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Assessment of the relative contribution of growth and flowering characteristics of *Gladiolus hybrida* using factor analysis

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Abstract
Data for this study was taken from the department of "Floriculture and Landscape Architecture" for the accomplishment of objectives of this investigation which were to assess the relative contribution of growth and flowering characteristics using multivariate techniques i.e. Factor Analysis. The statistical parameters evaluated for different characters revealed the means for plant height, number of days taken for sprouting, percent sprouting, number of leaves per plant, cropping duration, number of cormels per plant, weight of cormels per plant, size of cormels, number of corms per square meter, weight of corms per square meter and size of corms as 33.79 (cm), 23.24, 76.49, 4.62, 197.19, 5.19, 1.06 (g), 0.82 (cm), 54.22, 1275.35 (g) and 3.12 (cm) respectively. Two factors were extracted by applying factor analysis which explained 79.203% of total variation of the original variables. Thus factor analysis has brought out two factors associated with morphological characteristics of *Gladiolus hybrida*.

Keywords: *Gladiolus hybrida*, growth and flowering characteristics, multivariate techniques, Factor Analysis, Variability, Statistical parameters

Introduction
Gladiolus, a member of the family Iridaceae and subfamily Ixoroideae, is one of the most popular ornamental bulbous plants grown commercially for its fascinating flowers in many parts of the world and is popularly called as "Queen of bulbous flowers". Cormel yield is a function of complex interacting morphological characters and these characters plays an important role in influencing the cormel yield. It shows a cause and effect relationship. Complex trait (yield), however are a composite of individual traits that often vary together in response to imposed treatments. Identifying a single variable representative of the complex trait may not be possible, so the researcher is faced with the possibility of separately examining many related variables. Factor analysis is closely related to principal component analysis. Both of the principal component analysis and the factor analysis are one of the most commonly used multivariate techniques that take into account the interdependence and relative importance of the various characters involved and give more meaningful information.

Methodology
Data on various growth and flowering characteristics of Gladiolus cultivar "Solan Mangla" with four treatments of foliar spray of N and three treatments of planting density each replicated three times over two years and two seasons per year were taken from the Department of Floriculture and Landscape Architecture, Dr. Y.S. Parmar University of Horticulture & Forestry, Nauni, Himachal Pradesh.

Factor Analysis
Factor analysis is closely related to principal component analysis. Factor analysis can be considered as an extension of principal component analysis, both can be viewed as an attempt to approximate the variance-covariance matrix. However approximation based on factor analysis is more elaborate. The difference between two is that factor analysis assume a definite model, where each observed variable is expressed linearly in terms of common factor and a unique factor, whereas principal component analysis summarizes the data by means of linear combination of observed data. In factor analysis each observed variable (x_j, j =1,2,..,p) is expressed linearly in terms of few unobservable random variables $F_1, F_2, \ldots, F_m$ called common factors and p additional sources of variation $e_1, e_2, \ldots, e_p$ called error or sometimes

specific/unique factors. The common factors account for correlation among variables and each unique factor account for the remaining variance of the variable. In particular, common factor analytic model can be written as: -

$X_j = lj1F1 + l_{j2}F_2 + \ldots + l_{jm}F_m + e_j$

For a set of p variables above linear model can be written as

$X_1 = l11F1 + l_{12}F_2 + \ldots + {}_{l1mFm} + e_1$

$X_2 = l21F1 + l_{22}F_2 + \ldots + {}_{l2mFm} + e_2$

…………………………………

$X_p = lp1F1 + l_{p2}F_2 + \ldots + l_{pm}F_m + e_p$

Such a set of equations is called 'Factor Pattern'. The factor analysis yield not only the pattern but also correlation between original variables and the factor and table of correlations is called 'Factor Structure'. Factor model in matrix notation can be put as;

X = LF + e

X = (p × 1) vector of observed variables

L = (p × m) matrix of unknown constants called factor loadings.

$$\begin{bmatrix} l_{11}\ l_{12} \cdots\ l_{1m} \\ l_{21}\ l_{22} \cdots\ l_{2m} \\ \cdots\cdots\cdots\cdots\cdots \\ \cdots\cdots\cdots\cdots\cdots \\ l_{p1}\ l_{p2} \cdots\ l_{pm} \end{bmatrix}$$

F = (m × 1) vectors of unobservable variables called common factor; $F' = (F_1, F_2 \ldots F_m)$

e = (p × 1) vectors of unobservable variables called specific factor; $e' = (e_1, e_2, \ldots, e_p)$

The unobservable random factor F and e satisfy

i) $E(F) = 0_{m\times1}$ ii) $cov(F) = E(F F)' = I_{m\times m}$ iii) $E(e) = 0_{p\times1}$ iv) $cov(e) = E(E E') = \varphi_{p\times p}$

Where $\varphi_{p\times p}$ is a diagonal matrix and $I_{m\times n}$ is a identity matrix. Since F and e are independent so $Cov(e, F) = E(e, F) = 0_{p\times m}$ i.e there is no correlation between unique factors and common factor. Now the co-variance structure for the orthogonal factor model is an under;

$Cov(X) = LL' + \Phi$

$Var(X_j) = l_{j1}^2 + l_{j2}^2 + \ldots + l_{jm}^2 + \varphi_j = h_j^2 + \varphi_j$ where $h_j^2 = l_{j1}^2 + l_{j2}^2 + \ldots + l_{jm}^2$

$Cov(X_j, X_k) = l_{j1}l_{k1} + l_{j2}l_{k2} + \ldots + l_{jm}l_{km}$; $Cov(X, F) = L$; $Cov(X_j, F_i) = I_{ij}$

Here I_{ji} the factor loading of the j^th^ variable on the i^th^ variable of the factor, which is equivalent to correlation between factor and variables, h_j^2 is called the communalities and is called uniqueness component or specific factor. The most important aspect of factor analysis is extraction of factor. Most widely used techniques are principal component method and maximum likelihood method. The next step in factor analysis is to determine the number of factors (m) to be retained for the further analysis. If m is too large, some of the error factor will be mixed with the common factor, and if m is too small important common factors will be deleted. The numbers of factors are decided so as to explain a good amount of variation**.**

Results and Discussion

Different statistical parameters for all the growth and flowering characteristics of *Gladiolus hybrida* were estimated and results are presented in table 1. It was observed from the table that the means for plant height, number of days for sprouting, percent sprouting, number of leaves per plant, cropping duration, number of cormels per plant, weight of cormels per plant, size of cormels, number of corms/m^2, weight of corms/m^2, size of corms were 33.79 cm, 23.24, 76.49, 4.62, 197.19, 5.19, 1.06 g, 0.82 cm, 54.22, 1275.35 g and 3.12 cm respectively.

Table 1: Statistical parameters for growth and flowering characteristics of *Gladiolus hybrid*

Characters	Mean	SE of Mean	Fiducially limits		Coefficient of variation (CV)
			lower	upper	
Plant height(X_1) (cm)	33.79	0.37	33.07	34.51	7.53
No. of days for sprouting(X_2)	23.24	1.35	20.59	25.89	40.28
Percent sprouting(X_3)	76.49	0.89	74.75	78.24	8.06
No. of leaves per plant(X_4)	4.62	0.08	4.45	4.79	12.66
Cropping duration(X_5)	197.19	1.58	194.09	200.28	5.55
No. of cormels per plant(X_6)	5.19	0.21	4.77	5.60	28.49
Weight of cormels per plant(X_7) (g)	1.06	0.04	0.98	1.15	27.15
Size of cormels(X_8) (cm)	0.82	0.01	0.79	0.84	10.82
No. of corms per square meter(X_9)	54.22	1.94	50.42	58.02	24.77
Weight of corms per sq. meter(X_{10}) (g)	1275.35	30.90	1214.79	1335.91	16.78
Size of corms(X_{11})	3.12	0.07	2.98	3.27	16.13

It was also observed that number of days for sprouting showed maximum variation indicated by its coefficient of variation i.e. 40.28% followed by number of cormels per plant (28.49%) and weight of cormels per plant (27.15%) whereas cropping duration showed minimum variation indicated by its coefficient of variation (5.55%).

The main results of factor analysis pertaining to this population have been presented in Table 2**.** Kaiser-Meyer-Olkin measure of sampling adequacy was found to be 0.765 indicating the appropriateness of factor analysis. Bartlett's test of sphericity was also applied to test the hypothesis that the variables are uncorrelated in the population and it was found that variables were significantly correlated. Two out of eleven factors were retained which explained 79.203% of total variation of the original variables.

Table 2: Factor pattern of Factor Analysis for characters of *Gladiolus hybrid*

Characters	F1	F2	Communality
Plant height(X_1)	0.912	-0.343	0.949
Days to sprouting(X_2)	0.573	-0.629	0.724
No. of leaves(X_3)	0.886	-0.294	0.872
No. of cormels/plant(X_4)	0.872	0.391	0.912
Wt. of cormels/plant(X_5)	0.873	0.478	0.990
Size of cormels(X_6)	0.853	0.292	0.814
Wt. of corms/m^2(X_7)	0.820	0.168	0.700
Size of corms(X_8)	0.970	0.011	0.941
Crop duration(X_9)	0.870	-0.470	0.978
No. of corms/plant(X_{10})	0.738	0.359	0.674
Percent sprouting(X_{11})	-0.263	0.300	0.159
Eigen value	7.178	1.534	
Cumulative %	65.254	79.203	
Per cent variance	65.254	13.949	
Kaiser-Meyer-Olkin value	0.765		

Thus factor analysis has brought out two basic factors associated with morphological characteristics of *Gladiolus hybrid*a. Ignoring the non-significant correlations, two orthogonal factors extracted can be expressed as

$F_1 = 0.912\ X_1 + 0.886\ X_3 + 0.872\ X_4 + 0.873\ X_5 + 0.853\ X_6 + 0.820\ X_7 + 0.970\ X_8 + 0.870\ X_9 + 0.738\ X_{10}$

$F_2 = -\ 0.629\ X_2 + 0.300\ X_{11}$

Ramachander *et al.* (1979) [6], Fanizza (1982) [3], El-Geddwani (1992) [2] and Jalikop (1984) [4] also used factor analysis in fruit crops.

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