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GENETIC VARIABILITY, CORRELATION STUDIES AND PATH COEFFICIENT ANALYSIS IN *GLADIOLUS ALATUS* CULTIVARS

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Abstract

A study was undertaken to find out the estimates of genetic variability, genetic parameters and character association among different flower traits between three gladiolus cultivars viz: Sancerre, Fado and Advanced Red. The experiment was repeated three times by using RCBD (Randomized complete block design) at Department of Horticulture, PMAS-UAAR, Rawalpindi. The highest genotypic coefficient variation (GCV) and phenotypic coefficient variation (PCV) magnitude was observed for spike length (16.00) and number of florets per spike (14.84) followed by number of leaves (10.00). Among the traits studied the highest heritability estimates was recorded in spike length (99.5%) followed by number of florets/spike (99.6%) and lowest in plant height (98.2%). The genetic advance as percent of mean was ranged from 2.8% to 24.75%. Genetic advance was highest for floret breadth (24.75%) and lowest for plant height (2.8%). High heritability combined with high genetic advance was noticed for number of florets per spike, spike length and floret breadth indicating additive gene action which suggested that improvement of these traits would be effective for further selection of superior genotypes. Plant height and number of florets per spike showed highly positive and significant association with spike length, number of leaves, leaf area, floret length and floret breadth while, spike length registered positive and significant correlation with number of leaves and floret breadth. The path coefficient analysis based on spike length, as responsible variable exposed that all of the traits exerted direct positive effect except leaf area and floret length. Spike length imparted maximum positive direct effect on the number of florets per spike. Hence, spike length and number of florets per spike may be considered for further improvement. However, Floret length and floret breadth may also be considered as a criterion for selection.

Key words: Gladiolus, GCV, PCV, Heritability, Genetic advance, Path analysis.

Introduction

Gladiolus (*Gladiolus alatus*) also called sword lily belongs to family Iridaceae, comprised of 255 species. Most of this genus are mostly heteroploid having very small number of chromosomes (n=15) in contrast with polyploids (diploid, triploid, tetraploid, pentaploid, hexaploid and octaploid). It is originated from South Africa and then it wide spread to central Europe, Mediterranean region and western Asia and Asia Minor (Bose *et al*., 2003). However, the centre of diversity of the genus is located in the cape floristic region (Lahijie, 2012). The species of the Cape region are primarily diploids (2n=30), while the European species are polyploids (2n=60-130), which substantiates the Southern origin of the genus. From the economical point of view it is rated as the second most important popular cut flower in the world. Gladiolus, occupies 8th place in international cut flower trade after rose, carnation and chrysanthemum (Ahmad *et al*., 2008). Gladiolus ranks second top selling cut flower in Pakistan after roses (Riaz *et al*., 2007). *Gladiolus*, the queen of the bulbous ornamentals, is the leading geophytes grown worldwide garden displays. It occupies a pristine place in the garden for its magnificent inflorescence, wide array of colors, and fascinating varieties of different shapes and sizes (Pragya, 2010). For a modern and industrialized floriculture, there is a dire need of introducing new varieties which cope with our environment efficiently. Gladiolus is an herbaceous plant, having deciduous leaves with overlapping bases and a stem bearing a terminal spike with a number of 30 florets or more that are either bilateral or radial symmetric. Flower size varies from 2 to 20 cm in diameter (Cantor & Tolety, 2011).

Yield and quality of flower are quantitative characters and are highly influenced by environmental factors. Thus, yield and association of yield contributing traits is considered to be of great importance for planning and executing breeding programme. Correlation study provides beneficial information regarding the interrelationship of quantitative traits among each other and influence of these traits on yield, thereby aid in selection (Kumar *et al*., 2012). The path coefficient analysis deals with the direct and indirect relationship of predicted variable with the responsible variables which help in assessing the relative influence of significant traits on the ultimate yield (Geeta *et al*., 2014).The present study was designed to find out the extent of genetic variability in *Gladiolus alatus* cultivars by determining the coefficient of variations, heritability, genetic advance, correlation analysis and path coefficient analysis.

Materials and Methods

Experimental trial: The present investigation was carried out in the experimental area of the Department of Horticulture, Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi. The study conducted was mainly focused on the hybridization of *Gladiolus alatus* cultivars. Corms of three cultivars of gladiolus i.e., Sancerre, Advanced Red and Fado were imported and kept under study for a period of three years in field by cultivating in autumn each year. At the end of spring season, the corms and cormels were removed from the soil, washed, dried and treated with fungicide Dithane M45 @ of 2g/Kg of corms, then packed and stored in the cold storage at 4^{o}C till sowing.

The genotypes i.e., Sancerre, Fado and Advanced Red were planted in the month of September, 2010 having row to row distance of 45cm and plant to plant distance of 30cm. The experiment was laid out in RCBD with three replications. Diaammonium Phosphate (DAP) and Urea fertilizer were applied @ 100 kgs per acre, whole dose of DAP was incorporated during soil bed preparation stage and urea was utilized in split doses, one at the time of emergence and other about one month after emergence. The experimental observations were recorded form five plants of each variety under each replication.

Statistical analysis: The analysis of variance was performed to study the variation among tested genotypes by using standard procedure suggested by (Steel & Torrie, 1980). Data were recorded for plant height. Number of floret/spike, spike length, number of leaves, leaf area, floret length & width, and analyzed for genetic advance, heritability (broad sense), phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV). Genotypic and phenotypic correlations were computed following (Hallauer & Miranda, 1988). Heritability and genetic advance were determined as per formulae suggested by Hanson *et al*. (1956) and Johnson *et al*. (1955) respectively. Path coefficient analysis was carried out according to Dewey & Lu (1959), where spike length was kept as predicted variable and other component traits as responsible variables.

Results and Discussion

Genetic variability, heritability and genetic advance: Analysis of variance indicated highly significant differences for all the traits studied among the genotypes (Table 1). This significant difference represents existence of genetic variability. Ahmad *et al.* (2012) also found significant variation in plant height (43.4a cm), number of leaves (13.6a) and leaf area (53.28a) in three genotypes of rose. Genetic parameters like genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability and genetic advance are useful biometrical tools for determination of genetic variability (Aditya *et al*., 2011). The estimates of genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) for different traits of gladiolus varieties are presented in table 2. It is reported from earlier study that genetic variability is a basic pre requisite for plant breeding programme on which selection acts to evolve superior genotype. Thus the higher the amount of variation present for the various traits in the chosen materials, greater is the scope for its improvement through selection. The values of PCV for different traits were higher than corresponding GCV value indicating all the traits were influenced by environmental factors. The magnitude of (GCV) and (PCV) were recorded highest for spike length (16.98, 17.02) followed by number of floret/spike (14.84, 14.88) and number of leaves (10.24, 10.44) respectively. Hence these traits can be relied upon selection for further improvement. Minimum values of (GCV) and (PCV) were recorded for plant height (1.99, 2.014) and floret length (3.97, 4.16) which indicated that very minimum variation existed among genotypes with respect to these traits. Positive and significant genotypic and phenotypic correlation in 15 gladiolus cultivars between floret number and in cluster with flowering period and floret size were also reported by Sandhu *et al*. (1993). Results are in accordance with Moradi (2007), Bazzaz *et al*. (2007) and Sarangi *et al*. (1994). The environmental coefficient of variation (ECV) ranged from 0.269 (plant height) to 2.046 percent (number of leaves).

Heritability is important to a breeder since it specify the possibility and degree to which progress is potential through selection. Superior heritability only is not sufficient to put together competent selection in the higher generation unless attended by extensive amount of genetic advance. Thus genetic advance is another important selection parameter. Higher estimates of heritability along with high genetic advance test supply better scope for progressive improvement in advance generation. Heritability estimates for spike length and number of floret per plant were maximum (99.5% & 99.6%). Highest value of genetic advance was recorded for floret breadth (24.75%) following spike length (23.62%) and number of florets per spike (20.73%). Floret length gave minimum value (5.25%) for genetic advance indicated that this trait was being governed by non-additive genes. Similar work was also reported by Kumar *et al*. (2010) and Maurya *et al*. (2011). High heritability coupled with highest genetic advance was observed for floret breadth, spike length and number of floret per spike indicating the contribution of additive gene action in expression of these traits. These results further suggested the limited involvement of the environmental influence in the expression of these traits so the improvement could be made through selection. Bichoo *et al*. (2002) also reported high heritability coupled with high genetic advance for number of floret per spike in gladiolus.

Table 1. Mean estimates of different traits in gladiolus.

Source of variance	D.F.	Plant height (cm)	Spike length (cm)	No. of florets/spike	Number of leaves	Leaf area (cm^2)	Floret length (cm)	Floret breadth (cm)
Replication	5	0.7427	1.178	0.362	0.102	0.615	0.081	0.165
Genotypes	2	53.68**	691.54**	50.95**	2.676**	286.64**	0.666*	20.37**
Error	10	1.433	3.78	0.349	0.15416	3.309	0.090	0.32

*Significant, **Highly significant

Table 2. Estimation of genetic component for different traits in gladiolus.

Parameters	Mean	Coefficient of variations			Heritability h^2_{bs} (%)	Genetic advance	Genetic advance (%)
		GCV	PCV	ECV			
Plant height (cm)	148	1.996	2.014	0.269	98.2	4.11	2.8
No. of florets/spike	19.58	14.84	14.88	1.006	99.6	4.06	20.73
Spike length (cm)	63.07	16.98	17.02	1.027	99.5	14.9	23.62
Number of leaves	6.39	10.24	10.44	2.046	96	0.89	13.92
Leaf area (cm^2)	123	5.56	5.58	0.49	99.2	9.60	7.80
Floret length (cm)	8	3.97	4.16	1.25	91	0.42	5.25
Floret breadth (cm)	10.3	17.67	17.76	1.82	98.9	2.55	24.75

Correlation coefficient studies: Correlation coefficient analysis measures the mutual relationship between various plant characters and determines the component characters on which selection is based for genetic improvement for a particular character. The phenotypic and genotypic correlation coefficients were computed in all possible combinations for 7 quantitative traits (Table 3). In the present study, the phenotypic correlation co-efficient were higher in magnitude over genotypic correlation co-efficient for most of the traits studied. This indicated that these differences might be due to environmental variations. Plant height showed highly positive and significant association with number of florets per spike, spike length, number of leaves, leaf area, floret length and floret breadth indicating that with incensement of plant height these associated character could be improved. Plant height was positively and significantly correlated with rachis length, spike length, duration of flowering and number of florets per spike both at phenotypic and genotypic levels (Choudhary *et al*., 2011a). Positive and significant association of number of florets per spike with spike length, number of leaves, leaf area, floret length and floret breadth was observed. The results obtained are in agreement with the findings of De & Misra (1994) and Ranchana *et al*. (2013). Spike length registered highly significant and positive association with number of leaves and floret breadth both at phenotypic and genotypic level. A significant positive association between spike length, plant height and number of florets was evidenced by Anuradha & Gowda, (1992) in gladiolus. Number of leaves per plant showed significant and positive correlation with leaf area, floret length and floret breadth. A significant and positive correlation between leaf area and floret length was noted. Similar work was carried out by Zorana *et al*. (2011).

Path coefficient studies: Path coefficient analysis has been used to organize the relationship between independent variable and responsible variables. To understand the direct and indirect effects of each character on flower yield, partitioning of correlation coefficient into direct and indirect effects through path coefficient analysis is very important.

The path coefficient analysis based on number of florets per spike indicated that spike length imparted maximum positive direct effect (0.783) on number of florets per spike which was minimized by negative direct effect of floret breadth (-0.14). Leaf area (0.249) and plant height (0.201) had moderate positive direct effect on number of florets per spike. Number of leaves (0.0377) and floret length (0.01) had low positive direct effect whereas floret breadth (-0.142) exerted negative direct effect on number of floret/spike (Fig. 1 & Table 4). The results are in line with the finding of Kumar *et al*. (2012).

The path coefficient analysis based on spike length as dependent variable revealed that all traits except leaf area and floret length exhibited positive direct effects on spike length. Path analysis of spike length demonstrated that plant height (0.11), number of florets/spike (0.53), number of leaves (0.047) and floret breadth (0.45) had high positive direct effect on spike length (Fig. 2 & Table 5). Direct effect of leaf area (-0.2015) and floret length (-0.074) were recorded to be negative on spike length. Plant height, number of leaves and floret breadth showed positive indirect effect through number of florets per spike on spike length. Leaf area showed maximum negative (-0.2015) direct effect on spike length but had maximum negative indirect effects through plant height, number of florets per spike and number of leaves. In the light of these inferences it is clear that selection will be rewarding if focused in the direction of the traits, possessing high positive direct and indirect effects with positive correlation. Similar findings have been reported by Choudhary *et al*. (2011b) for spike length which suggested that the improvement in spike length, rachis length and plant height would directly increase number of florets per spike. Patra & Mohanty (2015) reported direct and indirect effect of various traits on length of spike both at genotypic and phenotypic level similar to the present finding. Further results revealed that plant height, number of leaves, leaf area and floret length showed maximum positive indirect effect through number of leaves. The indirect positive effects suggested that selection for any of these characters would improve the yield through the associated characters. It can be concluded that association as well as indirect effects was appreciable which can be efficiently used for selecting superior genotypes in future breeding programme.

Table 3. Genotypic (rg) and phenotypic (rp) correlation coefficient of component traits in gladiolus.

Parameters	Correlations	Plant height (cm)	No. of florets /spike	Spike length (cm)	No. of leaves	Leaf area (cm^2)	Floret length (cm)	Floret breadth (cm)
Plant height (cm)	rg	1.000	1.0039*	0.8954*	0.9873*	0.7269*	0.7220*	0.8794*
	rp	1.000	0.9950**	0.8888**	0.9583**	0.7215**	0.6789**	0.8663**
No. of florets/spike	rg		1.000	0.9326*	0.9512*	0.6538*	0.6409*	0.9233*
	rp		1.000	0.9300**	0.9251**	0.6490**	0.6034**	0.9117**
Spike length (cm)	rg			1.000	0.7368*	0.3231*	0.2802*	1.0069*
	rp			1.000	0.7207**	0.3238	0.2680	0.9989**
No. of leaves	rg				1.000	0.9177*	0.9024*	0.7071*
	rp				1.000	0.8893**	0.8610**	0.6874**
Leaf area (cm^2)	rg					1.000	1.0571*	0.2795*
	rp					1.000	0.9983**	0.2791
Floret length (cm)	rg						1.000	0.2186
	rp						1.000	0.2225
Floret breadth (cm)	rg							1.000
	rp							1.000

* Significant at probability level 0.05
** Significant at probability level 0.01

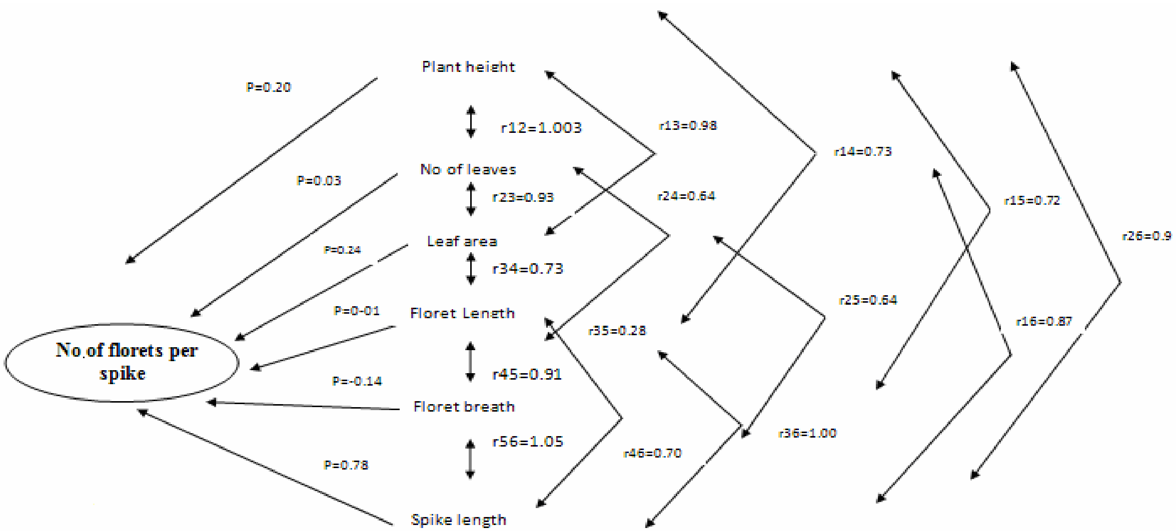

Fig. 1. Path diagram for number of florets/spike.

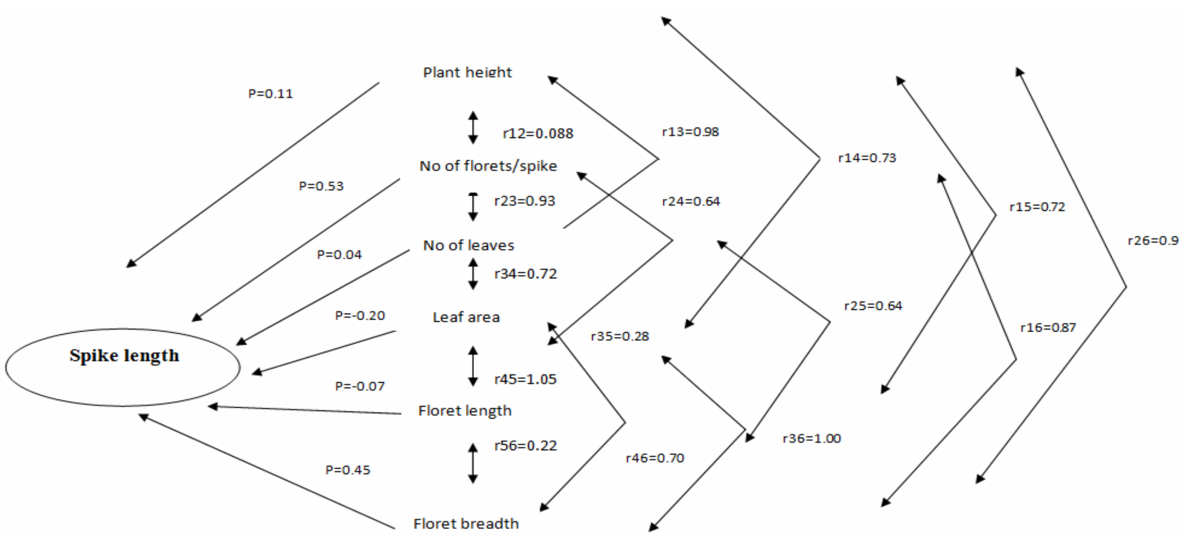

Fig. 2. Path diagram for spike length.

Table 4. Direct and indirect effect of component traits on number of florets per spike in gladiolus cultivars.

Parameters	Plant height	No. of leaves	Leaf area	Floret length	Floret breadth	Spike length	No. of florets/spike
Plant height	**0.2015**	0.0372	0.1811	0.0068	-0.1242	0.7015	1.0039
No. of leaves	0.1989	**0.0377**	0.2286	0.0085	-0.0999	0.5773	0.9512
Leaf area	0.1465	0.0346	**0.2491**	0.0099	-0.0395	0.2531	0.6538
Floret length	0.1455	0.0340	0.2633	**0.0094**	-0.0309	0.2196	0.6409
Floret breadth	0.1772	0.0267	0.0696	0.0020	**-0.1412**	0.7889	0.9233
Spike length	0.1804	0.0278	0.0805	0.0026	-0.1422	**0.7835**	0.9326

Table 5. Direct and indirect effect of component traits on spike length in gladiolus cultivars.

Parameters	Plant height	No. of florets/ spike	No. of leaves	Leaf area	Floret length	Floret breadth	Genotypic correlation
Plant height	**0.1190**	0.5329	0.0473	-0.1465	-0.0540	0.3966	0.8954
No. of florets/spike	0.1195	**0.5308**	0.0456	-0.1317	-0.0479	0.4163	0.9326
No. of leaves	0.1175	0.5049	**0.0479**	-0.1849	-0.0674	0.3188	0.7368
Leaf area	0.0865	0.3470	0.0440	**-0.2015**	-0.0790	0.1261	0.3231
Floret length	0.0859	0.3402	0.0433	-0.2130	**-0.0747**	0.0986	0.2803
Floret breadth	0.1047	0.4901	0.0339	-0.0563	-0.0163	**0.4510**	1.0069

Conclusion

Highly significant differences for all the traits studied among the genotypes. High estimates of heritability coupled with high values of genetic advance were observed for number of florets per spike, floret breadth and spike length which indicated towards the minor involvement of the environmental influence in the expression of these traits. Hence the scope of improvement is more by following standard selection procedures. On the basis of the inference made with respect to the high positive direct effects with positive correlations; three traits viz; number of florets per spike, floret breadth and spike length were investigated to be of fundamental importance. On the basis of the direct selection for number of florets per spike and indirect selection through spike length may be considered for further improvement of number of florets per spike in gladiolus because of the existence of a strong positive direct effect.

Similarly, apart from the direct selection for spike length, the indirect selection through floret breadth may also be considered for further improvement in spike length because of the presence of a strong direct effect. However, floret length and floret breadth may also be considered as a criterion for selection.

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