Environment and Ecology 42 (1) : 94—102, January—March 2024
Article DOI: https://doi.org/10.60151/envec/LNHT3933
ISSN 0970-0420

Genotype X Traits Analysis of Gerbera (*Gerbera jamensoii*) Varieties for Vegetative Traits by Biplots

Shivani Goel, Sonia Singh, Ajay Verma, Arvind Malik, Devender Singh Dahiya, Sarita Devi, Shahroon Khan

Received 20 July 2023, Accepted 28 November 2023, Published on 31 January 2024

ABSTRACT

Recent ten genotypes of gerbera were evaluated for vegetative traits during the year 2022-23 to determine genetic variability, heritability and genetic advance for 15 quantitative traits. Analysis of variance showed significant differences among genotypes for all the characters studied. Results revealed that magnitude of the Phenotypic Coefficient of Variation (PCV) was higher than Genotypic Coefficient of Variation (GCV) for all the traits, indicating greater genotype and environment interaction. High PCV and GCV were observed for number of leaves/plant and leaf width. In the present study bud initiation, plant spread after 100 days of panting, plant height after 45 days of planning showed the high heritability along with maximum genetic gain. Number of leaves (45 days) had maintained only positive correlation with the considered vegetative traits. Leaf length (45 days) exhibited showed direct relationship with plant height (45 days) and leaf length(100 days) while negative relation of plant spread (45 days) with leaf length (100 days) and days to bud initiation. Path coefficient analysis showed, plant spread (0.976) had highest positive effect on fresh weight of flowers followed by leaf length (0.824), number of leaves per plant (0.20) while negative effect of plant height (45 and 100 days), days to bud initiation, leaf length (100 days). Performance of Intense, Stanza, Brillance would be unstable type as compared to Golian and Dana Ellen as placed near to the origin of biplot analysis in the present study based on vegetative traits in biplot analysis. Next cluster in same quadrant was comprised of leaf length, leaf width, plant height at 45 days of planting. First cluster of other quadrant comprised of leaf length, leaf width, plant spread at 100 days of planting and last cluster of days to bud initiation with fresh weight of flowers formed across the quadrants.

Keywords Gerbera, Variability, Heritability, Genetic advance, PC1 vs PC2 biplot, Cluster analysis.

INTRODUCTION

Gerbera (*Gerbera jamesonii*), a member of family Asteraceae, originated from South Africa, and commonly known as Transvaal daisy or Barberton daisy, has been established as one of the important cut flower, grown for domestic as well as for export market (Abbas and Melika 2023). Now-a-days floral industry has become a very dynamic and fast growing industry

Shivani Goel[1], Sonia Singh[2]*, Ajay Verma[3], Arvind Malik[4], Devender Singh Dahiya[5], Sarita Devi[6], Shahroon Khan[7]

[3]Principal Scientist, [2, 7]Assistant Professor
[4, 5, 6] Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana, India

[1, 2, 7]Maharana Pratap Horticultural University, Karnal 132001, Haryana, India

[3]ICAR-Indian Institute of Wheat and Barley Research, Karnal 132001, India

Email : sangwan954@gmail.com
*Corresponding author

in world scenario (Zhou *et al.* 2022). This industry has an immense potential for employment generation and to generate foreign exchange (Terangpi *et al.* 2022). With expanding modernization, India can possibly rise as notable player of the flora industry in future (Sairam *et al.* 2022). Gerbera is commonly used as cut flower, garden flower and it makes a good showing in exhibitions and floral arrangements because of its numerous colors and shapes (Paikray *et al.* 2022). The flower stalks are long, thin, and leafless, and the plant grows in clumps with solitary flower heads on a long to slender stem that grows well above the foliage. Flower head is solitary, many flowered, with conspicuous ray florets in one or two rows (Rashid 2020). Based on flower head types or forms they are grouped into single, double and semi double cultivars (Rabina *et al.* 2021). The flower stalks are long, thin hollow and leafless. This characteristic has popularized gerbera and is in great demand in market for preparation of bouquets (Maitra *et al.* 2020).

Genetic variability in a group of germplasm is a pre-requisite for a successful breeding program. Since, most of the characters influencing yield are polygenic, it is essential for plant breeders to estimate the type of variation available in the germplasm (Rangnamei *et al.* 2019). The type of breeding program for developing suitable varieties depends largely on the availability of genetic variability in a given species. Gerbera is a vegetatively propagated crop through suckers on commercial scale and selection is an easy method for varietal improvement in it (Tomar *et al.* 2021). Selection is effective only when the observed variability in the population is heritable in nature.

MATERIALS AND METHODS

The experiments were carried out at Agri-Tourism Center, CCS Haryana Agricultural University, Hisar, which is located at 215.2 m above the Mean Sea Level with coordinates of 29°10′ North latitude and 75°46′ East longitudes during the year 2022-2023. The station has a semi-arid climate with hot and dry summer and extremely cold winter. The texture of the soil at the experiment site was sandy loam. The soil has good water holding capacity and medium fertility with a slightly alkaline pH of 8.3. The net plot size of the experimental plots were of 1.5 m × 1.5 m and plant to plant spacing was maintained as 30 cm × 30 cm. The study materials were planted on 2nd fortnight of October month. For experimental purpose, healthy tissue cultured plants (three – four leaf stage) of gerbera varieties namely Atlanta, Brillance, Stanza, Rosalin, Ankur, White house, Dana Ellen, Intense, Golianth and Silvester from KF Biotech Private limited, Pune. The important morphological traits i.e. Plant height (cm) , Number of leaves per plant , Plant spread (cm), Leaf length (cm), Leaf width (cm) were recorded . The phenotypic and genotypic coefficients of variation were calculated along with heritability in the broad sense along with the genetic advance was expressed in per cent of mean were calculated. The multivariate hierarchical clustering by Ward's method and the recent analytic biplot analysis was conducted by well-known and established SAS software.

RESULTS AND DISCUSSION

Analysis of variance

Extent of variability was measured in terms of mean, range, genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) along with per cent heritability (h^2) and genetic advance over per cent mean and is presented in Table 1. Highly significant variations had been observed by analysis of variance for the studied traits. The plant height varied significantly among different varieties. Data revealed that the significantly earlier flower bud initiation was observed in Ankur (52.93 days) followed by Golianth (56.27 days), Silvester (62.60 days), Brillance (67.56 days), Atlanta (74.28 days), White house (75.67 days), Dana Ellen (82.40 days) and Rosalin (84.67 days), whereas Stanza (91.54 days) took the maximum number of days which is at par with var Intense (90.32 days). The variety Atlanta and White house, Rosalin and Dana Ellen were statistically identical in their effect on days to bud initiation in gerbera. Silvester recorded maximum plant height (23.81 cm) which was statistically at par with Stanza whereas minimum plant height was recorded in Intense (15.02 cm) at 45 days after planting. Plant height significantly varied at 100 days after planting, the maximum plant height was found in Silvester (38.69 cm) which was statistically, at par with Stanza (36.59 cm), while minimum

Table 1. Analysis of variance for traits, heritability, genetic advance and pair wise comparisons among genotypes.

	45 days after sowing					100 days after sowing					
	Bud initiation	Plant height	No. of leaves per plant	Leaf length	Leaf width	Plant spread	Plant height	No. of leaves per plant	Leaf length	Leaf width	Plant spread	Fresh flower weight
Atlanta	71.80^{cd}	28.86^{b}	11.53^{ab}	20.75^{b}	8.64^{abc}	38.33^{a}	41.54^{a}	14.00^{cd}	25.68^{abc}	10.61^{ab}	56.50^{ab}	21.37^{de}
Brillance	54.27^{ef}	28.59^{bc}	9.40^{cd}	20.15^{bc}	8.93^{abc}	36.06^{a}	33.86^{cd}	10.60^{fg}	24.03^{c}	10.41^{ab}	46.39^{d}	21.07^{e}
Stanza	93.00^{a}	28.44^{bc}	10.20^{bc}	19.84^{bcd}	9.23	30.75^{a}	42.86^{a}	15.00^{c}	28.81^{ab}	12.67^{a}	58.13^{a}	24.67^{b}
Rosalin	89.07^{ab}	26.59^{bcd}	10.20^{bc}	22.69^{a}	9.15^{ab}	38.13^{a}	34.97^{cd}	12.40^{def}	29.27^{a}	11.27^{ab}	57.67^{a}	26.00^{a}
Ankur	43.33^{f}	26.21^{bcd}	10.20^{bc}	18.90^{de}	8.43^{bc}	38.22^{a}	35.51^{c}	13.47^{cde}	24.50	9.77^{ab}	54.18^{abc}	26.03^{a}
White house	77.33^{bc}	25.00^{cd}	10.07^{bc}	18.73^{ef}	8.23^{bc}	39.04^{a}	33.87^{cd}	19.40^{a}	25.61^{abc}	8.98^{b}	51.52^{abcd}	22.27^{cd}
Dana Ellen	89.93^{ab}	27.90^{bc}	10.07^{bc}	20.43	8.45^{bc}	35.97^{ab}	35.60^{c}	9.40^{g}	27.91^{abc}	10.45^{ab}	50.28^{bcd}	22.40^{c}
Intense	94.73^{a}	23.85^{d}	10.13^{bc}	17.87^{f}	7.90^{c}	26.21^{c}	33.37^{cd}	11.40^{f}	27.42^{abc}	10.19^{ab}	49.15^{cd}	25.20^{ab}
Golianth	59.40^{ef}	28.10^{bc}	8.13^{d}	19.43^{cde}	8.97^{abc}	35.30^{ab}	38.23^{b}	11.80^{ef}	27.82^{abc}	11.33^{ab}	48.26^{cd}	21.73^{cde}
Silvester	57.80^{e}	34.15^{a}	12.13^{a}	22.16^{a}	9.71^{a}	34.39^{ab}	42.48^{a}	17.60^{b}	28.41^{abc}	10.00^{ab}	50.27^{bcd}	22.50^{c}
CD at 5%	13.15	3.37	1.60	0.94	0.01	5.36	1.67	1.75	4.06	3.04	6.13	0.90
Heritability	0.846	0.762	0.617	0.916	0.300	0.831	0.935	0.934	0.257		0.487	0.935
Genetic advance	34.060	4.770	1.590	2.920	0.450	7.290	7.400	6.150	1.380		5.110	3.820
GCV	24.600	9.560	9.620	7.360	4.590	11.020	9.980	22.860	4.900		6.810	8.230
PCV	26.750	10.950	12.250	7.690	8.390	12.080	10.320	23.660	9.670		9.760	8.510

was recorded in Intense (25.15 cm). The data indicated that number of leaves varied significantly among different varieties. Silvester recorded highest number of leaves (13.40) which was statistically at par with Intense (12.18) and minimum number of leaves was recorded in Dana Ellen (8.67) at 45 days after planting (Fig. 1). At 100 days after planting, the highest number of leaves was found in Silvester (19.40) which was statistically at par with Intense (18.5) while lowest was recorded in Dana Ellen (12.93). The plant spread varied significantly among different varieties. Among different varieties, maximum plant spread (39.05 cm) was recorded in Silvester followed by Ankur (38.22 cm), Golianth (38.17 cm), Intense (38.15 cm) , Atlanta

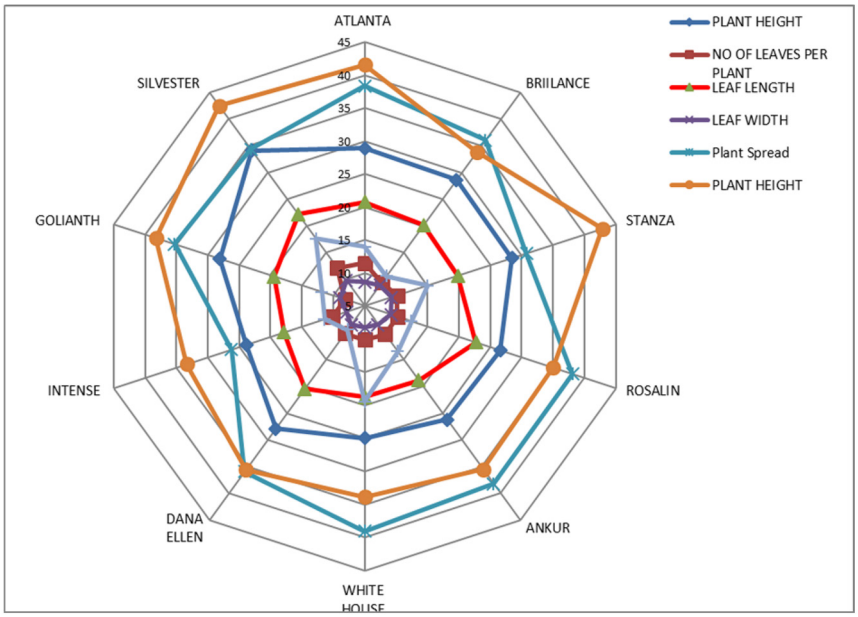

Fig. 1. Variability in vegetative traits for gebera genotypes.

Table 2. Correlation analysis of vegetative traits at genotypic and phenotypic levels.

	45 days after sowing					100 days after sowing				
	Bud initiation	Plant height	No. of leaves per plant	Leaf length	Plant spread	Plant height	No. of leaves per plant	Leaf length	Plant spread	Fresh flower weight
Bud initiation	**1**	**-0.421**	**0.042**	**0.005**	**-0.461**	**-0.061**	**-0.114**	**0.935**	**0.362**	**0.28**
	1.000	-0.293	0.046	-0.016	-0.453	-0.043	-0.127	0.373	0.313	0.264
Plant height	**-0.421**	**1**	**0.593**	**0.7**	**0.103**	**0.777**	**0.227**	**0.338**	**-0.102**	**-0.472**
	-0.293	1.000	0.332	0.595	0.160	0.660	0.215	0.125	0.002	-0.352
No. of leaves per plant	**0.042**	**0.593**	**1**	**0.495**	**0.067**	**0.516**	**0.531**	**0.029**	**0.53**	**0.085**
	0.046	0.332	1.000	0.371	0.009	0.428	0.390	0.149	0.222	0.010
Leaf length	**0.005**	**0.7**	**0.495**	**1**	**0.375**	**0.41**	**0.043**	**0.636**	**0.362**	**-0.069**
	-0.016	0.595	0.371	1.000	0.383	0.374	0.039	0.297	0.297	-0.058
Plant spread	**-0.461**	**0.103**	**0.067**	**0.375**	**1**	**-0.075**	**0.204**	**-0.62**	**0.17**	**-0.289**
	-0.016	0.595	0.371	1.000	0.383	0.374	0.039	0.297	0.297	-0.058
Plant height	**-0.061**	**0.777**	**0.516**	**0.41**	**-0.075**	**1**	**0.367**	**0.484**	**0.496**	**-0.182**
	-0.043	0.660	0.428	0.374	-0.068	1.000	0.338	0.306	0.333	-0.187
No. of leaves per plant	**-0.114**	**0.227**	**0.531**	**0.043**	**0.204**	**0.367**	**1**	**-0.003**	**0.301**	**-0.054**
	-0.127	0.215	0.390	0.039	0.227	0.338	1.000	-0.003	0.225	-0.032
Leaf length	**0.935**	**0.338**	**0.029**	**0.636**	**-0.62**	**0.484**	**-0.003**	**1**	**0.407**	**0.506**
	0.373	0.125	0.149	0.297	-0.180	0.306	-0.003	1.000	0.258	0.148
Plant spread	**0.362**	**-0.102**	**0.53**	**0.362**	**0.17**	**0.496**	**0.301**	**0.407**	**1**	**0.59**
	0.313	0.002	0.222	0.297	0.223	0.333	0.225	0.258	1.000	0.433
Fresh flower weight	**0.28**	**-0.472**	**0.085**	**-0.069**	**-0.289**	**-0.182**	**-0.054**	**0.506**	**0.59**	**1**
	0.264	-0.352	0.010	-0.058	-0.247	-0.187	-0.032	0.148	0.433	1.000

(38.00 cm) and Rosalin (37.06 cm) and minimum was recorded in White house (26.21cm) at 45 days after planting. At 100 days after planting, the maximum plant spread was found in Silvester (58.13 cm) while

Table 3. Direct and indirect effects of vegetative traits towards fresh flower weight (Genotypic and phenotypic levels)).

	45 days after sowing					100 days after sowing				
	Bud initiation	Plant height	No. of leaves per plant	Leaf length	Leaf width	Plant spread	Plant height	No. of leaves per plant	Leaf length	Plant spread
Bud initiation	**-0.486**	0.325	-0.006	0.004	-0.102	0.611	0.041	-0.023	-0.437	0.353
	-0.373	0.056	0	-0.004	-0.021	0.326	0.025	-0.015	0.022	0.247
Plant height	0.204	**-0.772**	-0.084	0.576	0.474	-0.137	-0.522	0.046	-0.158	-0.099
	0.109	-0.192	0.003	0.139	0.051	-0.115	-0.383	0.026	0.007	0.001
No. of leaves per plant	-0.021	-0.458	**-0.142**	0.408	0.122	-0.089	-0.346	0.106	-0.014	0.517
	-0.017	-0.064	0.01	0.087	0.018	-0.007	-0.248	0.046	0.009	0.175
Leaf length	-0.002	-0.54	-0.07	**0.824**	0.428	-0.497	-0.275	0.009	-0.297	0.354
	0.006	-0.114	0.004	0.234	0.048	-0.276	-0.217	0.005	0.018	0.234
Leaf width	0.119	-0.877	-0.042	0.846	**0.417**	-0.152	-0.588	0.062	-0.309	0.412
	0.091	-0.115	0.002	0.132	0.085	-0.114	-0.285	0.016	0.018	0.002
Plant spread	0.224	-0.08	-0.01	0.309	0.048	-1.327	0.05	0.041	0.29	0.166
	0.169	-0.031	0	0.09	0.013	-0.72	0.039	0.027	-0.011	0.176
Plant height	0.03	-0.6	-0.073	0.338	0.365	0.099	**-0.672**	0.073	-0.227	0.484
	0.016	-0.126	0.004	0.087	0.042	0.049	-0.58	0.04	0.018	0.262
No. of leaves per plant	0.055	-0.176	-0.075	0.035	0.129	-0.27	-0.246	**0.2**	0.002	0.293
	0.047	-0.041	0.004	0.009	0.011	-0.163	-0.196	0.119	0	0.178
Leaf length	-0.455	-0.261	-0.004	0.524	0.275	0.822	-0.325	-0.001	**-0.468**	0.397
	-0.139	-0.024	0.002	0.069	0.025	0.13	-0.177	0	0.06	0.204
Plant spread	-0.176	0.079	-0.075	0.298	0.176	-0.225	-0.333	0.06	-0.19	**0.976**
	-0.117	0	0.002	0.069	0	-0.161	-0.193	0.027	0.015	0.789

Table 4. Loadings of traits and genotypes towards the first and second as per principal components in biplot analysis.

Traits	Principal component 1	Principal component 2	Genotypes	Principal component 1	Principal component 2
Bud initiation	0.0071	0.4844	Atlanta	0.2028	-0.1935
Plant height (45 days)	0.4087	-0.2608	Brillance	-0.2060	-0.3766
Number of leaves per plant (45 days)	0.2764	-0.1074	Stanza	0.3637	0.4977
Leaf length (45 days)	0.3995	-0.0606	Rosalin	0.2256	0.3551
Leaf width (45 days)	0.4423	-0.0897	Ankur	-0.2485	-0.1911
Plant spread (45 days)	0.0477	-0.3655	White house	-0.3133	-0.2559
Plant height (100 days)	0.4247	-0.0110	Dana Ellen	-0.0919	0.1051
Number of leaves per plant (100 days)	0.1616	-0.1870	Intense	-0.4619	0.4527
Leaf length (100 days)	0.2774	0.3946	Golianth	-0.0603	-0.0365
Leaf width (100 days)	0.2421	0.3748	Silvester	0.5898	-0.3571
Plant spread (100 days)	0.2367	0.2548	% share of factors (56.57%)	33.20%	23.37%
Fresh flower weight	-0.0304	0.3798			

minimum was recorded in Brillance (46.72 cm). The leaf length varied significantly among different varieties as maximum leaf length was recorded in Silvester (22.16 cm) at 45 days after planting which was statistically at par with Intense (21.92 cm) and Ankur (21.23 cm) while minimum leaf length was recorded in White House (18.73 cm). At 100 days after planting, the maximum leaf length was observed in Silvester (33.94 cm) while minimum was recorded in Brillance (24.03 cm). The leaf width varied significantly among different varieties as maximum leaf width was recorded in Stanza (10.09 cm) followed by Silvester (9.71cm), Ankur (9.15 cm) and Dana Ellen (9.11 cm) and minimum was recorded in White house (7.90 cm) at 45 days after planting. At 100 days after planting, the maximum leaf width was found in Stanza (16.08 cm) which was statistically at par with Dana Ellen (13.57) while minimum was recorded in White house (8.98 cm). An appraisal of the values indicated that all the fresh weight differed significantly with different varieties of gerbera. The variety Rosalin showed maximum fresh weight (34.33 g) followed by Stanza (32.67 g), Golianth (32.07 g), Ankur (31.03 g), while minimum was recorded in White house (24.17 g).

Heritability and genetic advance

The estimates of phenotypic coefficient of variance (PCV) were found higher than genotypic coefficient of variance (GCV) for all the studied traits implied that the apparent variation was not only due to genotypes but was also due to the influence of environmental in the expression of genotypes. In the study, phenotypic and genotypic coefficients of variation were higher for bud initiation, number of leaves per plant and plant spread and plant height indicated high variation in these characters, predicting greater scope for improvement of these characters. The estimates of heritability in broad sense give a measure of transmission of characters from one generation to another, thus giving an idea of heritable portion of variability and enabling the plant breeder in isolating the elite selection in the crop. Heritability and genetic advance increase the efficiency of the selection in a breeding program by assessing the influence of environmental factors and additive gene action. The estimates of heritability in broad sense specifying the heritable portion of total variation, helps in identification of the appropriate characters for selection. High estimates of heritability in broad sense were obtained for all the characters except leaf length after 100 and 45 days of planting, plant spread reflected the importance of these traits in selection program (Table 1). The magnitude of heritable variability is the most important aspect of genetic constitution of the genotype which has close bearing on the response to selection (Vijayalaxmi *et al.* 2021). GCV and heritability (broad sense) are not sufficient to determine the amount of variation which is heritable. Heritable variation can be determined with greater accuracy when heritability along with genetic advance is studied. Heritability

along with genetic gain is more useful criterion in predicting the resultant effects of selecting the best individual (Singh *et al.* 2016). High heritability with high genetic advance tells that the character is governed by additive gene action, for that simple selection is advocated. In the present study bud initiation, plant spread after 100 days of panting, plant height after 45 days of planning showed the high heritability along with maximum genetic gain. Thus, selection on the basis of number of flowers per plant, number of suckers per plant and flower dry weight would be more effective for further breeding programs.

Genotypic and phenotypic correlations

Improvement in any crop depends on the magnitude of genetic variability and the degree of transmission of characters from one generation to next generation. Besides this, the knowledge of association between yield and its contributing traits will be of great value in planning a breeding program. In plant breeding, correlation coefficient analysis measures the mutual relationship between various characters and determines the component characters on which selection can be based for genetic improvement in yield. The knowledge of association between different characters with yield helps the breeder to sort out the characters associated with yield. Genotypic correlation coefficients provide a measure of genotypic association between characters and give an indication of characters which may be useful for over all improvement in the crop Sangma *et al.* (2017). In the present investigation the genotypic correlations were higher than the phenotypic ones, which revealed that the phenotypic expressions of the correlation are reduced under the influence of environment, although there is a strong inherent association between various characters (Table 2). Very high direct correlation had been maintained by days to bud initiation with leaf length (100 days) and weak indirect with plant spread and plant height (45 days). Direct association of plant height (45 days) had observed with plant height (100 days), leaf length and number of leaves at 45 days after planting whereas indirect with fresh lower weight and days to bud initiation. Number of leaves (45 days) had maintained only positive correlation with the considered vegetative traits. Leaf length (45 days) exhibited showed direct relationship with plant height (45 days) and leaf length (100 days) while negative relation of plant spread (45 days) with leaf length (100 days) and days to bud initiation. Direct relation of plant height (100 days) observed with plant height (45 days), number of leaves (45 days) and plant spread (100 days). Direct relation of plant spread (100 days) found with fresh flower weight, number of leaves (45 days), plant height (100 days).

Path analysis

Path coefficient analysis is employed to measure the direct and indirect effect of variables on yield. Yield is dependent variable not only by the interrelationship of associated characters but also changes in any trait could affect the whole cause and effect relationship. Yield is a complex character and selection for yield and yield components deserves considerable attention. A crop breeding program, aimed at increasing the plant productivity requires consideration not only of yield but also of its components that have direct or indirect bearing on yield. Yield is a complex character and selection for yield and yield components deserves considerable attention. A crop breeding program, aimed at increasing the plant productivity requires consideration not only of yield but also of its components that have direct or indirect bearing on yield (Senapati *et al*. 2013). Yield is a complex character and selection for yield and yield components deserves considerable attention.

Path coefficient analysis showed, plant spread (0.976) had highest positive effect on fresh weight of flowers followed by leaf length (0.824), number of leaves per plant (0.20) while negative effect of plant height (45 and 100 days), days to bud initiation, leaf length (100 days) (Table 3). Leaf width length had also expressed positive direct effect but low in magnitude. Days to bud initiation had maximum positive indirect effect through plant spread (45 and 100 days), negative indirect effect by leaf length (100 days). Positive indirect effect of plant height (45 days) by leaf length (45 days) negative by plant height (100 days) whereas of number of leaves (45 days) by plant spread (100 days) and negative of leaf length (45 days) by plant height and plant spread (100 days). Positive indirect effect of leaf length (100 days) by plant spread (100 days) and leaf length (45 days) by

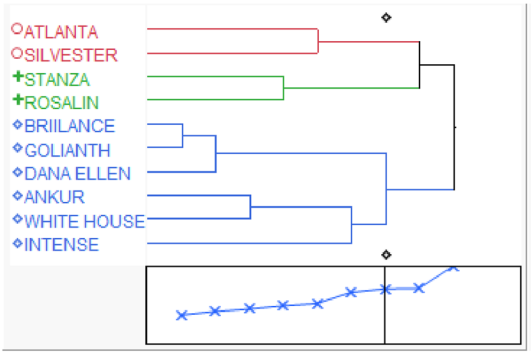

Fig. 2. Multivariate hierarchical clustering of varieties based vegetative traits.

on fresh flowers weight.

Multivariate hierarchical clustering pattern

Cluster analysis appears to be faithful approach which is based on multivariate analysis and serves to be a good index of genetic diversity (Singh *et al.* 2017). The main aim of clustering of genotypes was selection as well as rejection of genotypes for further breeding program. By the application of multivariate hierarchical clustering as per Ward's method while considering vegetative traits, 10 genotypes were grouped into three distinct clusters (Fig. 2). Atlanta and Silvester formed the first cluster followed by cluster of Stanza with Rosalin. Other varieties form the last bigger group. Plant height after 45 sowing of planting had been observed as a point of partition of traits in two broad categories at the first node of classification in two ways clustering of traits and genotypes also (Fig. 3). Days to bud initiation along with fresh flower weight were observed in first group while values of traits observed after 100 days of planting formed a group with plant height at 45 days after planting of varieties.

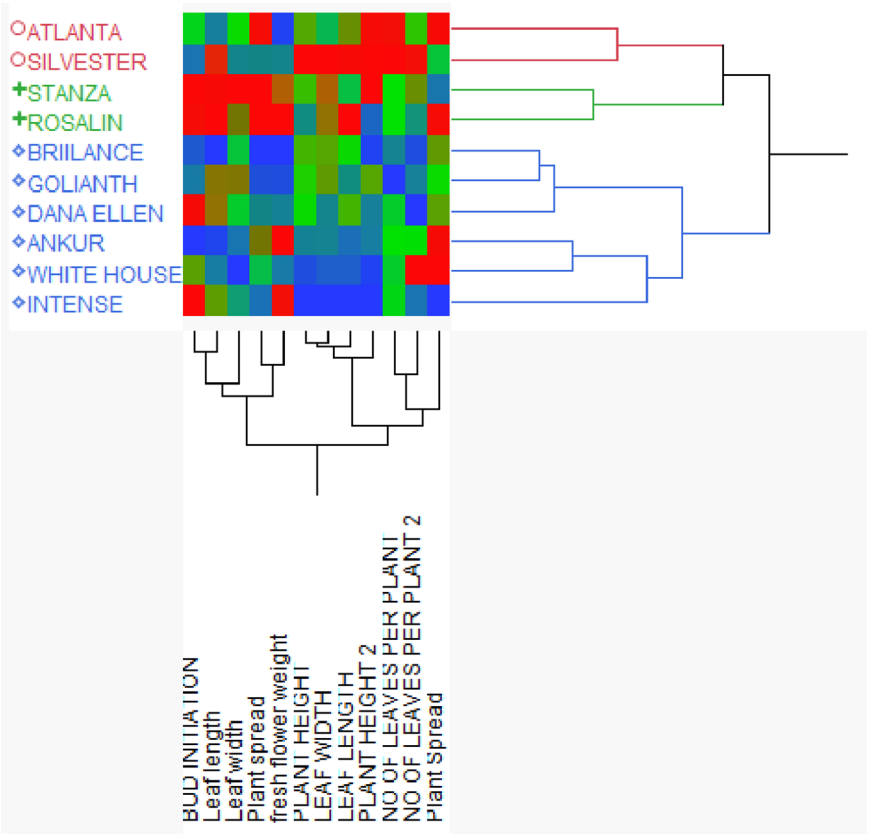

Fig. 3. Two way multivariate hierarchical clustering as per ward's method.

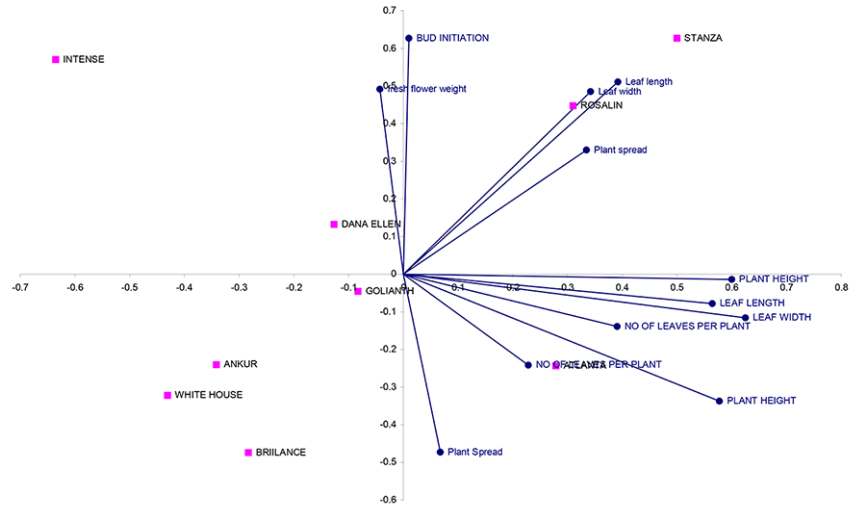

Fig. 4. Association among vegetative traits vs varieties by biplot analysis.

Biplot analysis of morphological traits and varieties

Approximately 56.6% of total variations among vegetative traits of Gebera varieties had been accounted by first two significant principal components of the present study (Table 4). Leaf width, plant height after 100 days of planting, plant height after 45 days of planting and leaf length after 45 days of planting contributed more in first component while days to bud initiation, leaf length and leaf width after 100 days of planting, plant spread after 45 days of planting contributed in second principal component. Varieties Silveser, Intense, Stanza appended more in first whereas Stanza, Intense, Brillance were for second component. Performance of Intense, Stanza, Brillance would be unstable type as compared to Golian and Dana Ellen as placed near to the origin of biplot

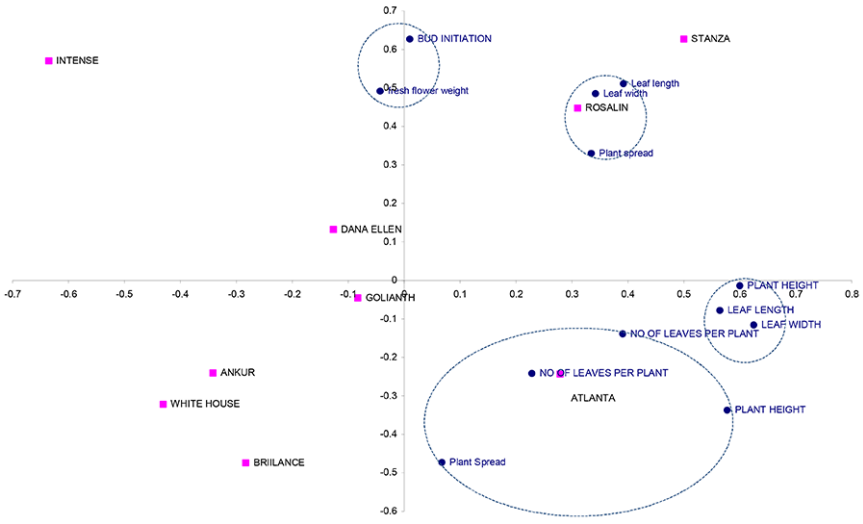

Fig. 5. Clustering of vegetative traits and varieties based on PC1 and PC2.

analysis in the present study based on vegetative traits (Fig. 4). The principal component analysis yielded Eigen values of each principal component axes of coordination of genotypes with the first axes totally accounted for the variation among the genotypes (Table 4). The pattern of distribution of genotypes in the biplot revealed that considerable variability existed in the studied genotypes. Plant spread at 45 days after planting has expressed straight line angle with fresh flower weight and obtuse angles with days to bud initiation. Group of leaf length, width and plant spread after 100 days of planting had expressed ninety degree angles with plant height, number of leaves at 45 days after planting. Number of leaves per plant at 45 and 100 days of planting formed a cluster with plant height and plant spread values of varieties at 45 days of planting (Fig. 5). Next cluster in same quadrant was comprised of leaf length, leaf width, plant height at 45 days of planting. First cluster of other quadrant comprised of leaf length, leaf width, plant spread at 100 days of planting and last cluster of days to bud initiation with fresh weight of flowers formed across the quadrants.

REFERENCES

Abbas S, Melika H (2023) Comparative assessment of ISSR, DAMD and RAPD markers for evaluation of genetic diversity of gerbera (*Gerbera jamesonii* Bolus ex Hooker F.) cultivars. *Acta Agriculturae Slovenica* 119 (1) : 1—8. https://doi:10.14720/aas.2023.119.1.2425.

Maitra S, Shankar T, Sairam M, Pine S (2020) Evaluation of gerbera (*Gerbera jamesonii* L.) cultivars for growth, yield and flower quality under protected cultivation. *Ind J Natural Sci* 10 (60) : 20271—20276.

Paikray DK, Sagar L, Nayak DK, Patel S, Biswamayeel DK, Pradhan A, Jena S, Sairam M, Santosh DT, Maitra S (2022) Evaluation of gerbera (*Gerbera jamesonii* L.) hybrids based on morphological characteristics under controlled environment conditions. *Ind J Natural Sci* 13 : 41368—41372. https://doi : 10.31830/2454-1761.2022.032.

Rabina I, Nazmul A, Mohammed KH (2021) Studies on varietal diversity and selection of potential varieties of gerbera (*Gerbera jamesonii* h. Bolus ex hook. F.) for commercial cultivation in Bangladesh. *Bangladesh J Bot* 50 (3) : 541—550. https://doi: https://doi.org/10.3329/bjb.v50i3.55833.

Rangnamei KL, Kumar M, Lireni KE, Meena KL, Rajkhowa DJ, Namei A, Pungding L (2019) Evaluation of different gerbera cultivars for growth and flower characteristics under naturally ventilated polyhouse under Nagaland condition. *J Agric Sear* 6 (4) : 166—169. https://doi. org/10.21921/jas. v6i04.-16897.

Rashid MH (2020) Effects of varieties and inorganic fertilizers on growth and flowering of gerbera (*Gerbera jamesonii*). *J Agric, Food Environ* 1 (4) : 2708—5694. https: //doi: 10.47 440/JAFE.2020.1402.

Sairam M, Maitra S, Shankar T, Sagar L, Santosh DT (2022) Performance of different gerbera (*Gerbera jamesonii* L.) cultivars under protected cultivation in south Odisha condi tions. *Crop Res* 57 (3) : 211—215.

Sangma SM, Kumar S, Collis JP, Momin BC (2017) Performance of gerbera (*Gerbera jamesonii* Bolus ex Hooker F.) cultivars for growth, flowering and yield characters under naturally ventilated polyhouse. *J Ornamental Hortic* 20 (3–4) : 108—112.20 (3–4): 108—112. https://doi: 10.47815/ apsr.2021. 10083.

Senapati AK, Prajapati P, Singh A (2013) Genetic variability and heritability studies in *Gerbera jamesonii* Bolus. *Afr J Agric Res* 8 (41) : 5090—5092. https://doi: 10.5897/AJAR 2013. 8038.

Singh MK, Sindhu SS, Sanjay K (2016) Evaluation of gerbera (*Gerbera jamesonii* Bolus ex. Hooker F.) under poly house conditions in mid hills of western Himalayas. *Int J Trop Agricult* 34 (3) : 837—839.

Singh P, Bhardwaj A, Kumar R, Singh D (2017) Evaluation of gerbera varieties for yield and quality under protected environment conditions in Bihar. *Int J Curr Microbiol Appl Sci* 6 (9) : 112—116. https://doi.org/10.20546/ijcmas.2017.609.013.

Terangpi H, Borthakur U, Buragohain N (2022) Performance of gerbera (*Gerbera jamesonii* L.) cultivars under open condition in the hill zone of Karbi Anglong district, Assam. *The Pharma Innov J* 11 (9) : 2170—2173.

Tomar R, Bohra M, Chauhan V, Chaudhary M (2021) Effect of pulsing solution for improving vase life of gerbera (*Gerbera jamesonii* Bolus ex. Hook) cv Rucha. *J Pharmacog Phytochem* 10 (1) : 2545—2548.

Vijayalaxmi M, Rao A M, Saidaiah P, Swathi K (2021) Evaluation of gerbera varieties for yield and quality under protected environment conditions in Hyderabad. *Int J Curr Microbiol Appl Sci* 10 (3) : In press.

Zhou Y, Yin M, Abbas F, Sun Y, Gao T, Yan F, Li X, Yu Y, Yue Y, Yu R, Fan Y (2022) Classification and association analysis of gerbera (*Gerbera hybrida*) flower color traits. *Front Pl Sci* 12:779288. https://doi.org/10.3389/ fpls.2021.79288.