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Genetic Evaluation of Gerbera (*Gerbera jamesonii* Bolus ex. Hooker F.) under Naturally Ventilated Polyhouse in Prayagraj

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

An investigation was carried out in nine genotypes for eleven quantitative characters of gerbera to examine genetic variability, heritability, genetic advance, correlation, path coefficient during 2021-2022 in Randomized block design at Research field of Department of Horticulture, Sam Higginbottom University of Agriculture, Technology And Sciences, Prayagraj (U.P), India. The results revealed that the genotype Cut T/C Pink (5.67) was identified best for flower yield per square meter whereas Cut T/C Red and Sisal was having lowest flower yield per meter square. Analysis of variance showed significant difference among nine genotypes, indicating ample scope for selection of promising genotypes. Highest PCV and GCV were recorded for length of stalk (cm) (49.06 and 48.45 respectively) followed by plant height (cm) (47.56 and 46.95 respectively). Lowest PCV and GCV were recorded by vase life (18.67 and 16.26 respectively) followed by diameter of disc (24.185 and 23.487 respectively). High heritability (h^2) coupled with high genetic advance were observed for the characters like days to first flower bud initiation (95.31 & 52.73), length of stalk (97.52 & 33.04), plant height (97.45 & 28.79) and plant spread (95.31 & 52.73). Number of leaves and flowers per plant showed significant positive correlation. Plant height, plant spread, number of leaves, days to first flower bud initiation and flower per plant had direct positive effect on flower yield per meter square.

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Keywords: Gerbera; genetic variability; genetic advance; heritability; correlation; path coefficient.

1. INTRODUCTION

Gerbera (*Gerbera jamesonii* Bolus ex. Hooker F.) is commonly known as Transvaal daisy or Barberton daisy or African daisy. It is an important cut flower crop. It belongs to the Asteraceae family and originates from Southern Africa and Asia. Genus *Gerbera L.* consists of approximately 45 species. It is the most popular cut flower in the Netherlands, Germany and the United States of America and is among the top 10 cut flowers in the world. The major producing states in India are Karnataka, Maharashtra, Tamil Nadu, West Bengal, Himachal Pradesh, Jammu & Kashmir and Gujarat.

Gerbera plants are stemless and tender perennial herbs, leaves are radical, petioled, lanceolate and deeply lobed. Flower heads are solitary; many flowered with conspicuous ray florets in one or two rows. Based on flower head types or forms they are grouped into single, double and semi double cultivars. The flower stalks are long, thin hollow and leafless, this character made gerbera very popular in the market for the preparation of bouquets.

Nowadays, gerbera is gaining popularity because of its long lasting nature, graceful appearance, hardiness, ability to stand the vigor of transportation admirably and has good export potential. It also occupies a tremendous place under protected cultivation. During the past three decades, the improvement of gerbera has evolved into a multibillion-dollar industry. Though the crop could be cultivated in moderately warmer areas in open sunny conditions, performance of the crop has enhanced when grown under protected or semi protected conditions. To get longer stems, brighter flower color, high productivity per unit area, better consumer acceptance and to sustain competition, it is essential to adopt appropriate production technologies and an efficient crop management technique. The market demand for cut flowers is very specific and it could be met consistently, when the crop is grown under protected conditions.

Genetic variability in a group of germplasm is a prerequisite for a successful breeding programme. Since, most of the characteristics influencing yield are polygenic, it is essential for plant breeders to estimate the type of variation available in the germplasm. The type of breeding programme for developing suitable varieties depends largely on the availability of genetic variability in a given species. Heritability estimated, gave a measure of transmission of characters from one generation to the other, as consistency in the performance of the selection depends on the heritable portion of the variability [1]. Thus, the variation and the estimates of the heritability and genetic advance are the important parameters on which the success of selection lies.

Correlation studies are important for crop improvement which aids selection of genotypes with desired characters. Correlation between characters has genetic significance, as pleiotropic action of genes governing two characters and or tight linkage between the genes governing these two traits may be genetic cause of correlation. Improvement brought about by the selection through correlated characters hastens the selection process. The correlation value decides only the nature and degree of association existing between the pairs of characters. A character like yield is dependent on several mutually associated components characters. The knowledge of association alone however is often misleading as the correlation observed may not reflect true nature of association. Since two characters may show association just because they are correlated with a common third one.

Correlation coefficient values do not reveal the real association pattern of the independent variables with the dependent one. The path coefficient analysis is the standardized partial regression coefficient which splits the correlation coefficient into the measures of direct and indirect effect of independent variables on the dependent variable. This approach is more important to comprehend genetic makeup of independent trait when the determining component characters are correlated.

With this background in view, the present research was undertaken to assess and estimate the magnitude of variation among 9 genotypes of gerbera with respect to various vegetative, flower, quality and yield attributes.

2. MATERIALS AND METHODS

The present investigation was conducted at the research field of Department of Horticulture, Sam

Higginbottom University of Agriculture, Technology And Sciences, Prayagraj (U.P) during the year November, 2021- March, 2022. Nine genotypes of gerbera *viz.,* Sisal, Martyana, Salsa, Berta, Berenika, Cut T/C Yellow, Cut T/C Rose red, Cut T/C White and Cut T/C Pink were raised in a naturally ventilated polyhouse (NVP) at the spacing of 30 × 30 cm in Randomized Block Design (RBD) with 3 replications. The beds were irrigated thoroughly to maintain the optimum soil moisture condition. Uniform cultural practices were imposed on all the genotypes to ensure good growth of the crop.

The average was worked out and results were used to study genetic parameters on various vegetative growth, flowering and yield characters as per genotypes. The genotypic and phenotypic coefficients of variation were estimated according to the methods of Panse and Sukhatme [2]. Parameters of variability were calculated as per the formula given by Burton [3] In general variability has been classified as low (<10%), moderate (10-20%) and high (>20%).

Heritability, Genetic advance is the improvement in mean genotypic value of selected plants over the parental population. Genetic advance and expected genetic gain were calculated by the formula suggested by Johnson et al. [4]. The estimation of genetic advance as percent of mean helps to understand the type of gene action involved in the expression of a character. It is classified as low (>10%), moderate (10-20%) and high (<20%) as proposed by Johnson et al*,* [4]. The path coefficient analysis is the standardized partial regression coefficient which splits the correlation coefficient into the measures of direct and indirect effect of independent variables on the dependent variable. Path coefficient analysis was calculated by the technique given by Goulden [5]. The mean and standard errors were worked out as per standard methods and coefficients of variations were computed.

3. RESULTS AND DISCUSSION

The results indicated the existence of sufficient genetic variability among all the genotypes of gerbera. In Table 1 the mean performance of genotypes gives an overall view of performance of genotypes. The maximum numbers of flowers per plant were observed in Cut T/C pink (5.67) followed by Cut T/C yellow (5.33). The maximum stalk length was observed in Salsa (50.94 cm) followed by Martyana (47.32 cm). The maximum flower diameter was observed in Martyana (10.39 cm) followed by Sisal (10.14 cm) and Berenika (10.03 cm). The maximum flower disc was observed in Salsa (2.18cm) followed by Martyana (2.03cm). The maximum girth of stalks was observed in Martyana (2.64 cm) followed by Sisal (2.53cm). The maximum numbers of flowers per square meter were observed in Cut T/C pink (51) followed by Cut T/C yellow (48). The maximum vase life was observed for Cut T/C pink (8.42 days) followed by Martyana (8.17 days) and Sisal (7.42 days).

In the Table 2 Higher estimates of phenotypic and genotypic variance were observed for days to first flower bud initiation followed by length of stalk, plant height, plant Spread, flowers per meter square, number of leaves, diameter of flower, vase life, diameter of disc and girth of stalk.

Table 2 revealed that the higher value of phenotypic coefficient of variation over genotypic coefficient of variation indicated the influence of environment on these characters. Phenotypic and genotypic coefficient of variation was highest for length of stalk followed by plant height, days to first flower bud initiation, plant spread, number of leaves, flower per meter square, flower per plant, girth of stalk, diameter of flower, diameter of disc and vase life. Similar findings were reported by Chobe et al*.,* [6], Kumari et al., [7], Senapati et al*.,* [8] and Islam et al., [9]. The results revealed that higher value of phenotypic coefficient of variation over genotypic coefficient of variation indicated the influence of environment on these characters. High to moderate values of phenotypic and genotypic coefficient of variation suggested that there is a significant variability present among the characters under study which represent availability of divergent genetic source which will be useful for improving flower yield in gerbera. High to moderate phenotypic and genotypic coefficient of variation were recorded for all the characters indicates the availability of sufficient variability among these characters and thus offer scope for genetic improvement through effective selection. High phenotypic and genotypic coefficient of variation values for the characters also revealed that these traits had a broad genetic background as well as good potential to respond well to selection in breeding programmes.

Table 1. Mean performance of genotype for different characters of gerbera

Sl. No.	Genotype	Plant height (cm)	Plant spread (cm)	Numbers of leaves	Number of days taken for 1st flower bud initiation	Length of stalk (cm)	Diameter of flower (cm)	Diameter of disc (cm)	Girth of stalk (cm)	Flower per plant	Flower per meter square	Vase life (Days)
1	**Sisal**	35.93	35.69	11.67	80.25	41.95	10.14	1.38	2.53	3.00	27.00	7.42
2	**Martyana**	43.86	43.20	9.25	77.58	47.32	10.39	2.03	2.64	3.67	33.00	8.17
3	**Salsa**	42.94	39.64	12.58	83.75	50.94	9.19	2.18	1.89	3.17	28.50	6.50
4	**Berta**	43.46	49.20	16.17	78.42	40.36	8.63	1.65	2.37	3.83	33.42	5.67
5	**Berenika**	37.24	43.62	11.92	87.58	46.31	10.03	1.81	2.19	3.42	30.75	7.33
6	**Cut T/C Yellow**	14.08	22.81	24.50	27.83	13.58	6.39	1.34	1.42	5.33	48.00	6.17
7	**Cut T/C Rose Red**	6.99	12.38	13.00	24.75	9.53	4.45	0.95	1.05	3.17	28.50	4.83
8	**Cut T/C Red**	31.15	33.94	15.83	61.58	37.39	9.48	1.79	1.90	3.00	27.00	6.67
9	**Cut T/C Pink**	15.68	23.18	20.08	29.33	14.38	6.09	1.42	1.79	5.67	51.00	8.42
Mean		30.15	33.74	15.00	61.23	33.53	8.31	1.62	1.98	3.81	34.13	6.80
CV		7.59	6.14	5.72	9.49	7.72	8.50	5.77	5.23	8.97	8.85	9.19
SEm		1.32	1.20	0.50	3.36	1.49	0.41	0.05	0.06	0.20	1.74	0.36
CD at 5%		3.96	3.58	1.48	10.06	4.48	1.22	0.16	0.18	0.59	5.23	1.08
CD at 1%		5.46	4.94	2.05	13.86	6.17	1.69	0.22	0.25	0.81	7.20	1.49

Table 2. Genetic variability of parameters for quantitative characters of gerbera

Sl No.	Characters	Phenotypic variance	Genotypic variance	PCV	GCV	h^2(bs)	GA at 5%	GA as % of mean 5%
1	**Plant height (cm)**	205.652	200.417	47.568	46.959	97.454	28.79	95.497
2	**Plant Spread (cm)**	146.898	142.609	35.923	35.395	97.08	24.238	71.841
3	**Number of leaves**	23.199	22.463	32.11	31.597	96.829	9.607	64.049
4	**Days to first flower bud initiation**	721.252	687.477	43.86	42.821	95.317	52.733	86.121
5	**Length of stalk (cm)**	270.62	263.918	49.063	48.451	97.524	33.049	98.566
6	**Girth of stalk (cm)**	0.278	0.268	26.702	26.186	96.169	1.045	52.899
7	**Diameter of flower (cm)**	4.885	4.386	26.593	25.197	89.777	4.088	49.182
8	**Diameter of disc (cm)**	0.153	0.144	24.185	23.487	94.315	0.759	46.988
9	**Flowers per plant**	1.088	0.972	27.411	25.902	89.293	1.919	50.421
10	**Flowers per meter square**	87.992	78.864	27.485	26.02	89.627	17.319	50.745
11	**Vase life (Days)**	1.611	1.221	18.675	16.26	75.806	1.982	29.163

GCV- Genotypic coefficient of variation; GA- Genetic advance; PCV- Phenotypic coefficient of variation

Table 3. Genotypic correlation matrix for flower per meter square

Genotypic Correlation Matrix											
	Plant height (cm)	**Plant Spread (cm)**	**Number of leaves**	**Days to 1st flower bud initiation**	**Length of stalk (cm)**	**Girth of stalk (cm)**	**Diameter of flower (cm)**	**Diameter of disc (cm)**	**Flowers per plant**	**Vase life (Days)**	**Flowers per meter square**
Plant height (cm)	1.0000	0.971**	-0.584*	0.966**	0.977**	0.867**	0.937**	0.842**	-0.498*	0.3088	-0.505*
Plant Spread (cm)		1.0000	-0.449*	0.928**	0.909**	0.865**	0.895**	0.791**	-0.3477	0.2970	-0.3724
Number of leaves			1.0000	-0.676**	-0.677**	-0.514*	-0.578*	-0.384*	0.834**	-0.1550	0.825**
Days to first flower bud initiation				1.0000	0.997**	0.821**	0.949**	0.755**	-0.634**	0.2652	-0.634**
Length of stalk (cm)					1.0000	0.809**	0.967**	0.858**	-0.610**	0.3219	-0.624**
Girth of stalk (cm)						1.0000	0.904**	0.598**	-0.2741	0.610**	-0.2755
Diameter of flower (cm)							1.0000	0.778**	-0.516*	0.535*	-0.521*
Diameter of disc (cm)								1.0000	-0.2618	0.420*	-0.2753
Flowers per plant									1.0000	0.3228	0.824**
Vase life (Days)										1.0000	0.3499
Flowers per meter square											1.0000

, ** significant at 5% and 1% respectively

Table 4. Phenotypic correlation matrix for flower per meter square

Phenotypic Correlation Matrix											
	Plant height (cm)	**Plant Spread (cm)**	**Number of leaves**	**Days to 1st flower bud initiation**	**Length of stalk (cm)**	**Girth of stalk (cm)**	**Diameter of flower (cm)**	**Diameter of disc (cm)**	**Flowers per plant**	**Vase life (Days)**	**Flowers per meter square**
Plant height (cm)	1.0000	0.950**	-0.573*	0.944**	0.955**	0.849**	0.854**	0.804**	-0.440*	0.2821	-0.467*
Plant Spread (cm)		1.0000	-0.429*	0.901**	0.893**	0.842**	0.813**	0.744**	-0.3305	0.2711	-0.3390
Number of leaves			1.0000	-0.669**	-0.654**	-0.502*	-0.541*	-0.382*	0.750**	-0.1111	0.757**
Days to first flower bud initiation				1.0000	0.951**	0.813**	0.870**	0.725**	-0.559*	0.2455	-0.586*
Length of stalk (cm)					1.0000	0.783**	0.889**	0.810**	-0.577*	0.2782	-0.568*
Girth of stalk (cm)						1.0000	0.826**	0.561*	-0.2387	0.554*	-0.2687
Diameter of flower (cm)							1.0000	0.736**	-0.463*	0.3667	-0.460*
Diameter of disc (cm)								1.0000	-0.2607	0.3761	-0.2405
Flowers per plant									1.0000	0.2277	0.911**
Vase life (Days)										1.0000	0.2184
Flowers per meter square											1.0000

, ** significant at 5% and 1% respectively

Table 5. Genotypic path matrix of Flowers per meter square

PATH matrix of Flowers per meter square											
	Plant height (cm)	**Plant Spread (cm)**	**Number of leaves**	**Days to 1st flower bud initiation**	**Length of stalk (cm)**	**Girth of stalk (cm)**	**Diameter of flower (cm)**	**Diameter of disc (cm)**	**Flowers per plant**	**Vase life (Days)**	**Flowers per meter square**
Plant height (cm)	-0.4203	-0.4080	0.2453	-0.4059	-0.4105	-0.3642	-0.3936	-0.3539	0.2093	-0.1298	-0.505*
Plant Spread (cm)	-1.0146	-1.0451	0.4691	-0.9702	-0.9499	-0.9039	-0.9356	-0.8266	0.3634	-0.3104	-0.3724
Number of leaves	-0.1427	-0.1098	0.2445	-0.1654	-0.1656	-0.1256	-0.1414	-0.0940	0.2039	-0.0379	0.825**
Days to first flower bud initiation	0.7680	0.7382	-0.5379	0.7952	0.7928	0.6532	0.7548	0.6003	-0.5042	0.2109	-0.634**
Length of stalk (cm)	1.4366	1.3366	-0.9962	1.4660	1.4705	1.1893	1.4215	1.2617	-0.8965	0.4734	-0.624**
Girth of stalk (cm)	0.6820	0.6806	-0.4042	0.6464	0.6364	0.7869	0.7111	0.4705	-0.2157	0.4797	-0.2755
Diameter of flower (cm)	-1.1020	-1.0533	0.6803	-1.1168	-1.1374	-1.0632	-1.1766	-0.9149	0.6069	-0.6295	-0.521*
Diameter of disc (cm)	-0.0200	-0.0188	0.0091	-0.0179	-0.0204	-0.0142	-0.0185	-0.0238	0.0062	-0.0100	-0.2753
Flowers per plant	-0.6545	-0.4570	1.0959	-0.8332	-0.8012	-0.3602	-0.6778	-0.3441	1.3142	0.4242	0.824**
Vase life (Days)	-0.0373	-0.0359	0.0187	-0.0320	-0.0389	-0.0736	-0.0646	-0.0507	-0.0390	-0.1207	0.3499
Flowers per meter square	-0.505*	-0.3724	0.825**	-0.634**	-0.624**	-0.2755	-0.521*	-0.2753	0.824**	0.3499	1.0000
Partial R^2	0.2122	0.3891	0.2017	-0.5040	-0.9177	-0.2168	0.6127	0.0065	1.3779	-0.0422	

, ** significant at 5% and 1% respectively

Table 6. Phenotypic path matrix of flowers per meter square

PATH matrix of Flowers per meter square											
	Plant height (cm)	**Plant Spread (cm)**	**Number of leaves**	**Days to 1st flower bud initiation**	**Length of stalk (cm)**	**Girth of stalk (cm)**	**Diameter of flower (cm)**	**Diameter of disc (cm)**	**Flowers per plant**	**Vase life (Days)**	**Flowers per meter square**
Plant height (cm)	-0.9061	-0.8609	0.5191	-0.8552	-0.8654	-0.7689	-0.7741	-0.7281	0.3986	-0.2556	-0.467*
Plant Spread (cm)	0.2402	0.2528	-0.1085	0.2278	0.2257	0.2128	0.2055	0.1880	-0.0835	0.0685	-0.3390
Number of leaves	-0.0924	-0.0692	0.1613	-0.1080	-0.1055	-0.0810	-0.0872	-0.0617	0.1209	-0.0179	0.757**
Days to first flower bud initiation	-0.2743	-0.2619	0.1945	-0.2906	-0.2765	-0.2364	-0.2528	-0.2107	0.1624	-0.0713	-0.586*
Length of stalk (cm)	0.3644	0.3407	-0.2496	0.3629	0.3815	0.2985	0.3390	0.3090	-0.2202	0.1061	-0.568*
Girth of stalk (cm)	0.4296	0.4262	-0.2542	0.4117	0.3961	0.5062	0.4180	0.2838	-0.1208	0.2805	-0.2687
Diameter of flower (cm)	-0.1988	-0.1891	0.1258	-0.2024	-0.2068	-0.1921	-0.2327	-0.1713	0.1076	-0.0853	-0.460*
Diameter of disc (cm)	0.2865	0.2652	-0.1363	0.2585	0.2888	0.1999	0.2625	0.3565	-0.0929	0.1341	-0.2405
Flowers per plant	-0.2902	-0.2180	0.4945	-0.3686	-0.3807	-0.1575	-0.3052	-0.1720	0.6597	0.1502	0.911**
Vase life (Days)	-0.0256	-0.0246	0.0101	-0.0223	-0.0253	-0.0503	-0.0333	-0.0341	-0.0207	-0.0908	0.2184
Flowers per meter square	-0.467*	-0.3390	0.757**	-0.586*	-0.568*	-0.2687	-0.460*	-0.2405	0.911**	0.2184	1.0000
Partial R^2	0.4230	-0.0857	0.1221	0.1704	-0.2167	-0.1360	0.1071	-0.0858	0.6011	-0.0198	

Heritability estimates were high for all the characters. High heritability for all the characters is due to close correspondence between the genotype and phenotype. Estimates of genetic advance ranged from 52.733 (days to first flower bud initiation) to 0.759 (diameter of disc). High heritability (h^2) coupled with high genetic advance were observed for the characters like days to first flower bud initiation (95.317 & 52.733), length of stalk (97.524 & 33.049), plant height (97.454 & 28.79) and plant spread (95.317 & 52.733) which indicated additive gene action. Similar finding were reported by Kumari et al., [7], Senapati et al*.,* [8] and Islam et al., [9]. In the present investigation, high genetic advance as percent of mean coupled with high heritability was recorded for all the characters which show that these characters were under the control of additive gene action. Hence, significant improvement in gerbera is possible through pure line selection for these characters.

Tables 3 & 4 shows that among all the characters, number of leaves (0.825**) and flowers per plant (0.824**) showed significant positive correlation where as vase life (0.3499 days) showed non significant positive correlation with number of flower per plant at genotypic level and at phenotypic level number of leaves (0.757**) and flowers per plant (0.911**) showed significant positive correlation with number of flower per meter square. Similar findings were reported by Nair et al*.,* [10] in gerbera and Kumar et al*.,* [11] in chrysanthemum. Correlation analysis at genotypic and phenotypic level revealed that characters such as number of leaves, flowers per plant and vase life are most important characters as these exhibited significant positive and strong association with number of flower per meter square. This indicates effective selection of these traits leads to improvement in flower yield in gerbera.

In Table 5, at genotypic level, length of stalk (1.4705), flower per plant (1.3142), days to first flower bud initiation (0.7952), girth of stalk (0.7869) and number of leaves (0.2445) had direct positive effect on flower yield per meter square and in Table 6, at phenotypic level, flower per plant (0.6597), girth of stalk (0.5062), length of stalk (0.3815), diameter of disc (0.3565), plant spread (0.2528) and number of leaves (0.1613) had direct effect on number of flower per meter square.

4. CONCLUSION

In the present investigation, it is concluded that genotype Cut T/C Pink was identified best for flower yield per plant and flower yield per square meter. Highly significant differences were observed for all characters which illustrated significant variation. High heritability coupled with high genetic advance as percent of mean revealed for days to first flower initiation, length of stalk, plant height and plant spread. Correlation analysis revealed that characters such as number of leaves and flower per plant are the most important characters as these exhibited positive and strong association with flower yield. Path coefficient analysis revealed that characters like flower per plant, plant height, days to flower bud initiation, number of leaves and vase life exhibited direct positive effect at both phenotypic and genotypic level.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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