



Genetic Variability of Gladiolus (*Gladiolus grandifloras* L.) Varieties Under Prayagraj, Uttar Pradesh Agro- Climatic Conditions

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A study on genetic variability of gladiolus (*Gladiolus grandifloras* L.) varieties under prayagraj agro-climatic conditions was carried out at Departmental research field of Horticulture, Naini Agriculture Institute during the Rabi season of 2021-2022 with ten cultivars in Randomized Block Design (RBD) with three replications viz., Punjab Flame, Source Biscuits, Arka Naveen, White Prosperity, Dhanvantri, Phule Neelrekha, Pusa Srijan, Arka Amar, Priscilla, Yellow Stone were evaluated. Out of these ten cultivars, genetic variability, heritability, phenotypic coefficient of variation (PCV) was higher than the genotypic coefficient of variation (GCV) and genetic correlation for the characters viz., plant height at (30, 60, 90 DAS), number of leaves per plant at (30,60,90 DAS), no. of shoot per plant, days taken for corm sprouting, rachis length, days taken to spike emergence, days taken colour break stage, no. of floret per spike, no. of spike per plant, no. of days taken for first basal open, no. of days taken for last floret open, spike length, floret diameter, weight of daughter corm, weight of mother corm, corm diameter, corm weight, no. of corm per hectare, and corm yield/ plant were observed. for all characters, the highest GCV and PCV were recorded for the characters viz.,

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weight of daughter corm (g) (33.6786 and 47.569), number of leaves per plant at 30 DAS (25.70 and 37.81), number of leaves per plant at harvest (24.73 and 35.25), number of shoots per plant (25.47 and 31.19), weight of mother corm (25.18 and 33.90), corm weight (25.11 and 33.38), days taken for corm sprouting (23.7566 and 23.7566) and the lowest GCV and PCV were recorded for floret diameter (17.50 and 40.95). The genotypes Phule Neelrekha followed by Arka Amar were identified as high corm yielding and no. of corms per hectare and produced more no. of spikes/ plot and also yield per plot which indicated that these genotypes have resulted for higher yield and indicated good response to selection owing to their high heritability, variability and genetic advance showing additive gene effect. These genotypes can be used for improvement of yield and component traits by selection.

Keywords: *Gladiolus*; phenotypic coefficient of variation; genotypic coefficient of variation heritability; genetic advance as percentage of mean (GAM).

1. INTRODUCTION

Gladiolus, a member of the Iris family, Iridaceae, is a widely used flowering plant in India. It has a basic chromosome number of 15, and most species are diploid, with 30 chromosomes ($2n=30$). The genus contains about 260 species, native to Africa, Europe, and Asia. They are propagated by corms, which are underground storage organs that provide food and energy for the plant. They have sword-shaped leaves and trumpet-shaped flowers, with colours ranging from red, yellow, orange, pink, purple, and white [1-4]. The name *gladiolus* comes from the Latin word "gladiolus", meaning a sword due to its foliage shape. "Its cultivation is confined to Northern Indian plains, including the whole U.P., coastal areas of Tamil Nadu, and Pondicherry, has the potential to change the economic scenario of farmers in these areas. It provides both money and employment in rural areas, making *gladiolus* an ideal crop for establishing the floriculture industry by progressive farmers and entrepreneurs [5-9]. "Genetic variability refers to the presence of differences among plant populations, which results from differences in the genetic constitution of individuals or in the environment in which they are grown. Genetic variability is an essential component of breeding programs designed to improve the characteristics of crops" [10]. Morphological characterization is a method of studying genetic variability by measuring physical traits, such as Plant height, no. of spikes, etc., It is relatively inexpensive and easy to use and can be used to study populations of any size. However, it does not provide information about the genetic basis of variation, which can be obtained using molecular markers. *Gladiolus* is a genetically diverse crop with a wide range of morphological variation, which is important for breeding new cultivars with improved characteristics [11-15]. The

morphological characterization of *gladiolus* has also been used to study the effect of environmental factors on genetic variability [16-22]. This information will be valuable for breeders and conservationists working to improve and conserve *gladiolus*.

2. MATERIALS AND METHODS

In the experimental block of the Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj - 211007 (Uttar Pradesh) India, the experiment was set up using a randomized block design with eight treatments, each replicated three times. In each replication, the treatments were distributed at random to a unit plot. For the study, ten distinct types were used, including Punjab Flame, Source Biscuits, Arka Naveen, White Prosperity, Dhanvantri, Phule Neelrekha, Pusa Srijan, Arka Amar, Priscilla, and Yellow Stone. There were a total of 30 plots on the entire experimental site, each measuring 1.2 m by 1.2 m. For the goal of documenting observations on vegetative, blooming, and corm features, five randomly chosen plants were tagged in each treatment combination and replication (non-destruction sampling). The observations were made on quantitative traits chosen for genetic variability study, including number of days for corm sprouting, plant height (cm), number of leaves per plant, day to spike emergence, days taken for color break stage, first floret opening (days), spike length (cm), size of floret (cm), spike per plant, weight of mother corm, weight of daughter corm (g), corm diameter, number of corms per hectare, and corm yield/plot.

2.1 Estimation of Component of Variance

The mean square for error was subtracted from the mean square value to genotype and the

difference was divided by replication for obtaining the genotype variance, which was calculated according to the method suggested by Burton (1952). The genotype variance was calculated following the procedure given by Burton and Devance (1953).

Genotypic and phenotypic variance for individual environments was obtained with the help of following formula:

$$\text{Genotypic Variance } (\sigma^2p) = \frac{\text{Genotypic MSS} - \text{Error MSS}}{\text{Number of Replications}}$$

$$\text{Phenotypic variance } (\sigma^2p) = (\sigma^2g + \sigma^2e)$$

Where,

- σ^2e = Error M.S.S.
- σ^2g = Genotypic variance
- σ^2p = Phenotypic variance

3. EXPERIMENTAL RESULTS

There was a significant difference between genotypes in terms of number of days for corms to sprout to germinate. The earliest sprout of the corm (8.07 days) recorded at Yellow Stone was on par with Priscilla (8.85 days) but significantly different from Phule Neelrekha (9.22 days) Where the days taken for corm sprouts are more. More number of days was observed in Punjab Flame (10.04 days). The gladiolus genotypes showed significant differences in plant height at all growth stages. At harvest, the highest plant height (64.87 cm) was recorded by Phule Neelrekha, followed by Source Biscuits (64.43 cm). Minimum plant height recorded by Priscilla

(54.87 cm) at harvest. There was a significant difference among the gladiolus varieties in terms of leaf count at 30, 60 DAP and at maturity. At maturity, the maximum number of leaves per plant recorded by Phule Neelrekha (16.6) was on par with Arka Amar (13.8) and Yellow Stone (13.73) but while the minimum number of leaves per plant was observed in White Prosperity (8,15). There was considerable variations between varieties in terms of number of shoots per plant. The value for this observation ranged from 1.55 cm to 1.05 cm. The maximum number of shoots was recorded in Phule Neelrekha (1.55), followed by Arka Amar (1.38) and Yellow Stone (1, 2) which were statistically equal to other varieties while Punjab Flame (1.05) has a minimum leaf length. The rachis length varied considerably among genotypes. The Phule Neelrekha genotype showed maximum rachis length (58.02 cm), followed by Arka Amar (54.99 cm). Minimum rachis length was recorded (44.77 cm) in Priscilla.

The genotype showing the earliest spike emergence was Punjab Flame (58.07 days), which was significantly superior to the other genotypes, while the genotypes showed slow spike emergence especially Yellow Stone (77.40 days). Days for the basal floret to show colour and the number of days for the basal floret to show colour showed significant variations among the different gladiolus varieties studied. The lowest number of days required for the basal floret to show its colour was observed in the Punjab Flame hybrid (67.1 days) which is statistically on par with Source Biscuits (67.2 days) but significantly different from Phule Neelrekha (73.73 days). The maximum number

Table 1. Mean performance of 10 varieties of gladiolus for morphological parameters

Genotype	Days to sprouting	Plant height (cm) 90 DAS	Number of leaves per plant at harvest	Number of shoots per plant	Rachis length (cm)
Arka Amar	8.97	62.21	13.8	1.38	54.99
Arka Naveen	9.60	58	9.47	1.1	48.71
Dhanvantri	9.36	55.53	11.5	1.11	50.34
Phule Neelrekha	9.22	64.87	16.6	1.55	58.02
Priscilla	8.85	54.87	8.09	1.1	44.77
Punjab Flame	10.04	63.83	7.57	1.05	42.72
Pusa Srijan	8.98	61.87	11.17	1.16	52.45
Source Biscuits	9.67	64.43	12.87	1.16	53.27
White Prosperity	9.40	57.57	8.15	1.1	46.85
Yellow Stone	8.07	58.87	13.73	1.2	53.39
Mean	9.22	60.21	11.30	1.19	50.55
S.Em±	1.17	1.17	0.94	0.05	1.51
CD @5%	2.95	21.06	4.87	0.37	16.42

of days required for the floret at the base to show its colour was recorded in Yellow Stone (85.67 days). Minimum number of days for basal floret to open showed significant differences among the gladiolus varieties studied. The lowest number of days required to open the basal floret was observed in the Punjab Flame hybrid (69.37 days) which was statistically comparable to the Source Biscuit (70.2 days) but significantly different compared to Phule Neelrekha (76.13 days). The maximum number of days required for basal floret opening was stated in the yellow Stone (87.27 days).

Data indicated that there was a significant difference among the gladiolus genotypes for length. Among the varieties evaluated, the spike length was highest in Phule Neelrekha (113.28 cm), followed by Arka Amar (109.29 cm). The lowest spike length was observed in Punjab Flame (80.76 cm). The observed difference for number of flowers per plant among the varieties was found to be significant. Among the different varieties, Phule Neelrekha (1.33) was recorded with maximum number of spikes per plant, followed by Arka Amar (1.18). The minimum number of spikes per plant was observed in Punjab Flame, Arka Naveen, Priscilla, and White Prosperity. There was a significant among gladiolus varieties studied in terms of number of florets per spike. Phule Neelrekha recorded the highest number of florets per spike (11.77) which is on par with Arka Amar (11.52) and Yellow Stone (11.5). The lowest number of florets per spike was recorded at Punjab Flame (10.77). There was considerable variations among the varieties for floret diameter. Among the varieties, Punjab Flame and Priscilla (12.50 cm each) recorded maximum floret diameter comparable to Phule Neelrekha (11.30 cm), Dhanvantri (11.37 cm), Arka Naveen (11.3 cm) and White Prosperity (12.00 cm). The smallest floret diameter was recorded by Pusa Srijan (11.27 cm).

Corm weight varied significantly from 350 to 813.33 g. The Phule Neelrekha Variety recorded with the highest corm weight (813.33 g), followed by Arka Amar (710 g) and Yellow Stone (680 g). While the lowest corm weight (g) was observed for Punjab Flame (350 g). Mother corm weight (g) showed a wide range of difference from 280 to 704 g. The variety Golden Stone recorded the highest corm weight (600 g) While the lowest weight was noticed in Punjab Flame

(280 g). Weight of daughter corm showed significant difference (55 to 200 g). The highest weight of daughter corm was noticed for the variety Phule Neelrekha (200 g) and it was followed by Arka Amar (170 g) and Yellow Stone (125 g). While the lowest weight of daughter corm was observed in Punjab Flame (55 g). Corm diameter showed great diversity among the varieties, from 5.78 cm to 3.59 cm. While the largest corm was observed in the Phule Neelrekha (5.78 cm), followed by Arka Amar (4.85 cm) and Yellow Stone (4.85 cm), While the smallest corms were observed in the Punjab Flame (3.59 cm). Number of corms per hectare showed a wide range of variations from 25,650 to 297,500. The highest number of corms per ha noticed in Phule Neelrekha genotype (297500), followed by Arka Amar (287500) and Yellow Stone (283500). While the lowest number of corms per hectare was observed for Punjab Flame (25650). The yield of corms per plant (g/plant) showed a wide range of variations from 53.66 g to 105.37 g. The corm yield per plant (g) was highest for the Phule Neelrekha (105.37 g), followed by Arka Amar (103.37 g) and Yellow Stone (101.44 g). While the lowest corm yield per plant was observed for Punjab Flame (53.66 g).

3.1 Correlation Studies

3.1.1 Correlation coefficient analysis at genotypic level

Genotypic correlation coefficient analysis revealed that Corm weight/plant (g) showed positive significant association with no. of spike per plant (cm) (1.17**), weight of mother corm (g) (0.99**), corm diameter (cm) (0.93**), no. of leaves per plant at 60 DAS (0.82*), number of corms per hectare (0.90**) and number of corms/hectare (0.46**), the significant and negative association was observed with No. of leaves at 30 DAS (-0.81*), Floret diameter (cm) – (0.83*), (-0.73*) while non-significant and negative association was observed with plant height (cm) at 60 DAS (-0.52), plant height (cm) at 90 DAS (-0.32), days taken for corm sprouting (-0.15), rachis length (cm) (-0.39), days taken for spike emergence (-0.33), days taken for colour break stage (-0.34), no. of florets per spike (-0.48), no. of days taken for first floret open (-0.55), no. of days taken for last floret open (-0.44), spike length (cm) (-0.38) and weight of daughter corm (g) (-0.54).

Table 2. Mean performance of 10 varieties of gladiolus for flowering parameters

Genotype	Days to spike emergence	Days to basal floret to show colour	Days to lowest floret to open	Number of florets per spike	Spike length (cm)	Number of spikes per plant	Floret diameter (cm)
Arka Amar	69.53	78.07	81	11.52	109.29	1.18	12
Arka Naveen	59.47	68.47	70.93	11	91.05	1	11.3
Dhanvantri	61.13	68.87	71.53	11.11	98.44	1.05	11.37
Phule Neelrekha	65.4	73.73	76.13	11.77	113.28	1.33	11.30
Priscilla	76.4	84.93	85.33	10.89	84.65	1	12.50
Punjab Flame	58.07	67.1	69.37	10.77	80.76	1	12.50
Pusa Srijan	66.73	75.13	77.73	11.15	100.78	1.07	11.27
Source Biscuts	59.17	67.2	70.2	11.16	100.94	1.1	11.57
White Prosperity	60.8	68.56	71.47	11	84.93	1	12.00
Yellow Stone	77.4	85.67	87.27	11.5	106.78	1.11	11.30
Mean	65.41	73.77	76.10	11.19	97.09	1.08	11.81
S.Em±	2.24	2.24	2.07	0.10	3.56	0.03	0.31
CD @5%	24.65	27.24	27.34	5.19	47.39	0.69	4.12

Table 3. Mean performance of 10 varieties of Gladiolus (*Gladiolus grandiflorus* L.) for corm characters

Genotype	Corm weight(g)	Weight of mother corm(g)	Weight of daughter corm(g)	Corm diameter (cm)	No. of corm per hectare	Corm yield/plant(g)
Arka Amar	813.33	704	200	5.78	297500	105.37
Arka Naveen	710	607	170	4.85	287500	103.37
Dhanvantri	680	600	125	4.85	283500	101.44
Phule Neelrekha	670	594	105	4.78	271300	97.27
Priscilla	640.5	562	85	4.78	263750	92.21
Punjab Flame	630	560	75	4.71	259942	89.02
Pusa Srijan	626.66	544	74	4.57	251300	83.51
Source Biscuts	620	520	70	4.32	246785	82.51
White Prosperity	484.33	357	57	3.85	153300	76.93
Yellow Stone	350	280	55	3.59	25650	53.66
Mean	622.48	532.80	101.60	4.61	234052.70	88.53
S.Em±	39.91	39.41	15.57	0.19	26390.03	4.91
CD @5%	234.95	207.42	35.65	1.58	112905.07	29.02

3.1.2 Phenotypic correlation coefficient

Among different characters studied, yield per plant had positive and high significant association with weight of corm (0.424 g) followed by number of corms produced (0.320g), days to 50% of flowering (0.208), number of florets (0.190), number of open florets (0.170), spike girth (0.165 cm), spike length (0.143 cm), weight of Corm (0.126 g), rachis length (0.056 cm) and number of corms produced (0.05g).

3.1.3 Heritability

The genotypic coefficient of variation does not offer full scope to estimate the variations that are heritable and therefore, estimation of heritability becomes necessary. Burton and De Vane (1953) had suggested that “genetic coefficient of variation along with heritability estimates would give a reliable indication of expected amount of improvement through selection. The estimates of heritability (broad sense) varied from 21.25-91.75% for different characters. It was found high for all the traits viz., weight of corms, spike length, rachis length, number of corms produced, number of florets, number of days for spike emergence, spike girth, number of days for lowest floret to show colour, number of open florets, number of days for lowest floret to open, number of leaves at maturity, plant height at maturity, weight of corms whereas, medium heritability was observed for number of corms produced”.

3.1.4 Path co-efficient analysis

Spikes yield is dependent on several growth and yield component traits which are naturally interconnected. The change in any growth and yield component traits is going to disturb the whole network of cause-and-effect relationship [23-26]. Thus, each component has two paths of action like direct influence on spike yield and indirect effect. These component traits are not revealed by simple correlation studies. Although correlation studies are helpful in determining the components of yield, but it does not provide a clear picture of nature and extent of contributions made by number of independent traits. Path coefficient analysis devised by Dewey and Lu (1959), however, provides a realistic basis for allocation of appropriate weightage to various attributes while designing a pragmatic programme for the improvement of yield. “Path coefficient analysis depicts the effects of different independent characters individually and in

combination with other characters on the expression of different characters on flower yield per plant. In the present investigation path analysis was carried out at genotypic level considering genotypic correlation coefficient. Among all the characters studied, number of days for lowest floret to show colour had highest positive direct effect on spike per plant followed by weight of corms, leaf width at maturity, spike length, number of florets, days to 50% of flowering, spike girth. Whereas negative direct effect was executed by number of days for spike emergence, followed by number of days for lowest floret to open, number of corms produced, rachis length, leaf length at maturity, weight of corm, number of leaves at maturity, plant height at maturity, number of open florets, number of corms produced at phenotypic level” (Dewey and Lu, 1959). The maximum positive indirect effects of plant height at maturity via Number of florets, number of leaves at maturity via days to 50% of flowering, leaf length via spike girth, plant height via spike length, number of days for spike emergence via spike girth, number of days for lowest floret to show colour via number of days for spike emergence, number of days for lowest floret to open via spike girth, spike length via rachis length, rachis length via spike girth, spike girth via number of florets were recorded on spike per plant at phenotypic level. Maximum indirect negative effect of plant height at maturity estimate via Number of leaves at maturity, number of leaves at maturity via plant height at maturity, leaf length at maturity via rachis length, leaf width at maturity via weight of corms, number of days for Spike emergence via number of days for lowest floret to show colour, number of days for lowest floret to show colour via spike girth, number of days for lowest floret to open via number of days for lowest floret to show colour, spike length via number of days for lowest floret to show colour, rachis length via spike length, spike girth via number of days for lowest floret to show colour, at phenotypic level [27-29].

3.1.5 Genetic advance

In the present investigation, the genetic advance estimates were found to be high for weight of mother corm (249.6294), corm weight (234.9176), number of corms per hectare (98.200), number of corm/hectare (97.500), corms yield/plant (g) (30.93) , weight of daughter corm (47.6865), no. of days taken for first floret open (41.8654), while as moderate estimates were observed plant height at 90 DAS (21.0558) showed low genetic advance estimate were

Table 4. Estimation of component of variance and genetic parameters for growth, flowering and corm characters in gladiolus varieties

Characters	Mean	Range		Vg	Vp	GCV	PCV	H ² (%)	GA	Genetic Gain
		Max	Min							
No. of days for corm sprouting	9.216	10.04	8.07	5.37	8.32	25.14	31.30	64.47	3.83	41.576
Plant height (cm) 30 DAS	33.474	36.93	31.70	68.36	115.43	24.70	32.10	59.22	13.11	39.155
Plant height (cm) 60 DAS	51.737	56.63	46.05	163.41	278.16	24.71	32.24	58.75	20.18	39.013
Plant height (cm) 90 DAS	60.205	64.87	54.87	222.62	373.30	24.78	32.09	59.64	23.74	39.424
Number of leaves per plant at 30 DAS	5.545	9.2	2.83	2.03	4.40	25.70	37.81	46.21	2.00	35.994
Number of leaves per plant at 60 DAS	10.142	15.54	5.80	6.11	14.42	24.37	37.44	42.37	3.31	32.681
Number of leaves per plant at harvest	11.295	16.6	7.57	7.81	15.85	24.73	35.25	49.23	4.04	35.752
Number of shoots per plant	1.191	1.55	1.05	0.09	0.14	25.47	31.19	66.67	0.51	42.835
Rachis length (cm)	50.551	58.02	42.72	159.87	251.49	25.01	31.37	63.57	20.77	41.082
Days taken for spike emergence	65.41	77.4	58.07	256.27	462.69	24.47	32.89	55.39	24.54	37.521
Days to basal floret to show colour	73.773	85.67	67.1	327.81	579.89	24.54	32.64	56.53	28.04	38.012
Days to basal floret to open	76.096	87.27	69.37	352.21	606.25	24.66	32.36	58.10	29.47	38.724
Number of spikes per plant	97.09	113.28	80.76	477.05	1240.34	22.50	36.27	38.46	27.90	28.740
Spike length (cm)	11.814	14.30	10.80	8.63	14.38	24.86	32.10	59.99	4.69	39.668
Number of florets per spike	11.187	11.77	10.77	6.45	15.61	22.70	35.32	41.30	3.36	30.045
Floret diameter (cm)	1.084	1.33	1.00	0.04	0.20	17.50	40.95	18.27	0.17	15.414
Corm weight(g)	622.482	813.33	350.00	24424.58	43182.99	25.11	33.38	56.56	242.12	38.897
Weight of mother corm(g)	532.8	704	280.00	18004.15	32624.55	25.18	33.90	55.19	205.34	38.539
Weight of daughter corm(g)	101.60	200	55.00	872.61	1304.47	29.07	35.55	66.89	49.77	48.986
Corm diameter (cm)	4.608	5.78	3.59	1.34	2.19	25.09	32.10	61.10	1.86	40.401
Corm yield/plant	88.5296	105.37	53.657	503.57	789.75	25.35	31.74	63.76	36.91	41.696
No. of corm per hectare	234052.7	297500	25650	3189411596.98	7521188387.06	24.13	37.05	42.41	75759.06	32.368

found in spike length (19.3327), days taken for colour break stage (18.4779), days taken for spike emergence (17.6558), rachis length (8.091), plant height at 60 DAS (7.9491), plant height at 30 DAS (5.3765), days taken for corm sprouting (2.2022), floret diameter (1.698), no. of days taken for last floret open (1.5125), no. of leaves per plant at 90 DAS (1.0369), vase life (1.0022), corm diameter (0.8644), no. of leaves at 30 DAS (0.7271), no. of leaves per plant at 60 DAS (0.6566), no. of floret per spike (0.5207), no. of shoot per plant (0.2548), no. of spike per plant (0.092).

4. CONCLUSION

Based on the investigation's findings, it was concluded that most qualities with additive genetic effect had large heritability (in the broad sense) and substantial genetic gain. For each of the examined features, PCV was greater than GCV. The highest GCV and PCV was recorded for weight of daughter corm (g) (33.6786 and 47.569), no. of days taken for first floret open (30.0614 and 30.0889), weight of mother corm (25.6022 and 28.1499), days taken for corm sprouting (23.7566 and 23.7566) respectively. Corm weight/plant (g) showed a significant positive association with the number of leaves per plant at 60 DAS, the weight of the mother corm (g), and corm diameter (cm), but a significant negative association with the number of leaves per plant at 30 DAS and floret diameter, according to an analysis of the genotypic and phenotypic correlation coefficients. The varieties Creamy green, followed by White prosperity, Nova, Suchitra, and Hunting song exhibited additive gene effect and produced higher spike yield per plot due to their high heritability, variability, and genetic advancement, indicating that these varieties may be shown for higher yield and indicating good response to selection. The selection of these genotypes may be taken into account to improve the gladiolus yield properties.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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