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GENETIC VARIABILITY AND ASSOCIATION STUDIES AMONG YIELD CONTRIBUTING TRAITS IN GLADIOLUS (*Gladiolus hybridus* Hort.) UNDER SUB-TROPICAL CONDITIONS OF PUNJAB (INDIA)

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ABSTRACT

Fifty seven genotypes of gladiolus were assessed for their efficiency with respect to yield and its contributing traits at PAU Ludhiana (Punjab). The higher PCV and GCV estimates were observed for the number of cormels plant^{-1}, weight corm^{-1} and polar diameter of corm. High heritability with high genetic advance was registered for weight corm^{-1}, spike length, number of cormels plant^{-1}, days taken to heading and days taken to open 1st floret. The correlation studies revealed strong positive association of the number of florets spike^{-1} with the number of leaves, flower duration, spike length, spike diameter, weight corm^{-1}, polar diameter of corm and number of cormels plant^{-1} at both phenotypic and genotypic level. The path analysis indicated that spike length followed by polar diameter of corm and flower duration had highest magnitude of positive direct effect on the number of florets spike^{-1} at phenotypic level, while polar diameter of corm followed by spike length and flower duration had highest direct effect on the number of florets spike^{-1} at genotypic level.

Key words: Association, gladiolus, genetic variability, path coefficient

INTRODUCTION

Gladiolus (*Gladiolus x hybridus* Hort.) is an important bulbous plant which belongs to the family Iridaceae. It is a high value crop next to rose in floriculture trade (Pal and Singh, 2012). Gladiolus has attractive spikes, florets of different colours and longer shelf life so its cut spikes are in great demand. There is a constant fluctuation in the preference of consumers towards gladiolus spikes with time which has induced breeders to develop new varieties with desirable attributes. Though many varieties are available in gladiolus, yet the development of new varieties having better flower quality and adaptability to local environments has remained stationary due to non-availability of better parents or diverse germplasm.

The success of any breeding programme depends upon the availability of sufficient genetic variability in germplasm and its mode of inheritance. The characters for which variability is present should be highly heritable for effective selection. Selection depends upon the heritability, selection intensity and genetic advance of character. Heritability and genetic advance estimates for different targeted traits helps a breeder to apply appropriate breeding methodology in crop improvement (Yadava *et al*., 2011). The major thrust of gladiolus breeding is to improve flower quality and yield. It is an established fact that the flower quality and yield are complex traits which are dependent on several other characters. These characters vary in their relationship with flower quality and yield both in magnitude and direction (Choudhary *et al*., 2011a). The components which have high heritability and positive correlation with yield can be used in indirect selection for yield. However, when the indirect selection becomes complex, path coefficient analysis is used to measure direct and indirect cause of association among different variables. Path coefficient analysis method splits correlation coefficients into direct and indirect effects which help in measuring the relative influence of each character on yield and flower quality (Choudhary *et al*., 2011b). Hence knowledge of direct and indirect effects on flower quality and yield becomes necessary in selection of better genotypes. The present investigation was undertaken to assess genetic variability in gladiolus under Punjab conditions by involving exotic and Indian genotypes and newly developed hybrids.

MATERIALS AND METHODS

The field trials were conducted in two consecutive years (2012-13 and 2013-14) at the Research Farm of Floriculture and Landscaping Department, PAU, Ludhiana, India. The plant material comprised of 57 genotypes of gladiolus *viz*., 26 exotic, 22 Indian and 9 newly developed hybrids were assessed for their growth, flowering and yield contributing characters. All the genotypes were procured from the Department of Floriculture and Landscaping, PAU, Ludhiana. Uniform sized corms (4.0-5.0 cm dia.) were planted during 2^{nd} week of October each year. The experiment was laid out in a randomized block design with three replications. Corms were planted at a plant spacing of 20 cm x 30 cm in 1.2 m^2 plot. Uniform package of practices was followed for all the genotypes throughout the experiment. Corms and cormels were harvested in the 3^{rd} week of April and then shade-dried. The observations were recorded on randomly selected plants for number of leaves plant^{-1}, days taken to sprouting, days taken to heading, days taken to open 1^{st} floret, flower duration, spike length, spike diameter, number of corms plant^{-1}, weight corm^{-1}, polar diameter of corm, number of cormels plant^{-1} and number of florets spike^{-1}.

The number of leaves plant^{-1} was counted 80 days after corm planting. The number of days taken to sprouting, heading and opening of 1^{st} floret was counted from the date of planting. Flower duration was noted by counting the number of days taken from opening of 1^{st} floret to senescence of last floret. Spike length and number of florets spike^{-1} were recorded during peak flowering stage of crop. Spike diameter and polar diameter of corm were recorded with the help of digital Vernier calliper. Genotypic coefficients of variation (GCV) and phenotypic coefficients of variation (PCV) were estimated according to Burton (1952); heritability in broad sense (h^2bs) as per Burton and De vane (1953); genetic advance (GA), genetic advance as percent mean, correlation coefficients at phenotypic and genotypic levels were calculated as per Johnson *et al*. (1955) and path coefficient analysis as per Dewey and Lu (1959). In the present study, path coefficient analysis was carried out by taking number of florets as dependent variable and other traits as independent variables in each year and also for pooled data. All the genetic components were estimated on two year pooled data.

RESULTS AND DISCUSSION

Analysis of variance revealed significant variation among all the genotypes for all the traits studied (Table 1). The phenotypic coefficient of variation (PCV) was higher than the genotypic coefficient of variation (GCV) for all the traits studied (Table 2). The difference between PCV and GCV was low indicating low sensitivity to environment and consequently greater role of genetic factors in

Table 1: The analysis of variance (ANOVA) among 12 characters of gladiolus

Trait	d.f.	Leaves plant^{-1} (No.)	Days taken to sprouting	Days taken to heading	Days taken to open 1st floret	Flower duration (day)	Spike length (cm)	Spike dia (mm)	Corms plant^{-1} (No.)	Weight corm^{-1} (g)	Polar dia. of corm (cm)	Cormels plant^{-1} (No.)	Florets spike^{-1} (No.)
Replication	2	4.07	69.83	23.92	20.74	6.18	3.00	3.68	4.63	4.05	4.30	2.19	6.11
Treatments	56	0.80*	2.10*	175.1*	183.6*	16.72*	485.5*	3.22*	0.21*	388.3*	2.26*	158.9*	11.0*
Error	112	0.11	0.77	3.74	5.03	2.08	5.10	0.21	0.01	0.22	0.03	0.96	0.26

*significant at p = 0.001

influencing the expression of these characters. Similar results were reported by Bhujbal *et al.* (2013) in gladiolus. The PCV and GCV were highest for the number of cormels plant^{-1} followed by weight corm^{-1}, polar diameter of corm and number of cormels plant^{-1}, suggesting that these characters might be under genetic control. Hence, these characters can be relied upon for further crop improvement. PCV and GCV values were also high for the number of cormels plant^{-1} in gladiolus (Lepcha *et al.,* 2007). Minimum values of PCV and GCV were observed for characters like number of leaves plant^{-1} and days taken to open 1st floret and sprouting. This indicated that minimum amount of variation existed among the genotypes with respect to these characters. Hence, improvement of genotypes with respect to these characters is required as the improved genotypes would not be affected by environmental expressivity. Similar trend has also been reported in gladiolus by Anuradha and Gowda (1994) for the number of leaves and spike length. The highest estimate of heritability was noted for weight corm^{-1}, number of cormels plant^{-1}, spike length, polar diameter of corm, days taken to heading and number of florets spike^{-1},while low heritability was recorded for days taken to sprouting. High heritability coupled with high genetic advance was observed for weight corm^{-1}, spike length, number of cormels plant^{-1} and days taken to heading and opening of 1st floret. This indicated lesser influence of environment in expression of these characters and prevalence of additive gene action in their inheritance, hence suitable for selection. High heritability and genetic advance was recorded for number of cormels plant^{-1}, days to opening of basal floret and spike length (Bichoo *et al.*, 2002) in gladiolus. Kumar *et al*. (2011) reported high heritability and genetic advance for weight of corm and cormel production. On the other hand, high heritability coupled with low genetic advance was recorded for polar diameter of corm. This indicated that this characters is under the control of non-additive genes and selection of this character for improvement will be lesser effective. The genetic advance as per cent mean was highest for the number of cormels plant^{-1}.

Table 2: Estimates of variability and genetic parameters for yield and yield attributing character in gladiolus

Characters	Range	Mean	Coefficient of variation		Heritability (BS %)	Genetic Advancement (5%)	GA (as % mean)
			GCV	PCV			
Number of leaves plant^{-1}	6.30 - 8.60	7.54	5.64	7.84	51.70	0.63	8.35
Days taken to sprouting	6.15 - 11.92	8.37	6.94	11.43	36.81	0.73	8.67
Days taken to heading	65.00 - 89.35	77.43	9.72	10.19	91.05	14.80	19.11
Days taken to open 1st floret	85.93-113.67	102.77	7.40	7.86	88.63	14.75	14.36
Flower duration (day)	8.02 - 16.41	13.00	14.51	19.88	53.29	2.84	21.82
Spike length (cm)	42.50 - 90.93	71.84	17.27	17.69	95.22	24.93	34.71
Spike diameter (mm)	6.36 - 10.41	8.47	11.06	12.88	73.65	1.66	19.55
Number of corms plant^{-1}	1.10 - 1.90	1.38	17.42	19.94	76.32	0.43	31.35
Weight corm^{-1} (g)	24.57 - 86.16	56.37	30.60	30.96	97.66	35.11	62.29
Polar diameter of corm (cm)	1.82 - 4.53	3.04	28.04	28.91	94.01	1.70	56.00
Number of cormels plant^{-1}	8.61 - 30.5	18.05	39.66	40.21	97.24	14.54	80.56
Number of florets spike^{-1}	9.57 - 16.56	12.90	15.43	16.51	87.37	3.83	29.71

Table 3: Estimates of phenotypic (P), genotypic (G) and environmental (E) correlation coefficient among various traits of gladiolus

Characters		Leaves plant^{-1} (No.)	Days taken to sprouting	Days taken to heading	Days taken to open 1st floret	Flower duration (day)	Spike length (cm)	Spike dia. (mm)	Corms plant^{-1} (No.)	Weight corm^{-1} (g)	Polar dia. of corm (cm)	Cormels plant^{-1} (No.)	Florets spike^{-1} (No.)
Leaves plant^{-1} (No.)	P		-0.05	0.16	0.02	0.32**	0.29**	0.33**	0.15	0.20*	0.18	0.19*	0.23*
	G		-0.43***	0.35***	0.17	0.38***	0.37***	0.54***	0.43***	0.32	0.26	0.26**	0.34***
	E		0.25**	-0.40***	-0.41***	0.25**	0.19*	0.00	-0.37***	-0.34**	-0.00	0.09	0.00
Days taken to sprouting	P			0.27**	0.46***	0.13	0.12	-0.01	-0.06	-0.01	-0.03	-0.16	0.06
	G			0.57***	0.97***	0.08	0.17	0.10	-0.12	0.06	-0.02	-0.28**	0.06
	E			-0.24*	-0.34***	0.17	0.13	-0.16	0.00	-0.22	-0.09	0.05	0.08
Days taken to heading	P				0.77***	0.07	0.25**	0.30**	-0.16	0.02	-0.04	-0.06	0.12
	G				0.78***	0.20*	0.27**	0.39***	-0.19*	0.01	-0.03	-0.05	0.15
	E				0.60***	-0.35***	0.08	-0.11	0.02	0.11	-0.10	-0.12	-0.07
Days taken to open 1st floret	P					0.11	0.32**	0.22*	-0.14	0.07	-0.00	-0.11	0.18
	G					0.36***	0.35***	0.28**	-0.17	0.08	0.00	-0.12	0.20
	E					-0.60***	-0.05	-0.02	-0.01	0.05	-0.07	-0.05	-0.07
Flower duration (day)	P						0.67***	0.46***	-0.02	0.18	0.16	0.37***	0.58***
	G						0.91***	0.65***	-0.02	0.56	0.19	0.48***	0.79***
	E						0.15	0.16	-0.02	0.08	-0.02	0.19*	0.15
Spike length (cm)	P							0.53***	-0.09	0.37***	0.31**	0.47***	0.73***
	G							0.60***	-0.11	0.38***	0.34***	0.49***	0.77***
	E							0.21*	0.02	0.12	-0.23*	0.08	0.37***
Spike diameter (mm)	P								-0.15	0.52***	0.42***	0.32**	0.47***
	G								-0.18	0.58***	0.48***	0.36***	0.53***
	E								-0.04	0.29	0.18	0.23*	0.21*
Corms plant^{-1} (No.)	P									0.19	0.19	0.12	-0.05
	G									0.19	0.20	0.14	-0.04
	E									0.27	0.08	-0.05	-0.10
Weight corm^{-1} (g)	P										0.93***	0.58***	0.42***
	G										0.96***	0.58***	0.47***
	E										0.20*	0.34***	-0.17
Polar dia. of corm (cm)	P											0.51***	0.41***
	G											0.52***	0.47***
	E											0.23*	0.22*
Cormels plant^{-1} (No.)	P												0.38***
	G												0.42***
	E												0.01
Florets spike^{-1} (No.)	P												
	G												
	E												

***, **,*significant at p=0.001, 0.01and p=0.05, respectively

The genotypic and phenotypic correlation coefficients were computed in all possible combinations for twelve characters (Table 3). In present study most of the characters exhibited increased estimates of genotypic than phenotypic correlation coefficient. Although there was strong inherent association among various characters under study, the phenotypic expression of correlation was lessened under the influence of environment. The number of florets spike^{-1} was significantly and positively correlated with the number of leaves plant^{-1}, flower duration, spike length, spike diameter, weight corm^{-1}, polar diameter of corm and number of cormels plant^{-1} at both phenotypic and genotypic level. Pal and Singh (2012) also recorded significant positive correlation for number of florets spike^{-1} with spike length and weight of corm. Flower duration showed positive association with number of leaves plant^{-1} and days taken to heading and opening of 1st floret at genotypic level while it showed significant negative association with days taken to heading and opening of 1st floret at environmental level. Spike length, an important quality parameter, showed significant positive association with number of leaves plant^{-1}, days taken to heading and opening of 1st floret, flower duration, number of florets spike^{-1}, weight corm^{-1} and polar diameter of corm at phenotypic and genotypic level as well. Similarly, the spike length had shown positive correlation with duration of flowering and number of florets spike in gladiolus (Choudhary *et al*., 2011a). Polar diameter of corm showed positive correlation with spike length and diameter and weight corm^{-1}. Anuradha and Gowda (1994) suggested that large sized corms produced taller plant.

Path coefficient analysis permits the examination of direct effect of various characters on dependent variable as well as indirect effect via other component characters. Path coefficient analysis indicated that spike length followed by polar diameter of corm and flower duration had highest magnitude of positive direct effect upon number of florets spike^{-1} at phenotypic level (Table 4). Direct effect of spike length on number of florets spike^{-1} has also been observed by Choudhary *et al.* (2011b). However, polar diameter of corm followed by spike length and flower duration had highest direct effect upon number of florets spike^{-1} at genotypic level. While highest negative direct effect was noticed for weight corm^{-1} followed by days taken to heading at genotypic level. The highest indirect effect, at phenotypic as well as genotypic level, upon number of florets spike^{-1} was shown by flower duration which indicated that selection for flower duration indirectly improved the yield. The high positive significant association of number of florets spike^{-1} with flower duration and spike length were the result of positive indirect effect of these traits via polar diameter of corm, days taken to opening of 1st floret and spike diameter and also due to some individual direct effect of polar diameter of corm towards number of florets spike^{-1}. The residual effect indicated that the characters studies contributed 66.66% variation in the number of florets spike^{-1} while 33.33% was due to known factors like other characters which were not included in the analysis.

Table 4: Estimates of direct and indirect effect of different characters on yield at phenotypic (P) and genotypic (G) levels in gladiolus

Characters		Leaves plant^{-1} (No.)	Days taken to sprou-ting	Days taken to head-ing	Days taken to open 1st floret	Flower dura-tion (day)	Spike length (cm)	Spike dia. (mm)	Corms plant^{-1} (No.)	Weight corm^{-1} (g)	Polar dia. of corm (cm)	Cormels plant^{-1} (No.)	Correlation coefficient with florets spike^{-1}
Leaves plant^{-1}	P	**0.00**	0.00	0.01	0.00	0.01	0.38	0.00	0.00	0.01	0.07	0.00	0.23*
(No.)	G	**0.03**	0.04	-0.05	0.03	0.09	0.16	0.05	-0.01	-0.16	0.16	0.00	0.34***
Days taken to	P	0.00	**-0.03**	-0.02	0.02	0.01	0.08	-0.00	0.00	-0.00	-0.01	0.01	0.06
sprouting	G	-0.01	**-0.09**	-0.08	0.18	0.02	0.07	0.01	0.00	-0.03	-0.02	-0.00	0.06
Days taken to	P	-0.00	-0.01	**-0.07**	0.03	0.01	0.15	0.02	-0.00	-0.00	-0.01	0.00	0.12
Heading	G	0.01	-0.05	**-0.13**	0.15	0.05	0.12	0.04	0.01	-0.01	-0.02	-0.00	0.15
Days taken to	P	-0.00	-0.02	-0.06	**0.05**	0.01	0.20	0.01	0.00	-0.01	-0.00	0.01	0.18
open 1st floret	G	0.01	-0.09	-0.10	**0.19**	0.09	0.15	0.03	0.01	-0.04	0.00	-0.00	0.20
Flower	P	-0.00	-0.00	-0.01	0.00	**0.10**	0.41	0.03	0.00	-0.04	0.10	-0.02	0.58***
duration (day)	G	0.01	-0.01	-0.03	0.07	**0.24**	0.40	0.06	0.00	-0.28	0.32	0.00	0.79***
Spike length	P	-0.00	-0.00	-0.02	0.01	0.07	**0.61**	0.03	0.00	-0.03	0.08	-0.02	0.73***
(cm)	G	0.01	-0.02	-0.04	0.07	0.22	**0.44**	0.06	0.00	-0.19	0.22	0.00	0.77***
Spike dia.	P	-0.00	0.00	-0.02	0.01	0.05	0.32	**0.05**	0.00	-0.04	0.11	-0.01	0.47***
(mm)	G	0.02	-0.01	-0.05	0.05	0.16	0.26	**0.09**	0.01	-0.30	0.30	0.00	0.53***
Corms plant^{-1}	P	-0.00	0.00	0.01	-0.00	-0.00	-0.05	-0.01	**-0.02**	-0.02	0.05	-0.01	-0.05
(No.)	G	0.01	0.01	0.03	-0.03	-0.01	-0.05	-0.02	**-0.03**	-0.10	0.14	0.00	-0.04
Weight corm^{-1}	P	-0.00	-0.00	-0.00	0.00	0.04	0.22	0.03	-0.00	**-0.08**	0.24	-0.03	0.42***
(g)	G	0.01	-0.01	-0.00	0.01	0.13	0.16	0.05	-0.01	**-0.51**	0.61	0.00	0.47***
Polar dia. of	P	-0.00	0.00	0.00	-0.00	0.04	0.19	0.02	-0.01	-0.08	**0.26**	-0.02	0.41***
corm (cm)	G	0.01	0.00	0.00	0.00	0.12	0.15	-0.04	-0.01	-0.49	**0.63**	0.00	0.47***
Cormels	P	-0.00	0.01	0.00	0.01	0.04	0.29	0.02	-0.00	-0.05	0.13	**-0.05**	0.38***
plant^{-1} (No.)	G	0.01	0.03	0.01	-0.02	0.11	0.21	0.03	-0.00	-0.29	0.33	**0.01**	0.42***

Conclusion: The germplasm used in the present study is of diverse nature and can be used in the breeding programme for developing improved varieties. The heritable variability exists in germplasm for number of cormels plant^{-1}, weight corm^{-1} and spike length and selection of genotypes on the basis of these traits would be more fruitful for crop improvement programme. Selection for spike length and corm size may play a major role in increasing the yield.

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