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Genetic variability studies in gladiolus (*Gladiolus hybridus* Hort.)

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Abstract
Assessment of variability, heritability and genetic advances of forty gladiolus genotypes were evaluated. The presence of high amount of variability (GCV and PCV) was observed for days to corm sprouting, number of shoots per plant, leaf area per plant, leaf area index, number of spikes per plant, spike weight, weight of corm before planting, number of daughter corms per plant, average weight of daughter corm, number of cormels per plant and average weight of cormels. High heritability coupled with high genetic advance as per cent of mean was observed for characters like days to corm sprouting, plant height, number of shoots per plant, number of leaves per plant, leaf width, leaf area per plant, leaf area index, stem girth, number of spikes per plant, spike length, spike weight, rachis length, number of florets per spike, vase life, weight of corm before planting, number of daughter corms per plant, average weight of daughter corm, number of cormels per plant, average weight of cormels. It was concluded that highly significant varietal differences indicated the presence of high amount of variability.

Keywords: Gladiolus, genetic variability, heritability, genetic advance

Introduction
Gladiolus (*Gladiolus hybridus* Hort.) is an important bulbous ornamental prized for its beauty of spikes as well as longer vase-life and said to be "Queen of bulbous flower crops". In International florist trade, it ranks fifth next to tulip, lily, freesia and Hippeastrum among the geophytes and first in domestic bulbous flower trade according to Council of Holland. It is extensively grown in hills and plains almost all over the world. There are many excellent cultivars of gladiolus with magnificient inflorescence, in exhaustive range of colours, different shades, varying number of florets, size, wide range of keeping quality and adaptability to different seasons. It is relatively easy to grow and is ideal for bedding and exhibition purposes. The spikes are used in vase arrangements, in bouquets and for indoor decorations. Popularity of this crop as a cut spike is increasing day by day because of its long keeping quality and exhaustive range of colours of the spikes.
Genetic variability is an important factor for heritable improvement in any crop. The knowledge with regards to nature and degree of divergence in existing germplasm is extremely valuable in identifying suitable parental combinations to create heterotic progenies with high degree of genetic variability for their effective utilization in breeding programmes. The variability for various characters is pre requisite for a plant breeder to develop a high yielding variety. It is important to study genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability (h^2) and genetic advance over mean (GAM) which would help to encourage the efficiency of selection.

Material and Methods
The present investigation was carried out at the Department of Floriculture and Landscape Architecture, Kittur Rani Channamma College of Horticulture (University of Horticultural Sciences, Bagalkot), Arabhavi, Gokak taluk, Belagavi district of Karnataka during the period of 2015 to 2017. Forty gladiolus genotypes were evaluated in a Randomized Block Design with two replications.

Estimation of genetic parameters
Genotypic, phenotypic and environmental variances
Variance due to genotype, phenotype and environment were computed as follows

$$\text{Genotypic variance } (\sigma^2 g) = \frac{\text{Treatment MSS-Error MSS}}{r}$$

Environment variance (σ^2e) = Error mean sum of squares
Phenotypic variance (σ^2p) = Genotypic variance (σ^2g) + Environnement variance (σ^2e)
Where, r is number of replications.

Coefficient of variation
The coefficient of variation (CV) being a standardized form of variance is useful for comparing the extent of variation between different characters with different scales (Singh and Choudhary, 1979) [7]. Genotypic and phenotypic coefficients of variation were estimated according to Burton and Devane (1953) [6] based on estimate of genotypic and phenotypic variance and expressed in percentage.

$$\text{Genotypic coefficient of variation (GCV)} = \frac{\sqrt{\sigma^2 g}}{\overline{X}} \times 100$$

$$\text{Phenotypic coefficient of variation (PCV)} = \frac{\sqrt{\sigma^2 p}}{\overline{X}} \times 100$$

Where
$\overline{X}$ = General mean of the character
σ^2g = Genotypic variance
σ^2p = Phenotypic variance

PCV and GCV were classified as suggested by Shivasubramanian and Menon (1973) [25] as follows.
0 – 10% - Low
10-20 - Moderate
20% and above - High

Heritability (h^2)
In broad sense, heritability was calculated as the ratio of genotypic variance to the phenotypic variance and expressed in percentage (Falconer, 1981)

$$\text{Heritability } (h^2) = \frac{\sigma^2 g}{\sigma^2 p} \times 100$$

Where
σ^2g = Genotypic variance
σ^2p = Phenotypic variance

Heritability percentage was categorized as demonstrated by Robinson *et al.* (1949) [24].
0 – 10% - Low
10-20% - Moderate
>20% - High

Genetic advance (GA)
Genetic advance was calculated using the formula given by Robinson *et al*. (1949) [24].

$$\text{Genetic advance (GA)} = i \times h^2 \times \sigma p$$

Where
i = Selection of differential (i=2.06) at 5 per cent selection intensity
h^2 = Heritability in broad sense
σp = Phenotypic standard deviation of the trait

Genetic advance over mean (GAM)
Genetic advance as per cent over mean was worked out as suggested by Johnson *et al.* (1955) [11].

$$\text{GAM (\%)} = \frac{GA}{\overline{X}} \times 100$$

Where
GA = Genetic advance
$\overline{X}$ = General mean of the character

The genetic advance as per cent mean was categorized as suggested by Johnson *et al.* (1955) [11].
0 – 10% - Low
10-20% - Moderate
>20% - High

Results and Discussion
Genetic parameters like genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability, genetic advance are useful biometrical tools for determination of genetic variability (Aditya *et al*., 2011) [1]. Significant differences for the characters indicated appreciable amount of variability exists among the genotypes studied. The genotypic coefficient of variation measures the extent of variability among the different genotypes for different traits caused due to the inherent capacity of the genotype. The genotypic and phenotypic coefficients of variation are required to understand the effect of environment on various polygenic traits (Naresh *et al*., 2015) [19].
The phenotypic coefficient of variation (PCV) was higher than the genotypic coefficient of variation (GCV) for all the traits studied indicating that the apparent variation is not only due to genotype, but also due to the influence of environment. Similar results were reported by Pratap and Rao (2006) [22], Kumar *et al*. (2011) [14], Mishra *et al*. (2014) [18], Naresh *et al*. (2015) [19] in gladiolus. The difference between GCV and PCV gives us an idea about role of genotypic and environment on the character (Bhujbal *et al*., 2013) [5].
Narrow differences were observed between PCV and GCV for days to corm sprouting, plant height, leaf length, leaf width, stem girth, days to 50 per cent flowering, duration of flowering, spike length, spike weight, rachis length, number of florets per spike, floret diameter and vase life indicating that little role of environment on the expression of these characters. Similar results were obtained by Geeta (2013) [9], Balamurugan *et al*. (2002) [3], Katwate *et al*. (2002) [13] and Kumar *et al*. (2011a) [15] in gladiolus.
The greater difference between GCV and PCV were observed for the characters *viz*., spike emergence to first floret opening, weight of corm before planting, daughter corm diameter, average weight of daughter corm, number of cormels per plant, average weight of cormels indicates more sensitiveness of these characters to environmental factors. Thus selection of genotypes based on these characters will yield poor results. Mishra *et al*. (2014) [18] also observed greater difference between PCV and GCV and concluded that these characters are influenced by environmental factors to a greater extent. The results are in accordance with the findings of Balaram and Janakiram (2009) [4] and Hegde and Patil (1995) [10] in gladiolus.

High values of GCV and PCV for the characters of days to corm sprouting, number of shoots per plant, leaf area, leaf area index, number of spikes per plant, spike weight, weight of corm before planting, number of daughter corms per plant, average weight of daughter corm, number of cormels per plant and average weight of cormels indicating high genetic variability exists among the genotypes for these traits. It offers greater scope for selection of potential parent in breeding programme with higher multiplication rate. Similar results were also reported by Naresh *et al*. (2015) [19], Singh *et al*. (2017) [27], Pattanaik *et al*. (2015) [21], Kumar *et al*. (2012) [16], Rashmi and Chandrashekar (2016), Sunil *et al*. (2015) [29], Subhendu *et al*. (2016) [28] in gladiolus. Ahmed and Dutt (2014) [2] suggested that the characters which have high GCV and PCV values might be under genetic control. Hence, these characters can be relied upon for further crop improvement.

Low values of GCV and PCV were observed for days to 50 per cent flowering suggesting low variability among the genotypes for this character. These results are in conformity with that of Kadam *et al*. (2014) [12] in gladiolus. This indicates the minimum amount of variation existing among the genotypes with respect to this characters.

However, the effectiveness of selection for any character depends not only on the amount of phenotypic and genotypic variability, but also on estimated broad sense of heritability. Heritability value indicates the heritable properties of variation. Estimation of GCV helps in the measurement of the range of heritable portion of genetic diversity in a character and provide means to compare the genetic variability in the quantitative characters. The genotypic coefficient of variation along with heritability estimates provide reliable estimates of the amount of genetic advance to be expected through phenotypic selection (Kadam *et al*., 2014) [12].

Robinson *et al*. (1949) [24] viewed that the knowledge of heritability is important to a breeder since it indicates the possibility and extent to which improvement is possible through selection. It is a measure of genetic relationship between parents and their offspring. High heritability alone is not enough to make efficient selection in the advanced generations and unless accompanied by substantial amount of genetic advance (Mishra *et al*., 2014) [18].

The traits such as days to corm sprouting, plant height, number of shoots per plant, number of leaves per plant, leaf length, leaf width, leaf area per plant, leaf area index, stem girth, number of spikes per plant, spike length, spike weight, rachis length, number of florets per spike, floret diameter, vase life, weight of corm before planting, number of daughter corms per plant, average weight of daughter corm, number of cormels per plant, average weight of cormels showed high heritability. These results were in accordance with the findings of Naresh *et al*. (2015) [19], Kumar *et al*. (2015) [17], Pattanaik *et al*. (2015) [21], Bhujbal *et al*. (2013) [5] and Choudhary *et al*. (2012) [7] in gladiolus.

High genetic advance over per cent mean was observed for days to corm sprouting, plant height, number of shoots per plant, number of leaves per plant, leaf width, leaf area per plant, leaf area index, stem girth, spike emergence to first floret opening, number of spikes per plant, spike length, spike weight, rachis length, number of florets per spike, vase life, weight of corm before planting, number of daughter corms per plant, average weight of daughter corm, number of cormels per plant and average weight of cormels indicating the operation of additive gene action for these traits. Simple selection schemes would suffice for these traits.

High heritability alone is not enough to make efficient selection in the advanced generations and unless accompanied by substantial amount of genetic advance (Mishra *et al*., 2014) [18].

High heritability coupled with high genetic advance were noticed for the traits such as days to corm sprouting, plant height, number of shoots per plant, number of leaves per plant, leaf width, leaf area per plant, leaf area index, stem girth, number of spikes per plant, spike length, spike weight, rachis length, number of florets per spike, vase life, weight of corm before planting, number of daughter corms per plant, average weight of daughter corm, number of cormels per plant, average weight of cormels. This indicates the lesser influence of environment in expression of these characters and prevalence of additive gene action in their inheritance. Hence, these traits are suitable for selection (Ahmed *et al*., 2014) [2]. Panse and Sukhatme (1957) [20] viewed that if a character is governed by additive gene action heritability and genetic advance would be high. Higher estimates of heritability along with high genetic advance provides good scope for further improvement in advance generation if these characters are subjected to mass progeny and clonal selection. Naresh *et al*. (2015) [19] opined that if there is less phenotypic variation for the characters, they are proved to be more suitable for selection. Similar findings were reported by Kumar *et al*. (2011) [14], Choudhary *et al*. (2012) [7], Mishra *et al*. (2014) [18], Naresh *et al*. (2015) [19], Thakur and Dhatt (2015) [30], Sunil *et al*. (2015) [29], Rashmi and Chandrashekar (2016) [23], Singh *et al*. (2017) [27] and Subhendu *et al*. (2016) [28] in gladiolus. Whereas high heritability with moderate genetic advance over per cent mean was observed for leaf length and floret diameter. Moderate heritability with moderate genetic advance over per cent mean was observed for days spike emergence, spike emergence to first floret opening, days to 50 per cent flowering and diameter of daughter corm. Days to 50 per cent flowering showed moderate heritability with low genetic advance. This indicates that this character is under the control of non-additive genes and selection of the genotypes based on this character for further crop improvement will be less effective (Ahmed *et al*., 2014 in gladiolus) [2]. Panse (1957) [20] also reported that if a character is governed by non-additive gene action it may give high heritability but low genetic advance.

Table 1: Details of gladiolus genotypes used in the experiment

S. No	Genotype	Origin	Source
1.	Summer Sunshine	Holland	Jammu & Kashmir
2.	Delhi Local	India	Jammu & Kashmir
3.	Green Bay	USA	Jammu & Kashmir
4.	Copper King	USA	Jammu & Kashmir
5.	Dhanvantari	-	IARI, New Delhi
6.	Jester Yellow	Holland	Jammu & Kashmir
7.	Local Yellow	India	Bengaluru
8.	Arka Amar	IIHR	IIHR, Banglore
9.	Arka Naveen	IIHR	IIHR, Banglore

10.	Arka Arti	IIHR	IIHR, Banglore
11.	Darshan	India	IIHR, Banglore
12.	Jyostna	-	IARI, New Delhi
13.	Suchitra	-	IARI, New Delhi
14.	Magma	-	Navsari, Gujrat
15.	Urmil	-	IARI, New Delhi
16.	White Prosperity	USA	Jammu & Kashmir
17.	Pusa Kiran	IARI	IARI, New Delhi
18.	Sindur	-	IIHR, Banglore
19.	Arka Thilak	IIHR	IIHR, Banglore
20.	Punjab Dawn	India	Navsari, Gujrat
21.	African star	-	IARI, New Delhi
22.	Local pink	-	Bengaluru
23.	Pusa Vidushi	IARI	IARI, New Delhi
24.	Legent	-	IARI, New Delhi
25.	Chandini	-	IARI, New Delhi
26.	Mohini	NBRI	IARI, New Delhi
27.	Hunting Song	-	IARI, New Delhi
28.	Golddust	-	IARI, New Delhi
29.	Surya Kiran	-	IARI, New Delhi
30.	Sunayana	-	Navsari, Gujrat
31.	Gunjan	-	PAU, Ludhiana
32.	Novalux	-	PAU, Ludhiana
33.	Punjab glance	India	IARI, New Delhi
34.	Anjali	IARI	Navsari, Gujrat
35.	Shagun	-	IARI, New Delhi
36.	Priscilla	-	IIHR, Banglore
37.	Arka Sagar	IIHR	IIHR, Banglore
38.	Arka Kesar	IIHR	IIHR, Banglore
39.	Arka Gold	IIHR	Jammu & Kashmir
40.	Candyman	USA	Jammu & Kashmir

Table 2: Analysis of variance (mean sum of squares) for different characters in gladiolus genotypes

Sl. No	Character	Replication d.f = 1	Genotypes d.f = 39	Error d.f = 39	SEm+	CD @ 5%
(a)	**Growth parameters**					
1	Days to corm sprouting	1.119	19.890*	0.542	0.52	1.49
2	Plant height (cm)	7.454	106.861*	7.613	1.95	5.58
3	Number of shoots per plant	0.047	0.282*	0.052	0.16	0.46
4	Number of leaves per plant	7.608	12.846*	2.439	1.10	3.16
5	Leaf length (cm)	0.137	96.969*	16.253	2.85	8.15
6	Leaf width (cm)	0.026	0.464*	0.050	0.16	0.45
7	Leaf area/plant (cm^2)	66.667	2901.139*	378.932	13.76	39.37
8	Leaf area index	0.00004	0.009*	0.001	0.02	0.06
9	Stem girth (cm)	1.033	7.960*	0.814	0.64	1.83
(b)	**Flower parameters**					
10	Days to spike emergence	2.588	115.614*	35.409	4.21	12.04
11	Spike emergence to first floret opening	0.338	7.210*	2.501	1.12	3.20
12	Days to 50% flowering.	0.012	96.815*	32.883	4.05	11.60
13	Flowering duration	1.827	7.820*	2.519	1.12	3.21
(c)	**Flower yield and quality parameters**					
14	No. of spikes /plant	0.206	0.976*	0.092	0.21	0.61
15	Spike length (cm).	1.434	388.640*	46.141	4.80	13.74
16	Spike weight (g)	29.028	220.572*	14.394	2.68	7.67
17	Rachis length (cm).	3.890	146.430*	14.915	2.73	7.81
18	No. of florets/ spike	0.265	7.645*	1.162	0.76	2.18
19	Floret diameter (cm).	0.741	1.801*	0.277	0.37	1.06
20	Vase life	0.092	5.923*	0.617	0.56	1.59
(d)	**Corm parameters**					
21	Weight of corm before planting (g)	220.747	122.586*	20.004	3.16	9.05
22	No. of daughter corms/plant	0.007	0.264*	0.036	0.13	0.39
23	Daughter corm diameter (cm)	0.000	0.717*	0.305	0.39	1.12
24	Average weight of daughter corm (g)	274.689	319.011*	70.074	5.92	16.93
25	No. of corbels /plant	47.895	215.009*	17.607	2.97	8.49
26	Average weight of cormels (g)	7.919	129.971*	9.080	2.13	6.10

* Significant at p = 0.05 probability

Table 3: Estimates of mean, range, components of variance, heritability and genetic advance for growth, flower, yield and quality parameters in gladiolus

Sl. No.	Character	Range	Mean	GV	PV	GCV (%)	PCV (%)	h² (%)	GA	GAM (%)
(a)	Growth parameters									
1	Days to corm sprouting	6.46 - 22.78	11.50	9.674	10.216	27.04	27.79	94.70	6.24	54.20
2	Plant height (cm)	43.77 - 75.50	62.91	49.624	57.237	11.20	12.03	86.70	13.51	21.48
3	Number of shoots per plant	1.00 - 2.72	1.70	0.115	0.167	20.01	24.10	69.00	0.58	34.24
4	Number of leaves per plant	8.51 - 21.10	11.89	5.204	7.642	19.19	23.26	68.10	3.88	32.63
6	Leaf length (cm)	43.34 - 74.28	60.01	40.358	56.611	10.59	12.54	71.30	11.05	18.41
7	Leaf width (cm)	2.06 - 4.04	2.96	0.207	0.257	15.39	17.15	80.60	0.84	28.46
8	Leaf area/plant (cm^2)	85.67 - 240.62	153.13	1261.103	1640.035	23.19	26.45	76.90	64.15	41.89
9	Leaf area index	0.14 - 0.42	0.25	0.004	0.005	24.48	27.51	79.10	0.11	44.86
5	Stem girth (cm)	6.67 - 14.04	10.27	3.573	4.387	18.41	20.40	81.40	3.51	34.23
(b)	Flower parameters									
10	Days to spike emergence	58.49 - 88.47	71.65	40.103	75.512	8.84	12.13	53.10	9.51	13.27
11	Spike emergence to first floret opening	7.25 - 15.00	10.23	2.355	4.855	15.01	21.55	48.50	2.20	21.53
12	Days to 50% flowering.	69.74 - 98.82	84.13	31.966	64.849	6.72	9.57	49.30	8.18	9.72
13	Flowering duration	16.57 - 25.75	21.70	2.65	5.169	7.50	10.48	51.30	2.40	11.07
(c)	Flower yield and quality parameters									
14	Number of spikes per plant	1.08 - 4.25	1.65	0.442	0.534	40.40	44.42	82.70	1.25	75.69
15	Spike length (cm)	54.82 - 126.50	98.39	171.249	217.39	13.30	14.99	78.80	23.93	24.32
16	Spike weight (g)	9.30 - 49.28	28.81	103.089	117.483	35.24	37.62	87.70	19.59	68.00
17	Rachis length (cm)	22.01 - 61.50	41.26	65.757	80.673	19.65	21.77	81.50	15.08	36.55
18	Number of florets per spike	6.63 - 14.46	11.53	3.241	4.403	15.62	18.21	73.60	3.18	27.61
19	Floret diameter (cm)	6.51 - 10.12	8.49	0.762	1.039	10.28	12.01	73.30	1.54	18.14
20	Vase life	4.78 - 11.81	9.27	2.653	3.270	17.57	19.50	81.10	3.02	32.59
Sl. No.	**Character**	**Range**	**Mean**	**GV**	**PV**	**GCV (%)**	**PCV (%)**	**h² (%)**	**GA**	**GAM (%)**
d)	Corm parameters									
21	Weight of corm before planting (g)	9.39 - 41.15	23.34	51.291	71.295	30.68	36.17	71.90	12.51	53.61
22	Number of daughter corms per plant	1.00 - 2.56	1.54	0.114	0.150	21.96	25.22	75.80	0.61	39.39
23	Daughter corm diameter (cm)	3.79 - 6.19	5.06	0.206	0.511	8.96	14.12	40.30	0.59	11.72
24	Average weight of daughter corm (g)	18.11 - 71.25	42.67	124.468	194.543	26.15	32.69	64.00	18.38	43.08
25	Number of cormels per plant	4.75 - 66.99	13.49	98.701	116.308	73.64	79.93	84.90	18.85	139.74
26	Average weight of cormels (g)	0.95 - 41.75	10.87	60.445	69.525	71.55	76.74	86.90	14.93	137.44

Conclusion

Through this study, it can be concluded that selection of genotypes based on characters like days to corm sprouting, number of shoots per plant, leaf area per plant, leaf area index, number of spikes per plant, spike weight, weight of corm before planting, number of daughter corms per plant, average weight of daughter corm, number of cormels per plant and average weight of cormels which are showing high GCV, PCV, heritability and genetic advance and will give potential parent in breeding program.

References

1. Aditya JP, Pushpendra B, Anuradha B. Genetic variability, heritability and character association for yield and component characters in Soybean (*G. max* (L.) Merrill). J Central European Agri. 2011; 12(1):27-34.
2. Ahmed Z, Dhatt KK. Genetic variability and association studies among yield contributing traits in gladiolus (*Gladiolus hybridus* Hort.) under sub-tropical conditions of Punjab (India). Appl. Biol. Res. 2014; 16(2):185-190.
3. Balamurugan Rengasamy P, Arumugan T. Variability studies in gladiolus. J Ornamental Hort. 2002; 5(1):38-39.
4. Balaram MV, Janakiram T. Genetic variability in gladiolus genotypes for corm characters. J Ornamental Hort. 2009; 12(2):123-126.
5. Bhujbal GB, Chavan NG, Mehetre SS. Evaluation of genetic variability heritability and genetic advances in gladiolus (*Gladiolus grandiflorus* L.) genotypes. The Bioscan. 2013; 8(4):1515-1520.
6. Burton GW, Devane EM. Estimating heritability from relicated clonal material. Agron. J. 1953; 45:478-481.
7. Choudhary M, Moond SK, Kumari A, Beniwal BS. Genetic variability in quantitative characters of gladiolus (*Gladiolus hybridus* Hort.). Int. J Agri. Sci. 2012; 8(1):138-141.
8. Falconer DS. Introduction to quantitative genetics, 2nd edition Oliver and Boyd, Edinburg, London, 1981, 316.
9. Geeta. Morphological and molecular characterization in gladiolus (*Gladiolus hybridus* Hort.) varieties. M.Sc. Thesis, University of Horticultural Sciences, Bagalkot, 2013.
10. Hegde MV, Patil AA. Studies on genetic variability in gladiolus (*Gladiolus hybridus*). South Indian Hort. 1995; 43:93-95.
11. Johnson HW, Robinson HF, Comstock RE. Estimates of genetic and environmental variability in soybeans. Agron. J. 1955; 47:314-318.
12. Kadam GB, Kumar G, Saha TN, Tiwari AK, Kumar R. Varietal evaluation and genetic variability studies on gladiolus. Indian J Hort. 2014; 71(3):379-384.
13. Katwate SM, Warade SD, Nimbalkar CA, Patil MT. Correlation and path analysis studies in gladiolus. J Maharashtra agric. Univ. 2002; 27(1):40-43.
14. Kumar R, Kumar S, Yadav YC. Variability studies for yield and yield attributing traits in gladiolus. Prog. Agric. 2011; 11(2):356-360.
15. Kumar J, Kumar R, Krishan P. Variability and character association in gladiolus (*Gladiolus grandiflorus* L.). Agri. Sci. Digest. 2011a; 31(4):280–284.
16. Kumar R, Kumar S, Yadav YC. Genetic variability, heritability, genetic advance, correlation coefficient and path analysis in gladiolus. Indian J Hort. 2012; 69(3):369-373.

17. Kumar P, Kumar M, Kumar A. Study of correlation coefficient and path coefficient analysis in gladiolus (*Gladiolus hybridus* Hort.). Annals Horti. 2015; 8(1):113-115.
18. Mishra P, Singh AK, Singh OP. Genetic variability, heritability, genetic advance, correlation coefficient and path analysis in gladiolus. IOSR J. Agric. Vet. Sci. 2014; 7(7):23-26.
19. Naresh S, Rao AVDD, Baskhar VV, Rao MM, Krishna UK. Genetic variability, heritability and genetic advance in gladiolus hybrids. Plant Arch. 2015; 15(1):377-381.
20. Panse VG, Sukhatme PV. Statistical Methods for Agricultural Workers, ICAR. New Delhi, 1967.
21. Pattanaik S, Paul A, Lenka PC. Genotypic and phenotypic variability and correlation studies in gladiolus, J Crop. Weed. 2015; 11(1):113-119.
22. Pratap M, Rao AM. Assessment and variability studies in gladiolus. J. Ornamental Horti. 2006; 9(2):145-147.
23. Rashmi R, Chandrashekar SY. Evaluation of genetic variability, heritability and genetic advances in gladiolus (*Gladiolus hybridus* L.) genotypes. The Bioscan. 2016; 11(3):1829-1832.
24. Robinson HF, Comstock RE, Harvey VH. Estimates of heritability and degree of dominance in corn. Agron. J. 1949; 41:353-359.
25. Shivasubramanian S, Menon N. Heterosis and inbreeding depression in rice. Madras Agric. J. 1973; 60:1139-1144.
26. Singh RH, Choudhary BD. Biometrical methods in quantitative genetic analysis. Kalyani Publishers, Ludhiana, 1979.
27. Singh N, Pal AK, Roy RK, Tewari SK, Tamta S, Rana T. S. Characterization of gladiolus germplasm using morphological, physiological, and molecular markers. Biochem Genet, 2017, 1-21. https://doi.org/10.1007/s10528-017-9835-4,
28. Subhendu GS, Suresh MK, Jayoti M. Genetic variability, character association and path coefficient analysis in gladiolus for various quantitative traits. Indian J Horti. 2016; 73(4):564-569.
29. Sunil K. Genetic variability and correlation studies on vegetative and floral characters of gladiolus (*Gladiolus grandiflorus*). Current Horti. 2015; 3(2):35-42.
30. Thakur T, Dhatt KK. Genetic variability, heritability and genetic advance of quantitative traits in gladiolus. Int. J Farm Sci. 2015; 5(4):174-180.