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Character association for vegetative and floral characters of gerbera (*Gerbera jamesonii* L.) under polyhouse conditions

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Abstract
The trial was carried out ten diverse genotypes of gerbera for different yield attributing traits under naturally ventilated polyhouse conditions. The experiment was laid out in randomized block design to determine association between different quantitative traits during 2015-2016. The magnitude of genotypic correlation was higher than their corresponding phenotypic correlation for most of the traits, indicating a strong inherent linkage between various traits under study. The results indicated that the plant height, leaf length, leaf breadth, number of leaves, leaf area, leaf area index, number of suckers per plant, chlorophyll content, flower diameter, flower stalk diameter, length of the flower stalk, disc diameter, duration of flowering, field life, fresh weight of flower and dry weight of flower showed positive significant correlation with number of flowers per plant at both genotypic and phenotypic level. Negative correlation was observed for days to first-flower opening and days for 50% flowering with number of flowers per plant. Number of suckers per plant and flower diameter were positively and significantly correlated with plant height, leaf area, leaf area index, chlorophyll content, flower stalk diameter, length of the flower stalk, disc diameter, duration of flowering, field life, fresh weight and dry weight of flower. The results revealed that flower diameter, number of flowers and suckers per plant were important yield characters. Hence, these characters may be considered as selection indices in gerbera breeding programme.

Keywords: Character association, gerbera, floral characters, polyhouse, vegetative characters

Introduction
Gerbera (*Gerbera jamesonii* L.), belongs to one of the largest families of flowering plants *i.e* 'Asteraceae' and occupied top position according to global trends in floriculture. It is an important commercial cut-flower and has a very good export potential because of its graceful appearance, hardiness and ability to withstand during transportation and long shelf life which fetches premium market prices. It is used in floral arrangements, flower beds, borders, pots and rock gardens. Besides floral arrangements, gerbera is widely used in bouquets and in dry flower crafts. Crop improvement programmes currently focus on developing of hybrid cultivars to boost productivity and profitability.

As the commercial cultivation of gerbera is gaining importance, introduction and identification of high yielding varieties of gerbera is necessary. Knowledge of the nature and the extent of association of yield with yield contributing characters are considered to be of great importance for planning an efficient breeding programme (Radhakrishna et al., 2004) [10]. The study of correlations may help the plant breeder to know how the improvement of one character will bring simultaneous improvement in other characters. Correlations between different characters help in finding out the degree of inter relationship among various characters and evolving selection criteria for improvement of the available germplasm. Studies on genetic association are useful to ascertain the important component characters on which selection can be made. Correlation between the important economic traits are of considerable help in this selection programme, because correlations ensures simultaneous improvement in one or two or more variables and negative correlations bring out the need to obtain a compromise between the desirable traits. Correlation between the characters may be due to either pleiotrophy or genetic linkage (Harland, 1939; Mode and Robinson, 1959) [5, 8].

Material and Methods
The experiment was carried out in Randomized Block Design with three replications in the Experimental block of Department of Horticulture, College of Horticulture, SKLTSHU, Hyderabad during the year of 2015-2016.

The experiment comprising ten different genotypes *viz.*, Balance, Stanza, Savannah, Dana Ellen, Goliath, Primerose, Helix, Liberty, Sabrina and Montenegro. The observations were recorded on five randomly selected plants per genotype of each replicate for twenty characters. Gerbera suckers were planted on raised bed comprised with recommended nutrient mixtures and adequate watering was supplied to the plants during entire investigation.

Other standard cultural practices were followed as per need for successful crop. Observations were recorded for plant height, number of leaves per plant, length of leaf, breadth of leaf, leaf area, LAI, number of suckers per plant per year, chlorophyll content, days to first-flower opening, flower diameter, flower stalk diameter, length of the flower stalk, number of ray florets, disc diameter, days taken for 50% flowering, duration of flowering, field life, number of flowers per plant, fresh weight and dry weight of flower and data were analyzed as suggested by Al Jibouri et al., (1958) [1].

Results and Discussion

The correlation coefficients (genotypic and phenotypic) between different characters in Gerbera are presented in Table 1. In most of the characters, genotypic correlation coefficient was found to be higher in magnitude than phenotypic correlation coefficient, indicating a strong inherent association among various characters but their phenotypic expression was impeded by the influence of environmental factors, although there is a strong inherent association between various characters (Table 1).

Table 1 reveals that number of flowers per plant showed highly positive significant correlation with dry weight of flower, duration of flowering, number of suckers per plant, fresh weight of flower, flower stalk diameter, field life, flower diameter, plant height, disc diameter, chlorophyll content, leaf length, leaf area, length of the flower stalk, number of leaves per plant, leaf breadth at both phenotypic and genotypic levels.

Increased yield of flowers per plant with increase in plant height, number of leaves per plant, leaf area, leaf area index and number of suckers per plant was also reported by Chauhan (2005) [4], Anand et al., (2014) [2] and Kumari et al., (2013) [6].

Some of the characters that have shown negative and significant association with yield in the characters *viz*., days to first flower opening and days taken for 50% flowering. Negative association of these characters with yield was reported by Tarannum and B. Hemla Naik, (2014) [12] in carnation, Magar et al., (2010) [7] and Sunil Kumar (2014) [11] in gerbera.

In case of morphological characters, plant height showed significant positive association with leaf length, leaf breadth, number of leaves, leaf area, leaf area index, number of suckers per plant, flower diameter, flower stalk diameter, length of flower stalk, disc diameter, duration of flowering, field life, fresh weight of flower and dry weight of flower but it has shown negative correlation with days to first flower opening and 50% flowering.

Positive but no significant correlation was recorded with chlorophyll content at phenotypic level and number of ray florets at both the levels.

Number of leaves per plant associated positively with leaf area, leaf area index, number of suckers, flower stalk diameter, length of flower stalk, disc diameter, duration of flowering, dry weight of flower and the association is significant this observation finds support from earlier worker Anuradha and Gowda (2000) [3] and Nair and Shiva (2003) [9]. Non significant positive association was recorded with number of suckers per plant and chlorophyll content, flower diameter, flower stalk diameter, field life and fresh weight of flower while negative non significant association was observed with number of ray florets, days to first flower opening and days to 50% flowering at both phenotypic and genotypic levels, while days to first flower opening did not show any significant negative association at phenotypic level.

Leaf area was significantly and positively correlated with leaf area index, number of suckers per plant, chlorophyll content, flower diameter, length of flower stalk, disc diameter, duration of flowering, field life, fresh weight of flower and dry weight of flower.

A non significant positive association was observed with stalk diameter and number of ray florets, while significant negative association was observed with days to first flower opening and days to 50% flowering at both the levels.

Number of suckers per plant recorded a positive significant association with chlorophyll content, flower diameter, flower stalk diameter, length of flower stalk, disc diameter, duration of flowering, field life, fresh weight of flower and dry weight of flower while number of ray florets recorded non significant association. The traits days to first flower opening and days taken for 50% flowering associated negatively with the character number of suckers per plant. Whereas significant negative correlation was observed between plant height number of suckers per plant, days to first flower opening and days taken for 50% flowering

The character chlorophyll content contributed indirectly and positively through plant height, leaf length, leaf breadth, number of leaves per plant, leaf area, leaf area index, number of suckers per plant, flower diameter, flower stalk diameter, length of the flower stalk, disc diameter, duration of flowering, field life, fresh weight of flower and dry weight of flower at both phenotypic and genotypic levels.

The character chlorophyll content has exerted negative indirect effect through days to first-flower opening, number of ray florets and days taken for 50% flowering at both the levels.

In case of floral characters, flower diameter exhibited a positive and highly significant correlation with flower stalk diameter, length of flower stalk, number of ray florets, disc diameter, duration of flowering, field life, fresh weight and dry weight at both phenotypic and genotypic levels.

Significant positive association of flower diameter was observed with number of suckers per plant, fresh weight and shelf life of flower. It shows that flower diameter can be increased with increase in any of these characters, specially the flower stalk diameter, flower stalk length and fresh weight of flower. Similarly, the market value and marketability of gerbera cut flower depend upon the flower stalk length which had positive correlation with shelf life, so a direct selection from germplasm lines may be effective for the improvement of this crop. Similar findings have also been reported by Chauhan (2005) [4], Kumari et al., (2013) [6] and Sunil Kumar (2014) [11] in gerbera.

Days to first-flower opening and days taken for 50% flowering have shown negative association with flower diameter, flower stalk diameter, length of flower stalk, disc diameter, duration of flowering, field life, fresh weight of flower and dry weight of flower while non significant was found with number of ray florets per flower. While days taken for 50% flowering has shown a positive association with days to first flower opening at both the levels.

Table 1: Correlation coefficients for different growth, yield and yield attributing characters in ten genotypes of gerbera

Variables		PH	LL	LB	NLP	LA	LAI	NSP	CH	DFO	FD	FSD	LFS	NRF	DD	DFF	DF	FL	FW	DW	NFP
PH	P	1.000	0.747**	0.594**	0.584**	0.645**	0.645**	0.443*	0.349	-0.559**	0.630**	0.359	0.482**	0.263	0.463*	-0.395*	0.654**	0.379*	0.510**	0.508**	0.634**
	G	1.000	0.944**	0.934**	0.698**	0.818**	0.821**	0.601**	0.429*	-0.764**	0.998**	0.737**	0.704**	0.355	0.844**	-0.666**	0.707**	0.737**	0.661**	0.570**	0.776**
LL	P		1.000	0.644**	0.659**	0.839**	0.840**	0.504**	0.407*	-0.580**	0.504**	0.326	0.590**	0.061	0.462*	-0.432*	0.585**	0.476*	0.581**	0.499**	0.601**
	G		1.000	1.096**	0.856**	0.991**	0.991**	0.320	0.377*	-0.734**	0.752**	0.452*	0.913**	0.050	0.678**	-0.594**	0.748**	0.585**	0.781**	0.714**	0.689**
LB	P			1.000	0.539**	0.647**	0.649**	0.005	0.161	-0.369*	0.407*	0.117	0.456*	0.015	0.363*	-0.226	0.341	0.222	0.375*	0.221	0.302
	G			1.000	0.849**	0.971**	0.973**	0.202	0.405*	-0.440*	0.520**	0.253	0.681**	0.020	0.440*	-0.284	0.421*	0.323	0.453*	0.382*	0.441*
NLP	P				1.000	0.678**	0.680**	0.268	0.357	-0.400*	0.248	0.044	0.463*	-0.141	0.538**	-0.343	0.405*	0.219	0.388*	0.381*	0.404*
	G				1.000	0.722**	0.725**	0.371*	0.537**	-0.428*	0.377*	0.056**	0.539**	-0.139	0.816**	-0.411*	0.397*	0.500**	0.437*	0.427*	0.477*
LA	P					1.000	0.999**	0.497**	0.511**	-0.667**	0.442*	0.314	0.821**	-0.181	0.389*	-0.566**	0.670**	0.540**	0.667**	0.595**	0.648**
	G					1.000	1.000**	0.553**	0.564**	-0.719**	0.552**	0.373*	0.901**	-0.187	0.554**	-0.649**	0.738**	0.737**	0.796**	0.745**	0.680**
LAI	P						1.000	0.496**	0.512**	-0.666**	0.443*	0.315	0.820**	-0.180	0.392*	-0.566**	0.669**	0.540**	0.666**	0.595**	0.647**
	G						1.000	0.552**	0.566**	-0.717**	0.553**	0.372*	0.900**	-0.186	0.557**	-0.648**	0.736**	0.736**	0.795**	0.749**	0.680**
NSP	P							1.000	0.606**	-0.710**	0.417**	0.506**	0.415*	0.057	0.451*	-0.729**	0.685**	0.705**	0.610**	0.608**	0.754**
	G							1.000	0.771**	-0.925**	0.730**	0.786**	0.693**	0.032	0.754**	-1.050**	1.000**	1.092**	0.905**	1.013**	0.990**
CH	P								1.000	-0.599**	0.212	0.202	0.406*	-0.116	0.365*	-0.623**	0.500**	0.640**	0.427*	0.465*	0.620**
	G								1.000	-0.863**	0.321	0.560*	0.522**	-0.142	0.577**	-0.979**	0.657**	0.851**	0.702**	0.700**	0.711**
DFO	P									1.000	-0.659**	-0.665**	-0.638**	-0.204	-0.495*	0.913**	-0.875**	-0.739**	-0.850**	-0.733**	-0.857**
	G									1.000	-0.764**	-0.817**	-0.718**	-0.198	-0.650**	0.986**	-0.977**	-0.995**	-0.908**	-0.952**	-0.976**
FD	P										1.000	0.694**	0.399*	0.502**	0.691**	-0.561**	0.645**	0.588**	0.620**	0.536**	0.655**
	G										1.000	0.982**	0.473**	0.611**	0.750**	-0.612**	0.891**	0.680**	0.780**	0.785**	0.865**

*and ** Significant at 5% and 1% level of significance, respectively.

Table 1: Contd….

VARIABLES		PH	LL	LB	NLP	LA	LAI	NSP	CH	DFO	FD	FSD	LFS	NRF	DD	DFF	DF	FL	FW	DW	NFP
FSD	P											1.000	0.181	0.575**	0.472**	-0.655**	0.652**	0.503**	0.660**	0.560**	0.713**
	G											1.000	0.312	0.722**	0.655**	-0.750**	0.936**	0.736**	0.864**	0.921**	0.933**
LFS	P												1.000	-0.355	0.327	-0.546**	0.614**	0.640**	0.611**	0.493**	0.551**
	G												1.000	-0.379*	0.387*	-0.624**	0.715**	0.808**	0.739**	0.755**	0.595**
NRF	P													1.000	0.178	-0.139	0.207	-0.068	0.142	0.120	0.309
	G													1.000	0.273	-0.136	0.247	-0.118	0.163	0.139	0.353
DD	P														1.000	-0.557**	0.520**	0.622**	0.544**	0.453*	0.618**
	G														1.000	-0.566**	0.767**	0.680**	0.740**	0.873**	0.761**
DFF	P															1.000	-0.809**	-0.765**	-0.772**	-0.712**	-0.838**
	G															1.000	-0.963**	-0.979**	-0.895**	-0.963**	-0.993**
DF	P																1.000	0.663**	0.872**	0.856**	0.897**
	G																1.000	1.040**	1.018**	1.025**	1.005**
FL	P																	1.000	0.657**	0.531**	0.747**
	G																	1.000	0.973**	1.111**	0.902**
FWF	P																		1.000	0.835**	0.832**
	G																		1.000	1.088**	0.962**
DWF	P																			1.000	0.741**
	G																			1.000	1.036**

PH = Plant height (cm)
LL = Leaf length (cm)
LB = Leaf breadth (cm)
NLP =Number of leaves per plant
LA= Leaf area (cm^2)
LAI= Leaf area index
NSP= Number of suckers per plant
CH = Chlorophyll content
DFO = Days to first-flower opening
FD = Flower diameter (cm)
FSD = Flower stalk diameter (mm)
LFS = Length of the flower stalk (cm)
NRF= Number of ray florets
DD= Disc diameter (cm)
DFF = Days to 50% flowering (Days)
DF = Duration of flowering (Days)
FL = Field life (Days)
FWP = Fresh weight of flower (g)
DWP= Dry weight of flower (g)
NFP =Number of flowers per plant

Conclusion

The yield in terms of flowers per plant can be increased with increase in quantitative traits like plant height, number of leaves, leaf area, number of suckers per plant and qualitative parameters like flower diameter, stalk diameter, stalk length, fresh and dry weight of flower because these characters were positively correlated with number of flowers per plant. Hence, selection of plants with number of flowers, suckers per plant and flower diameter duly balancing the stalk length would be the correct approach.

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