number of spikes per plant (0.43). The expected genetic advance was expressed as per cent of mean. It is the unit of measurement of the magnitude of genetic advance. Therefore, this cannot be avoided and to facilitate the comparison of genetic improvement in various parameters in per cent of mean. Expected genetic advance expressed as per cent of mean ranged from 4.90% to 38.63%. The highest genetic advance as percentage of mean was recorded for number of corms per plant (38.63%) followed by number of sprouts per corm (36.56%), number of leaves per plant (34.82%), vase life (34.09%), plant height (cm) (33.70%), days taken for complete sprouting (33.50%), number of spikes per plant (25.61%), length of spike (cm) (24.71%), number of spikes per ha (lac) (24.65%), number of florets per spike (20.83), duration of flowering (days) (18.66) and corms yield per ha (qt) (4.90%). Similar work was also reported by Kumar (2012) and Maurya (2011). The study of genetic divergence among the 12 varieties of gladiolus was carried out using Mahalanobis D^2 statistics. The 12 genotypes were grouped into four different non over lapping cluster (Table 4). Cluster 1 had highest number of genotypes (9) followed by cluster 2,3,4 (1). The distribution pattern of genotypes among different clusters also indicating that there is no geographical parallism in the grouping genotypes indicating that genotype of different geographical origin may group together or vice- versa.

The estimates of inter and intra cluster distances represented by D^2 values are given in (Table 5). The intra cluster D^2 values ranged from 0.00 (cluster 2,3 & 4) to 18.71 (cluster 1). The maximum inter-cluster distance was observed between 2 to 4 (31.02) which suggested that members of these two clusters were genetically very diverse to each other. Inter- cluster values between cluster 2 and cluster 3 (24.75), cluster 1 to 2 (22.50), cluster 1 to 4 (31.02), cluster 1 to 3 (24.75), cluster 3 to 4 (31.02) were very high. The minimum inter- cluster D^2 values was recorded in case of cluster 4 and 1

Table 3. Genetic parameters of different quantitative characters of gladiolus varieties.

Character	Mean	Range	Coefficient of variation (%)		Heritability (Broad sense)	Genetic Advance in per cent of Mean
			Phenotypic	Genotypic		
Days taken for complete sprouting	25	19-31	17.82	17.02	91.29	33.50
Number of leaves per plant	6.83	5.10-8.90	17.15	17.03	98.55	34.82
Number of sprouts per corm	1.98	1.20-2.45	20.27	18.96	87.58	36.56
Plant height (cm)	39.82	32.33-50.26	16.77	16.56	97.56	33.70
Duration of flowering (days)	25.62	21.26-29.48	11.01	9.99	82.29	18.66
Length of spike (cm)	30.28	20.00-35.33	13.27	12.62	90.40	24.71
Number of spikes per plant	1.68	1.20-2.13	22.00	16.54	56.52	25.61
Number of florets per spike	13.31	10.20-15.63	15.17	12.39	66.66	20.83
Number of spikes per ha (lac)	2.11	1.49-2.66	22.11	16.26	54.13	24.65
Number of corms per plant	1.90	1.40-2.53	26.95	22.48	69.58	38.63
Vase life (Days)	7	5-9	19.88	18.14	83.26	34.09
Corms yield per ha (qt)	38.55	34.79-41.44	6.59	3.96	36.06	4.90

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Table 4. Clustering pattern of ten genotype of gladiolus on the basis of Mahalanobis D² statistics.

Cluster	Number of genotypes	Name of germplasm in cluster
1	9	Regency(2), pink friendship(7), novalux(8), yellow stone(4), promise(9), tiger flam(3), praha(5), pacefica(1), spic and span(11)
2	1	Wind song(12)
3	1	Shagun(6)
4	1	True love(10)

Table 5. Average intra and inter clusters D² values for four clusters in gladiolus cultivars.

Cluster number	Cluster-1	Cluster-2	Cluster-3	Cluster-4
Cluster-1	18.71	22.50	24.75	24.85
Cluster-2		0.00	23.87	17.37
Cluster-3			0.00	31.02
Cluster-4				0.00

(17.37). The higher inter-cluster distance indicated greater genetic divergence between the varieties of these clusters while lower inter-cluster values between the clusters suggested that the genotypes of the clusters were not much genetically diverse from each other.

The intra-clusters mean

The intra-clusters mean for seventeen characters in gladiolus is given Table 6. Cluster 3 had maximum mean values corms yield per ha (q) (40.91), cluster 4 showed mean values for the days taken for complete sprouting (27.0), number of florets per spike (15.43), number of spikes per ha (lac) (2.58), number of corms per plant (2.43), number of spikes per plant (2.07), number of sprouts per corm (2.25) and number of leaves per plant (8.90) cluster 1 showed mean values for the plant height(cm) (41.38), duration of flowering (days) (26.30), length of spike (cm) (31.44). Cluster 1 showed minimum mean values for the days taken for complete sprouting (24.44), cluster 2 days taken for complete sprouting (1.37), number of spikes per plant (1.27), number of spike per ha (lac) (1.62), corms yield per ha (qt) (38.12), Cluster 3 plant height (cm) (30.40), duration of flowering (days) (21.27), length of spike (cm) (20.00), number of florets per

spike (10.20), number of leaves per plant (5.62), vase life (Days) (5.23) and number of corms per plant (1.47). Similar finding were recorded by Patil and Apte (2002), Sheikh and Khanday (2008) and Bhatia and Grewal (2009) for genetic divergence in gladiolus, Santhosha (2020) in chilli and Dhillon *et al* (2017) in sunflower.

A perusal of Table-7 showed that some characters zero contribution in duration of flowering (days), number of spikes per plant, number of florets per spike and number of spikes per hectare (lac) very low towards the divergence while number of leaves per plant was found for highest contribution (42.42%) followed by plant height (cm) (27.27%) and vase life (days) (12.12%) corms yield per ha (q) (6.06%), number of corms per plant & days taken for complete sprouting (3.03%) number of sprouts per corm (1.52%) for total divergence among the available genotypes of gladiolus.

CONCLUSION

It can be concluded that selection of genotypes based on characters like days taken for complete sprouting, number of leaves per plant, number of sprouts per corm, plant height (cm), duration of flowering (days), length of spike (cm), number

Table 6. Intra cluster group mean for seventeen characters in gladiolus genotype:

Number of cluster	Days taken for complete sprouting	Number of leaves per plant	Number of sprouts per corm	Plant height(cm)	Duration of flowering (days)	Length of spike (cm)	Number of spikes per plant	Number of florets per spike	Number of spike per ha (lac)	Number of corms per plant	Vase life (Days)	Corms yield per ha (qt)
I	24.44	6.62	2.01	41.38	26.30	31.44	1.74	13.64	2.17	1.91	6.69	38.37
II	26.00	7.96	1.37	39.47	24.45	30.83	1.27	11.30	1.62	1.70	8.50	38.12
III	26.33	5.62	2.07	30.40	21.27	20.00	1.30	10.20	1.62	1.47	5.23	40.91
IV	27.00	8.90	2.25	35.57	25.06	29.67	2.07	15.43	2.58	2.43	5.50	38.29

of spikes per plant, number of florets per spike, number of spikes per ha (lac), number of corms per plant, vase life and corms yield which are showing high GCV, PCV, heritability and genetic advance will give potential parent in breeding programme

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Table 7. Per cent contribution of seventeen characters towards total genetic divergence in gladiolus.

Sr. No.	Source	Times ranked 1 st	Contribution (%)
1.	Days taken for complete sprouting	2	3.03
2.	Number of leaves per plant	28	42.42
3.	Number of sprouts per corm	1	1.52
4.	plant height (cm)	18	27.27
5.	Duration of flowering (Days)	0	0.00
6.	Length of spike (cm)	3	4.55
7.	Number of spikes per plant	0	0.00
8.	Number of florets per spike	0	0.00
9.	Number of spikes per hectare (lac)	0	0.00
10.	Number of corms per plant	2	3.03
11.	Vase life (days)	8	12.12
12.	Corms yield per ha (q)	4	6.06

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