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Genetic variability and character association in gladiolus (*Gladiolus hybrida*)

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ABSTRACT

Ten gladiolus (*Gladiolus hybrida* Hort.) cultivars were evaluated for 18 characters to estimate the genetic variability, heritability, genetic advance and correlation to identify suitable gladiolus cultivar for mid-hill conditions of Arunachal Pradesh. The magnitude of phenotypic coefficient of variation (PCV) was higher than genotypic coefficient of variation (GCV). The high value of PCV along with GCV observed for plant height, leaf length, florets/spike, vase life, corm weight and cormels/plant indicated that there is variability in these characters. High heritability coupled with high genetic advance as per cent of mean was recorded for plant height, leaf length, florets/spike, corm diameter, corm weight and number of cormels/plant. Positive highly significant correlation of days to heading with days to first floret showing colour and days to opening of first floret was observed. Spike length was also significant and positively correlated with flower diameter and number of cormels/plant. Corm diameter was positive and highly significantly correlated with corm weight and polar diameter. Spike length was recorded maximum in cv. Chantiler (85.23 cm), whereas number of florets/spike was recorded maximum in cv. Red Majesty (15.94) followed by cv. Pusa Jyotsna (15.81). Cultivars Chantiler and Red Majesty are very prolific in producing number of cormels/plant.

Key words: Coefficient of variation, Corm, Correlation, Gladiolus, Heritability

Gladiolus (*Gladiolus hybrida* Hort.) popularly known as 'Queen of bulbous flowers', is an important cut-flower crop with keeping quality and exhaustive range of floret colour. This cut flower possesses a great potential for export market especially during winter. Though, India has suitable agro-climatic conditions for gladiolus cultivation, it is being grown commercially in an area of 1500 ha (Ramachandrudu and Thangam 2009). Major states growing gladiolus are Uttar Pradesh, Himachal Pradesh, Haryana, Delhi, Karnataka, Punjab, West Bengal, Asom, Sikkim and Meghalaya (Kumar and Yadav 2005).

Among the eight northeastern states, Arunachal Pradesh is the largest state, which lies between 26°28′ and 29°28′ N latitude and 91°35′ and 97°27′ E longitude with altitude ranges from 250 meter to 4114 meter above msl. With its congenial climate, the state offers great scope for cultivation of gladiolus (Kumar *et al.* 2008). The cultivars vary in colour range, flower size, growing period, spike length, number and size of floret, vase life etc. Therefore, there is need for evaluation of cultivars/hybrids before they are recommended for the particular agro-climatic region. Many workers evaluated different cultivars/hybrids under different regions (Pandey *et al.* 2009, Pragya *et al.* 2010, Moond *et al.* 2011). Since gladiolus is highly heterozygous, it is essential to evaluate the wide germplasm available before adopting hybridization programmes to exploit the diversity in growth and flowering traits. Considering the importance of gladiolus in both Indian market and abroad, increasing in the availability of gladiolus flower in large quantities over wider period of the year is of considerable important. Keeping in view the above facts, the present study was undertaken to assess the extent of genetic variability, heritability and correlation among different traits and evaluation for vegetative growth, flower quality, corm and cormel characters for their suitability as cut flower under mid-hill conditions of Arunachal Pradesh.

MATERIALS AND METHODS

A field experiment was conducted with ten gladiolus cultivars in RBD with three replications at ICAR Research Complex for NEH Region, Basar Centre during two growing seasons 2007-08 and 2008-09. The cultivars Chantiler, Jester Gold, Snow Princess, Pusa Jyotsna, Pusa Urvasi, Pusa Chandini, Candyman, White Prosperity, Red Majesty and Smoky Lady were taken for study. The soil in the experimental farm was sandy clay loam and slightly acidic pH (5.6). The mean maximum (27.5°C), minimum (10.7°C) temperature, relative humidity (60.7%) and rainfall (621.05 mm) was recorded during the growing period.

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Well decomposed farmyard manure @ 5 kg/m^2 was applied at the time of bed preparation. The corms were treated with Carbendazim (0.2%) solution for 30 minutes as a preventive measure against *Fusarium* wilt. Ten corms per genotype per replication were planted along the sides of the ridges at a depth of 5 to 6 cm with a spacing of 30 cm × 20 cm. The recommended dose of N: P: K (30:20:20 g/m^2) was uniformly applied to all the plots. Uniform cultural practices were followed to grow a successful crop.

The plant height was recorded from base of the plant to tip of the fully opened top most floret. Spike length was recorded from junction of second pair of leaf to the fully opened top most floret. Rachis length was recorded from the base of the lower most floret to the tip of the fully opened floret. These parameters were recorded with the help of the meter scale. Vase life was judged when the fifth floret from the basal floret started senescing. Corm diameter, polar diameter and equatorial diameter of corms were measured with the help of Digital Vernier Caliper. Five plants per cultivar per replication were labeled and used for recording observations on vegetative growth, flowering, corm and cormel characters. Mean values of both seasons data were pooled and analysed statistically using SPAR package (IASRI, New Delhi).

Phenotypic (σ^2p) and genotypic variance (σ^2g), phenotypic and genotypic coefficient of variation for all characters were calculated (Singh and Chaudhary 1979). Genetic advance was calculated as suggested by Johnson *et al.* (1955). Simple correlation coefficients pertaining to the phenotype and genotype for characters were computed (Singh and Chaudhary 1979).

RESULTS AND DISCUSSION

Genetic variability and heritability

The data presented in Table 1 revealed that the genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) values were in proximation to each other for all the characters studied.

The PCV was higher than GCV for all the characters studied.

Pratap and Rao (2006) also reported higher PCV than GCV for most of the characters. The high value of PCV along with GCV indicated that there is more variability in the characters like plant height, leaf length, number of florets/spike, vase life, weight of corm and number of cormels/plant. Kumar *et al.* (2010) also reported highest GCV for number of cormels/plant. Narrowness between PCV and GCV indicated that the phenotypic expression of all the genotypes is under genetic control and environment has less influence on their expression (Balaram and Janakiram 2009).

Heritability ranged from 71.57% (spike length) to 99.23% (cormels/plant). High heritability for plant height (Pratap and Rao 2006, Balaram and Janakiram 2009), days to heading (Nazir and Dwivedi 2006) and corm weight (Singh *et al.* 2000) has also been reported in gladiolus.

A relative comparison of heritability estimates and genetic advance as per cent of mean will give an idea of nature of gene action governing a particular character. High heritability estimates along with high genetic advance as per cent of mean will be more useful than heritability alone to know the ultimate effect of selection. In the present study,

Table 1 Estimates of mean, variance, range, genotypic and phenotypic coefficient of variation, heritability, genetic advance in gladiolus

Character	Mean	Range	σ^2G	σ^2P	GCV	PCV	H^2	Genetic advance	Genetic advance (% mean)
Plant height (cm)	102.12	80.56-132.18	223.24	230.80	14.63	14.88	96.72	30.65	30.01
Leaf length (cm)	46.46	33.18-56.42	62.99	64.60	17.08	17.30	97.51	16.29	35.06
Leaf breadth (cm)	2.74	2.51-3.18	0.05	0.06	8.30	9.12	83.00	0.45	16.42
Leaves/plant	8.73	7.88-10.83	0.87	1.00	10.65	11.40	87.34	1.91	21.87
Days to heading	81.08	68.17-97.66	60.36	69.66	9.58	10.29	86.66	15.92	19.63
Days to first floret showing colour	93.19	81.24-110.56	57.47	74.37	8.13	9.25	77.27	15.57	16.70
Days to full opening of first floret	95.94	83.95-113.04	55.42	75.12	7.76	9.03	73.77	15.24	15.88
Spike length (cm)	75.56	69.64-85.23	23.23	32.46	6.40	7.57	71.57	9.88	13.07
Rachis length (cm)	41.94	35.24-53.71	26.73	30.12	12.32	13.08	88.74	10.58	25.22
First internode distance (cm)	4.84	4.14-5.38	0.23	0.28	9.94	10.91	83.16	0.98	20.24
Florets/spike	13.23	9.66-15.94	4.84	5.30	16.63	17.39	91.36	4.51	34.08
Floret diameter (cm)	8.61	8.00-10.15	1.13	1.25	12.37	12.96	91.03	2.18	25.31
Vase life (days)	8.50	6.58-10.52	1.38	1.54	13.79	14.59	89.31	2.41	28.35
Corm diameter (cm)	5.70	5.28-6.78	0.42	0.47	11.37	12.06	88.95	13.26	232.63
Corm weight (g)	55.93	28.94-75.63	221.08	225.26	26.58	26.83	98.14	30.59	54.59
Polar diameter (cm)	2.13	1.83-2.43	0.03	0.04	7.84	8.91	77.30	0.35	16.43
Equatorial diameter (cm)	1.77	1.38-2.15	0.05	0.05	12.53	13.12	91.07	0.43	24.29
Cormels/plant	15.74	7.67-42.14	104.49	105.30	64.94	65.19	99.23	21.03	133.60

high heritability coupled with high genetic advance as per cent of mean was recorded for plant height, leaf length, florets/spike, corm diameter, corm weight and number of cormels/plant, appeared to be controlled by additive gene action and selection for such characters will be very effective. High heritability coupled with high genetic advance for plant height (Pratap and Rao 2006), leaf length (Ghimiray 2005), florets/spike (Bichoo *et al.* 2002), corm diameter, corm weight and cormels/plant (Lepcha *et al.* 2007) have also been reported.

Table 2 Genotypic correlation coefficients among eighteen characters in gladiolus

	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}	X_{18}
X_1	0.79*	0.50	0.54	0.00	–0.01	–0.04	0.24	0.43	0.56	–0.07	–0.05	0.21	0.23	0.18	–0.12	–0.04	0.03
X_2		0.29	0.73*	0.35	0.33	0.33	–0.17	0.05	0.71*	–0.22	–0.33	–0.04	–0.05	–0.12	–0.31	0.15	–0.45
X_3			0.05	–0.17	–0.19	–0.24	–0.23	0.08	0.30	0.13	–0.61	–0.16	0.03	0.28	–0.07	0.03	–0.25
X_4				0.09	0.12	0.12	0.40	0.31	0.89*	–0.69*	–0.16	0.56	0.35	0.19	0.15	0.00	–0.15
X_5					0.98**	0.95**	–0.37	–0.15	0.31	0.24	–0.20	–0.39	–0.09	–0.22	–0.24	0.07	–0.26
X_6						0.96**	–0.43	–0.18	0.37	0.23	–0.17	–0.34	–0.02	–0.19	–0.20	0.10	–0.23
X_7							–0.40	–0.20	0.35	0.22	–0.18	–0.37	0.00	–0.21	–0.20	0.09	–0.23
X_8								0.90**	0.13	–0.51*	0.63*	0.96**	0.51	0.26	0.26	–0.57*	0.67*
X_9									0.18	–0.10	0.57	0.63*	0.27	0.17	0.02	–0.54	0.38
X_{10}										–0.46	–0.35	0.26	0.52	0.38	0.31	0.09	–0.16
X_{11}											0.11	–0.62	–0.32	–0.11	–0.26	0.24	–0.02
X_{12}												0.24	0.18	–0.03	0.07	–0.41	0.55
X_{13}													0.55	0.48	0.55	–0.14	0.59
X_{14}														0.91**	0.95**	0.14	0.72
X_{15}															0.96**	0.44	0.67
X_{16}																0.48	0.75*
X_{17}																	0.01

*Significant at P=0.05, ** Significant at P=0.05. X_1 Plant height; X_2 Leaf length; X_3 Leaf breadth; X_4 Leaves/plant; X_5 Days to heading; X_6 Days to first floret showing colour; X_7 Days to full opening of first floret; X_8 Spike length; X_9 Rachis length; X_{10} First internode distance; X_{11} Florets/spike; X_{12} Floret diameter; X_{13} Vase life; X_{14} Corm diameter; X_{15} Corm weight; X_{16} Polar diameter; X_{17} Equatorial diameter; X_{18} Cormels/plant

Table 3 Phenotypic correlation coefficient among eighteen characters in gladiolus

	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}	X_{18}
X_1	0.76	0.45	0.53	–0.01	–0.06	–0.06	0.16	0.41	0.51	–0.08	–0.04	0.19	0.23	0.18	–0.11	–0.04	0.03
X_2		0.28	0.69	0.34	0.30	0.28	–0.13	0.05	0.66	–0.20	–0.33	–0.03	–0.03	–0.12	–0.29	0.12	–0.44
X_3			0.09	–0.10	–0.22	–0.17	–0.19	0.09	0.33	0.11	–0.54	–0.10	0.09	0.27	–0.05	–0.01	–0.22
X_4				0.06	0.03	0.03	0.26	0.31	0.80	–0.63	–0.14	0.49	0.35	0.18	0.11	0.01	–0.14
X_5					0.87	0.93	–0.28	–0.19	0.31	0.20	–0.20	–0.26	–0.06	–0.21	–0.20	0.03	–0.24
X_6						0.84	–0.19	–0.19	0.24	0.24	–0.16	–0.34	–0.04	–0.18	–0.12	0.09	–0.21
X_7							–0.23	–0.22	0.27	0.15	–0.15	–0.27	–0.07	–0.16	–0.10	0.06	–0.20
X_8								0.64	0.06	0.38	0.44	0.75	0.36	0.23	0.27	–0.47	0.55
X_9									0.14	–0.06	0.50	0.55	0.26	0.15	–0.03	–0.49	0.37
X_{10}										–0.39	–0.29	0.29	0.53	0.36	0.16	0.10	–0.13
X_{11}											0.08	–0.55	–0.28	–0.11	–0.21	0.24	–0.02
X_{12}												0.21	0.18	–0.04	0.05	–0.32	0.52
X_{13}													0.52	0.45	0.43	–0.13	0.57
X_{14}														0.84	0.73	0.13	0.69
X_{15}															0.86	0.41	0.65
X_{16}																0.40	0.64
X_{17}																	0.01

*Significant at P=0.05, ** Significant at P=0.05. X_1 Plant height; X_2 Leaf length; X_3 Leaf breadth; X_4 Leaves/plant; X_5 Days to heading; X_6 Days to first floret showing colour; X_7 Days to full opening of first floret; X_8 Spike length; X_9 Rachis length; X_{10} First internode distance; X_{11} Florets/spike; X_{12} Floret diameter; X_{13}Vase life; X_{14} Corm diameter; X_{15} Corm weight; X_{16} Polar diameter; X_{17} Equatorial diameter; X_{18} Cormels/plant

Coefficient of Correlation

Information on correlations between the cut flower characters are of considerable help in the efficient selection programme. Positive correlations ensure simultaneous improvement in one or more variables and negative correlations bring out the need to obtain a compromise between the desirable traits. The coefficient of correlations among different pairs of characters revealed that estimates of genotypic correlation coefficients were higher in magnitude than phenotypic correlation coefficients (Table 2 and 3), indicating strong inheriting association between different characters. Number of leaves/plant showed positive highly significant correlation with first internode distance and florets/spike. Balaram and Janakiram (2009) also reported positive correlation between number of leaves/plant and florets/spike. More photosynthates are made available through more number of leaves which in turn improved the number of florets/spike. Days to heading were positive highly significantly correlated with days to first floret showing colour and days to opening of first floret. Spike length was highly significant positively correlated with rachis length, vase life, flower diameter and cormels/plant. Balaram and Janakiram (2009) also reported positive association of spike length with floret diameter and rachis length. Rachis length was positive significantly correlated with vase life. Corm weight was highly significant positively correlated with number of cormels/plant.

Evaluation for quality traits

The data presented in Table 4 revealed that maximum plant height was recorded in cv. Red Majesty followed by Jester Gold, whereas cv. White Friendship recorded the minimum plant height. The leaf length was ranged from 33.18 cm (Chantiler) to 56.42 cm (Snow Princess), while, leaf breadth ranged from 2.49 cm (Pusa Jyotsna) to 3.18 cm (Pusa Chandini). Variation in vegetative growth due to genotypes has also been reported by Pandey *et al.* (2009) and Pragya *et al.* (2010).

Earliest days to heading was recorded in cv. Smoky Lady, while it was delayed in cv. Pusa Urvasi. Cultivar Smoky Lady took least days to first floret showing colour and for days to full opening of first floret. The results indicated that there is a particular set of period for each cultivar for flowering. These variations may be attributed to the inherent characters of cultivar and due to agro-climatic conditions of the particular area.

Spike characters are important ones with regard to cut flower production in gladiolus. The cultivars under study have shown significant differences with respect to spike length which is one of the important characters for quality assessment. Spike length was recorded maximum in cv. Chantiler followed by cv. Jester Gold, whereas it was recorded minimum in cv. Pusa Urvasi. Higher rachis length was recorded in Jester Gold followed by cv. Chantlier. Internodal distance between florets decides the compactness and number of the florets/spike; short first internode was recorded in cv. Pusa Jyotsna and long first internode was

Table 4 Vegetative and floral characters of gladiolus cultivars under mid hills of Arunachal Pradesh

Cultivar	Plant height (cm)	Leaf length (cm)	Leaf breadth (cm)	Leaves/ plant	Days to heading	Days to first floret showing colour	Days to full opening of first floret	Spike length (cm)	Rachis length (cm)	First internode distance (cm)	Florets/ spike	Floret diameter (cm)	Vase life (days)
Chantiler	95.31	33.18	2.51	8.26	73.84	86.81	89.81	85.23	46.25	4.53	13.37	10.15	10.52
Jester Gold	116.84	52.73	2.87	9.71	85.28	96.27	99.03	83.14	53.71	5.38	13.17	9.28	9.81
Snow Princess	110.28	56.42	2.72	10.83	80.35	93.34	95.72	76.49	40.87	5.79	10.56	7.54	9.85
Pusa Jyotsna	103.85	48.17	2.49	8.18	83.14	94.72	96.93	75.52	43.65	4.14	15.81	9.39	8.19
Pusa Urvasi	91.98	46.34	2.63	8.23	97.66	110.56	113.04	69.64	37.12	5.07	13.35	8.45	6.58
Pusa Chandini	95.56	40.63	3.18	7.88	75.57	86.19	89.27	72.37	39.28	4.56	12.94	6.64	8.04
Candyman	105.32	52.81	2.65	9.10	81.27	92.84	96.71	75.85	35.24	5.04	9.66	8.00	8.25
White Friendship	80.56	39.6	2.62	8.12	85.83	98.08	100.93	70.81	38.36	4.57	14.28	8.29	8.31
Red Majesty	132.18	55.46	3.10	8.74	79.74	91.86	94.06	80.19	46.17	5.15	15.94	8.53	9.01
Smoky Lady	89.35	39.28	2.65	8.28	68.17	81.24	83.95	74.38	41.84	4.45	13.29	9.87	7.65
LSD (P=0.01)	6.46	2.98	0.24	0.84	7.16	9.66	10.43	7.14	4.33	0.51	1.59	0.79	0.95

Table 5 Corm and cormel characters of gladiolus cultivars under mid hills of Arunachal Pradesh

Cultivar	Corm diameter (cm)	Corm weight (g)	Polar diameter (cm)	Equatorial diameter (cm)	Cormels/ plant
Chantiler	6.78	75.63	2.43	1.65	42.14
Jester Gold	5.89	54.39	2.04	1.38	15.17
Snow Princess	6.15	65.27	2.27	2.01	10.14
Pusa Jyotsna	4.41	28.94	1.83	1.74	11.25
Pusa Urvasi	5.64	45.32	2.04	1.68	9.32
Pusa Chandini	5.28	53.18	2.04	1.69	7.67
Candyman	5.44	45.94	2.07	1.74	11.48
White Friendship	5.93	68.35	2.33	2.15	18.66
Red Majesty	6.23	74.72	2.21	2.01	21.32
Smoky Lady	5.34	47.63	2.08	1.65	10.27
LSD (P=0.01)	0.53	4.81	0.21	0.16	2.11

recorded in cv. Snow Princess. These results are in accordance with Kumar and Yadav (2005). Along with these spike characters, number of florets/spike is also important for a cut flower variety as it will decide the attractiveness of the spike and vase life of the spike. Number of florets per spike was recorded more in cv. Red Majesty followed by cv. Pusa Jyotsana, but least number of florets was recorded in cv. Candyman. Significantly biggest florets were recorded in cv. Chantiler and smallest in cv. Pusa Chandini. The preference of consumers depends on the vase life of the cut spikes along with other good qualities of spikes as colour of floret, spike length and the number of florets per spike. In the present investigation, vase life was also recorded more in cv. Chantiler followed by cv. Jester Gold which was on par with cv. Red Majesty. Variation in quality and flowering characters in different genotypes has also been reported (Kumar and Kulkarni 2009) in gladiolus.

Corm and cormel characters are significantly varied among the varieties (Table 5). Maximum corm diameter was recorded in cv. Chantiler followed by cv. Red Majesty, while minimum values were observed with cv. Pusa Jyotsna. Similarly, maximum corm weight was also recorded in cv. Chantiler followed by cv. Red Majesty. Polar and equatorial diameter of corm is important parameters as it decides the quality and thickness of the corm which ultimately produce good, sturdy gladiolus spikes. Significantly highest polar diameter and equatorial diameter was recorded in cv. Chantiler and cv. White Friendship, respectively. Cultivars under study showed greater variation in producing number of cormels per mother corm. Cultivars Chantiler and Red Majesty are very prolific in producing cormels. Similar findings were reported by Kamble *et al.* (2004) and Kumar and Yadav (2005) in gladiolus.

From the present study, it could be concluded that cultivars Chantiler and Red Majesty performed well under mid-hill condition of Arunachal Pradesh. In addition, heritable variability exists in the breeding materials for characters like plant height, leaf length, florets/spike, corm diameter, corm weight and cormels/plant. Cultivars like Red Majesty, Chantiler, Pusa Jyotsna, Snow Princess and Jester Gold could be utilized in the future breeding programme to evolve better gladiolus lines.

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