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Multivariate Hierarchical evaluation of Gerbera (*Gerbera jamensoii*) varieties by Biplots analysis for flowering traits

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ABSTRACT: Analysis of Variance observed significant differences among varieties of Gerbera for the flowering traits studied during 2002-23 cropping season. Earlier opening of first flower was observed in variety Ankur followed by Golianth, maximum flower diameter was recorded in Rosalin, while the minimum was recorded in Brilliance. The maximum number of ray florets expressed by Rosalin and minimum was recorded in Dana Ellen. Rosalin showed maximum length of ray floret while minimum was expressed in Dana Ellen. The maximum and minimum shelf life of flowers was recorded in Ankur and Golianth respectively. The maximum fresh weight found for Rosalin followed by Stanza, Golianth, Ankur, while minimum was for White House. The highest heritability was recorded fresh flower weight, length of ray floret, stalk length, shelf life, and flower diameter. High heritability coupled with high genetic advance was observed for days to first flowering, plant height (cm), stalk length (cm) and number of disc florets/flower. Flower diameter had maintained positive with number of ray florets per flower, fresh flower weight, dry flower weight and negative with days to first flower, Stalk diameter had expressed negative relationship with shelf life, length of ray floret, dry flowers weight and positive with number of flowers in March as well as with February month. The multivariate hierarchical clustering as per Ward's method observed Atlanta and Golianth formed the first cluster of varieties followed by cluster of Brillance with White House while remaining six varieties formed the last bigger group. Biplot analysis found that Stalk diameter has expressed straight line angle with days to first flower weight and obtuse angles with shelf life. Number of ray floret had maintained ninety degree angle with dry flower weight, length of ray floret with shelf life, Number of flowers in March month with days to first flower.

Keywords: Flowering traits variation, heritability, genetic advance, multivariate cluster analysis.

INTRODUCTION

Due to the increasing demands of flowers in the international markets, the floriculture has become very popular in recent years for export demands (Abbas and Melika 2023). Gerbera (*Gerbera jamesonii* L.) has been considered as the latest sensation to the commercial cultivation wide variety of colours and shapes (Zhou *et al.*, 2022). The plants are fairly hardy and can be grown both in the plains as well as in the hill regions. In tropical and subtropical climates, gerbera are grown in the open, but in temperate climates the cultivation has gaining momentum in polyhouses conditions (Sairam *et al*., 2022). Flower head is solitary; many flowered, with conspicuous ray florets in one or two rows (Aswath and Kumar 2020). Based on flower head types or forms they are grouped into single, double and semi double cultivars (Paikray *et al.*, 2022). 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. The outer one or two rows of flower heads are conspicuously long ray florets (female), whereas the inner rows are hermaphrodite disc florets (Tomar *et al.*, 2021). The daisy-like flower in a variety of colours, such as yellow, orange, cream white, pink, brick red, crimson, salmon, maroon (Vijayalaxmi *et al.*, 2021). Some bicoloured double cultivars are found to be attractive (Rabina *et al.*, 2021). Severe winter is problem in major flower producing European countries, is also an advantageous factor to India, especially in cities like Bengaluru, Pune, Hyderabad, Nasik which enjoy moderate climate all through the year, besides comparatively cheap availability of land and labour has got a great potential for producing gerbera on commercial scale (Rangnamei *et al.*, 2019). The variation in the performance of varieties in flowering traits may be due to the response of cultivars to varying genetic makeup and

environmental conditions (Maitra *et al.*, 2020). The choice of suitable varieties is crucial for the large scale cultivation of flower crops to sustain the continuous supply of cut flowers in domestic and export markets.

MATERIAL AND METHODS

The experiments were carried out at Agri-Tourism Centre, 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. Station has a semi-arid climate with hot and dry summer and extremely cold winter. The texture of the soil at the experimental plots 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 experimental plots were of 1.5m×1.5 m and plant to plant spacing was 30cm×30 cm. The plant 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, Brilliance, Stanza, Rosalin, Ankur, White house, Dana Ellen, Intense, Golianth and Silvester from KF Biotech Private limited, Pune. The phenotypic and genotypic coefficients of variation were calculated along with heritability in the broad sense and genetic advance expressed in per cent of mean were calculated for flowering traits. The multivariate hierarchical clustering as per Ward's method and recent analytic tool biplot analysis was conducted by SAS software.

RESULTS AND DISCUSSION

A. Analysis of Variance

The variability in flowering traits was measured by analysis of variance, pair wise mean comparison, 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. Highly significant variations had been observed by analysis of variance for the flowering traits as reported by Sangma *et al.* (2017) and different superscripts denote varieties were in significant groups (Fig. 1). It was noted that number of days to first flower opening significantly varied with different varieties. Earlier opening of first flower was observed in variety Ankur (68.33 days) followed by Golianth (75.73 days), Silvester (78.70 days), Brilliance (84.23 days), Atlanta (93.03 days) and White House (95.17 days). The first flower opening was too late in the Stanza (110.70 days) which was at par with Intense (109.08 days). The Golianth and Silvester, Atlanta and White House, Dana Ellen and Rosalin were found statistically at par with each other in respect of number of days to first flower opening in gerbera. The stalk length differed significantly among the studied varieties of gerbera. Maximum stalk length was observed in Ankur (66.78cm) which was found statistically at par with Golianth (65.30 cm) while minimum was observed in White house (54.68cm) which was found statistically at par with Brilliance (56.35cm). The stalk diameter differed significantly among varieties of gerbera. Maximum stalk diameter was found in Atlanta (6.94mm) which was found statistically at par with Golianth (6.71mm) and Silvester (6.58mm) while minimum was observed in Dana Ellen (5.83mm) which was found statistically at par with Intense (5.87mm), White house (5.93), Rosalin (5.97mm), Stanza (6.01mm) and Ankur (6.13mm). Brilliance, Stanza and Rosalin were found statistically at par with each other in respect of stalk diameter (mm). The flower diameter (cm) differed significantly with different varieties of gerbera. The maximum flower diameter was recorded in Rosalin (12.55 cm) which was found statistically at par with Ankur (11.90cm), while the minimum was recorded in Brilliance (9.24cm) which was found at par with White house (9.71cm). Similarly, var. Stanza, Dana Ellen and Intense, Stanza, Intense and Golianth, Atlanta and Silvester, Silvester and Ankur were at par with each other in respect of flower diameter.

The disc diameter differed significantly with different varieties of gerbera. The maximum disc diameter was recorded in Rosalin (34.76 mm) followed by Dana Ellen (32.56 mm), Atlanta (31.29 mm) and White House (29.43mm) while minimum was recorded in Intense (23.65mm) which was found at par with Stanza (24.23mm) and Silvester (24.29mm). White house and Ankur, Ankur and Brilliance were found statistically at par with each other in respect of disc diameter. The significant influence of different varieties on number of ray florets per flower had expressed in Table 1. The variety Rosalin recorded maximum number of ray florets (95.33) which was statistically at par with Ankur (91.67) while minimum was recorded in Dana Ellen (65.00). Brilliance and White House, Atlanta, Intense and Silvester were found statistically at par with each other in respect of number of ray florets per flower.

Number of flowers / meter square / month differed significantly with different varieties of gerbera. Maximum number of flowers/ meter square was observed in Ankur (13.32) which was found statistically at par with Silvester (13.00) and Golianth (12.60) while minimum was observed in Rosalin (6.81) in February. Whereas, in month of March, maximum number of flowers/ meter square was found in Ankur (8.57) which was found statistically at par with Silvester (7.67), Atlanta (7.23), Intense (7.07) Stanza (6.63) while minimum was found in White House (4.83). The length of ray floret differed significantly with different varieties of gerbera. The maximum length of ray floret was found in Rosalin (5.25 cm) which is statistically at par with Silvester (5.04 cm) and Golianth (4.90cm) while minimum was recorded in Dana Ellen (3.69cm) which was found statistically at par with White House (3.91cm). Atlanta and Brilliance, Stanza and Atlanta, Ankur and Atlanta were found statistically at par with each other in respect of length of ray floret. A brief appraisal of the Table 1 indicated that dry weight differed significantly with different varieties of gerbera. Variety Rosalin showed maximum dry weight (4.87 g) followed by Stanza (4.63 g), Golianth (4.47 g),

Brilliance (4.40 g), while minimum was found with Dana Ellen (3.63 g) which was found statistically at par with White House (3.67 g), Silvester (3.67 g), Atlanta (3.80 g) and Intense (3.80 g). The shelf life of flowers influenced significantly by different varieties of gerbera. The maximum shelf life of flowers was recorded in Ankur (28.63 days) which was found at par with Stanza (27.90 days) and Silvester (27.67days) while minimum was recorded in Golianth (23.43 days) which was found statistically at par with Atlanta (24.40 days).

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

	Days to first flower	Stalk length	Flower diameter	Stalk diameter	Disc diameter	Number of ray floret per flower	Length of ray floret	Dry flower weight	Shelf life	Water uptake	Petal discolouration	Vase life	Number of flowers (March)	Number of flowers (February)	Fresh flower weight
Atlanta	103.60	65.30^{bc}	10.11^{a}	6.94^{a}	32.59^{c}	93.00^{b}	4.37^{def}	3.80	20.73	50.00	7.33	6.33	17.00	23.33	21.37^{de}
Briilance	88.93	60.07^{ef}	9.24^{d}	6.71^{a}	29.69^{de}	71.00e	4.12^{fg}	3.80	27.77	48.33	7.67	7.67	12.67	15.00	21.07^{e}
Stanza	106.57	67.45^{b}	11.01^{b}	6.01^{cd}	28.57^{ef}	88.33^{bc}	4.69^{bcd}	4.23	33.50	45.67	6.67	6.67	15.00	22.00	24.67^{b}
Rosalin	97.67	65.59^{bc}	12.55^{a}	6.13^{bcd}	39.93^{a}	78.67d	4.90^{abc}	4.63	30.67	46.00	7.67	9.33	12.33	15.33	26.00^{a}
Ankur	91.80	58.25^{fg}	10.19^{c}	5.93^{cd}	30.11^{d}	83.33^{cd}	4.57^{cde}	4.87	27.87	49.33	8.00	8.33	12.00	18.00	26.03^{a}
White house	100.73	56.35^{g}	9.71^{cd}	5.93^{cd}	30.43^{d}	70.33e	3.91^{gh}	3.63	26.80	47.00	4.33	4.67	5.67	16.00	22.27^{cd}
Dana ellen	106.90	62.33^{de}	10.09^{c}	5.83^{cd}	33.75^{bc}	82.33^{cd}	4.26^{egf}	4.30	33.13	52.00	9.33	5.67	6.33	15.67	22.40^{c}
Intense	110.93	72.89^{a}	10.34^{c}	5.87^{cd}	34.76^{b}	81.00^{cd}	3.69^{h}	4.40	33.07	52.33	10.67	8.33	16.00	16.00	25.20^{ab}
Golianth	82.77	64.31^{cd}	11.21^{b}	6.58^{ab}	27.99^{f}	103.67^{a}	5.04^{ab}	3.80	19.43	52.33	10.67	8.67	12.67	16.00	21.73^{cde}
Silvester	81.27	62.76^{cde}	11.90^{b}	6.45^{abc}	34.62^{b}	64.67^{e}	5.25^{a}	4.47	28.00	53.67	7.33	5.33	10.67	20.67	22.50^{c}
CD at 5%	15.06	2.69	0.66	0.52	1.33	7.62	0.37	0.46	3.28	4.60	1.52	1.12	6.51	5.98	0.90
Heritability	0.497	0.897	0.884	0.617	0.866	0.834	0.935	0.759	0.885	0.408	0.828	0.855	0.379	0.273	0.954
GA	13.130	9.120	1.940	0.590	21.600	0.920	3.820	0.710	9.310	3.100	3.440	2.940	3.800	2.400	7.200
GCV	9.310	7.360	9.410	5.820	13.800	10.870	8.230	9.430	17.110	4.750	23.010	21.750	24.900	12.540	11.210
PCV	13.200	7.770	10.010	7.400	14.830	11.910	8.510	10.820	18.190	7.430	25.280	23.520	40.460	24.020	11.470

The perusal of Table 1 regarding water uptake (g) observed that water uptake (g) by flowers differed significantly with different varieties of gerbera. Maximum water uptake by flowers in Ankur (48.63 g) which was found statistically at par with Silvester (46.92g) while minimum was recorded in White house (34.73g).

The fresh weight differed significantly with different varieties of gerbera. The variety Rosalin showed maximum fresh weight (34.33g) followed by Stanza (32.67g), Golianth (32.07g), Ankur (31.03 g), while minimum was recorded in White House (24.17g). The dry weight of flower indicated that dry weight differed significantly with different varieties of gerbera. Variety Rosalin showed maximum dry weight (4.87 g) followed by Stanza (4.63 g), Golianth (4.47 g), Brilliance (4.40 g), while minimum was found with Dana Ellen (3.63 g) which was found statistically at par with White House (3.67 g), Silvester (3.67 g), Atlanta (3.80 g) and Intense (3.80 g). It was revealed that shelf life of flowers influenced significantly by different varieties of gerbera. The maximum shelf life of flowers was recorded in Ankur (28.63 days) which was found at par with Stanza (27.90days) and Silvester (27.67days) while minimum was recorded in Golianth (23.43 days) which was found statistically at par with Atlanta (24.40 days). The vase life of flower influenced significantly by different varieties of gerbera. Maximum vase life was observed in Ankur (11.00 days) which was found statistically at par with Golianth (10.67 days) while minimum was observed in White House (4.67 days). The days taken for petal discolouration in flower influenced significantly by different varieties of gerbera. Maximum days taken for petal discolouration in flower observed in Golianth (8.67 days) which was found statistically at par with var. Intense (8.33 days), Ankur (8.00 days), Rosalin (7.67 days) and Silvester (7.33 days) while minimum days taken to petal discolouration was found in White House (4.33 days).

B. Heritability and Genetic Advance

The flowering traits had exhibited higher PCV than GCV values. A higher value for PCV than GCV is an indication of environmental influence on expression of that particular character (Rashid, 2020). Highest GCV and PCV were noticed for number of flowers in March, Petal decolourization, vase life, shelf life. Difference between phenotypic and genotypic coefficients of variation was highest for number of flowers in March, flowers in February, days to first flower (Table 1). Stalk diameter, flower diameter, length of ray floret, dry flower weight showed very low difference (Aswath *et al*., 2016). Therefore, the variation observed among these characters might be due to genetic makeup of varieties and less influence of environment. A high estimate of heritability indicates a relatively low contribution of the environmental factors to the phenotypic variance, while a low heritability estimates show a high contribution of the environment. Selection would be more effective for the character having high heritability than for those exhibiting low heritability. Most of the studied characters were highly heritable in the present study. The highest heritability was recorded fresh flower weight, length of ray floret, stalk length, shelf life, and flower diameter. High heritability

coupled with high genetic advance was observed for days to first flowering, plant height (cm), stalk length (cm) and number of disc florets/flower which suggested that the selection among the genotypes can bring about significant improvement for these characters (Table 2). In general, the characters which exhibit high heritability with high genetic advance are significantly controlled by additive genes (Senapati *et al.,* 2013) and can be improved through mass selection, progeny selection or any other modified selection procedures. The qualitative trait had high heritability and high genetic advance, which confirms the predominance of additive gene action. And the trait exhibited low amount of heritability and genetic advance which indicated the presence of non-additive gene action that include dominance and epitasis for these traits and thus, improvement of these traits by selection was not possible (Othman *et al.,* 2021).

C. Association analysis at Genotypic and Phenotypic levels

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 programme. 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. The genotypic correlations values were more than the phenotypic values of correlation, 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). At the genotypic level, stalk length found to be significantly and positively correlated with four characters namely, number of flowers in March, Petal discolourization, days to first flower, disc diameter. Flower diameter had maintained positive with number of ray florets per flower, fresh flower weight, dry flower weight and negative with days to first flower, Stalk diameter had expressed negative relationship with shelf life, length of ray floret, dry flowers weight and positive with number of flowers in March as well as with February month. Disc diameter had exhibited direct with number of flowers in March, petal discolourization, shelf life and indirect with shelf life and fresh flower weight.

Table 2: Genotypic and phenotypic correlation analysis of flowering traits of Gebera.

	Stalk length	Flower diameter	Stalk diameter	Disc diameter	Number of ray floret per flower	Length of ray floret	Dry flower weight	Days to first flower	Shelf life	Water uptake	Petal discolouration	Vase life	Number of flowers (March)	Number Of Flowers (February)	Fresh flower weight
G	1.000	0.375	-0.016	0.377	-0.033	0.334	0.192	0.531	0.302	0.218	0.589	0.395	0.898	0.287	0.333
P	1.000	0.326	-0.044	0.299	-0.050	0.288	0.202	0.336	0.239	0.176	0.539	0.376	0.482	0.108	0.327
G	0.375	1.000	-0.032	0.063	0.799	0.440	0.484	-0.344	0.085	0.049	0.122	0.336	0.172	0.136	0.571
P	0.326	1.000	-0.020	0.058	0.734	0.393	0.468	-0.179	0.049	-0.033	0.139	0.260	0.101	0.139	0.506
G	-0.016	-0.032	1.000	0.243	0.354	-0.734	-0.574	-0.568	-0.872	0.243	0.004	0.034	0.759	0.688	-0.190
P	-0.044	-0.020	1.000	0.163	0.232	-0.539	-0.400	-0.401	-0.579	0.083	0.031	0.062	0.141	0.099	-0.149
G	0.377	0.063	0.243	1.000	0.185	-0.034	-0.161	0.159	-0.459	0.120	0.506	0.447	0.529	0.272	-0.369
P	0.299	0.058	0.163	1.000	0.149	0.012	-0.176	0.056	-0.415	0.024	0.494	0.353	0.362	0.123	-0.327
G	-0.033	0.799	0.354	0.185	1.000	0.067	0.318	-0.818	-0.288	0.205	0.043	0.157	0.068	0.318	0.080
P	-0.050	0.734	0.232	0.149	1.000	0.030	0.267	-0.473	-0.250	0.019	0.070	0.139	0.062	0.343	0.082
G	0.334	0.440	-0.734	-0.034	0.067	1.000	0.892	0.366	0.592	-0.403	0.104	0.543	0.231	-0.090	0.405
P	0.288	0.393	-0.539	0.012	0.030	1.000	0.715	0.214	0.519	-0.212	0.095	0.450	0.177	-0.064	0.370
G	0.192	0.484	-0.574	-0.161	0.318	0.892	1.000	0.074	0.607	0.146	0.244	0.399	0.100	-0.032	0.522
P	0.202	0.468	-0.400	-0.176	0.267	0.715	1.000	-0.040	0.426	-0.016	0.236	0.343	0.070	0.037	0.440
G	0.531	-0.344	-0.568	0.159	-0.818	0.366	0.074	1.000	0.600	-0.547	0.039	-0.148	0.278	0.150	0.233
P	0.336	-0.179	-0.401	0.056	-0.473	0.214	-0.040	1.000	0.464	-0.047	-0.121	-0.108	-0.007	0.037	0.172
G	0.302	0.085	-0.872	-0.459	-0.288	0.592	0.607	0.600	1.000	-0.246	-0.003	-0.055	-0.139	-0.205	0.364
P	0.239	0.049	-0.579	-0.415	-0.250	0.519	0.426	0.464	1.000	-0.199	-0.038	-0.013	-0.188	-0.189	0.349
G	0.218	0.049	0.243	0.120	0.205	-0.403	0.146	-0.547	-0.246	1.000	0.826	-0.119	-0.059	-0.044	0.067
P	0.176	-0.033	0.083	0.024	0.019	-0.212	-0.016	-0.047	-0.199	1.000	0.439	-0.094	0.016	0.018	0.013
G	0.589	0.122	0.004	0.506	0.043	0.104	0.244	0.039	-0.003	0.826	1.000	0.610	0.415	-0.487	0.089
P	0.539	0.139	0.031	0.494	0.070	0.095	0.236	-0.121	-0.038	0.439	1.000	0.541	0.260	-0.129	0.085
G	0.395	0.336	0.034	0.447	0.157	0.543	0.399	-0.148	-0.055	-0.119	0.610	1.000	0.689	-0.502	0.175
P	0.376	0.260	0.062	0.353	0.139	0.450	0.343	-0.108	-0.013	-0.094	0.541	1.000	0.358	-0.242	0.165
G	0.898	0.172	0.759	0.529	0.068	0.231	0.100	0.278	-0.139	-0.059	0.415	0.689	1.000	0.525	0.010
P	0.482	0.101	0.141	0.362	0.062	0.177	0.070	-0.007	-0.188	0.016	0.260	0.358	1.000	0.445	-0.038
G	0.287	0.136	0.688	0.272	0.318	-0.090	-0.032	0.150	-0.205	-0.044	-0.487	-0.502	0.525	1.000	-0.233
P	0.108	0.139	0.099	0.123	0.343	-0.064	0.037	0.037	-0.189	0.018	-0.129	-0.242	0.445	1.000	-0.096
G	0.333	0.571	-0.190	-0.369	0.080	0.405	0.522	0.233	0.364	0.067	0.089	0.175	0.010	-0.233	1.000
P	0.327	0.506	-0.149	-0.327	0.082	0.370	0.440	0.172	0.349	0.013	0.085	0.165	-0.038	-0.096	1.000

The negative relation of Number of ray floret per flower had been observed with days to first flower and shelf life. Length of ray floret had showed significant positive correlation with dry flower weight, shelf life, vase life, fresh flower weight. Dry flower weight had direct association with fresh lower weight, shelf life, vase life, petal discolourization (Mohsin *et al.,* 2023). Days to first flower had exhibited indirect with water uptake, number of ray floret per flower and direct relation with shelf life, stalk length. Shelf life of flowers had negative correlation with stalk diameter, disc diameter and direct relation with days to first flower, dry flower weight, length of ray floret. Direct association of water uptake was observed with petal discolourization and indirect with days to first flower as well as with length of ray floret.

Number of flowers in March month had maintained direct association with most of the studied flowering traits except of very weak negative with shelf life.

D. Direct and indirect effects of flowering traits

Path coefficient analysis is employed to measure the direct and indirect effect of flowering traits on the fresh yield of flowers. Flower yield is dependent variable not only by the interrelationship of associated characters but also changes in any flowering trait could affect the whole cause and effect relationship. A crop breeding programme, 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. At genotypic path analysis, showed direct effects which were positive stalk length, number of ray floret per flower, length of ray floret, water uptake, number of flower in February (Table 3).

The other direct effect which was negatively impacted flower diameter, stalk diameter, dry flower weight, petal discolourization, days to first flower, number of flowers in March month. Stalk length showed positive indirect effect by length of ray floret, stalk diameter and negative indirect effect by flower diameter, days to first flower, petal discolourization. If direct effect is low and negative, positive correlation might have resulted due to indirect positive effects. Flower diameter exerted positive indirect effect by number of ray floret per flower, length of ray floret, stalk length and negative indirect effect via dry flower weight. Positive indirect effect of number of flowers in March month by stalk length and length of ray floret had been observed for fresh flower yield. Days to first flower had negative direct effects on fresh flower yield and negative indirect effects by number of ray floret per flowers, water uptake and positive indirect effects of stalk diameter and number of ray floret per flowers. Direct indirect influence of length of ray floret via stalk length and stalk diameter while negative indirect effects dry flower weight, flower diameter, das to first flower. Stalk diameter had positive indirect effect dry flower weight, days to first flower, shelf life and negative indirect observed for length of ray floret, number of flowers in March. Direct indirect effect of number of ray floret per flower found for days to first flower whereas negative indirect by flower diameter and dry flower weight.

Table 3: Direct and indirect effects of traits towards fresh flower weight by Path analysis.

	Stalk length	Flower diameter	Stalk diameter	Disc diameter	Number of ray floret per flower	Length of ray floret	Dry flower weight	Days to first flower	Shelf life	Water uptake	Petal discolouration	Vase life	Number of flowers mar	Number of flowers Feb
G	**38.444**	-15.953	0.296	-2.047	-0.822	12.097	-5.753	-15.027	-1.377	1.334	-7.324	-0.923	-3.028	0.416
p	-0.053	0.245	-0.008	-0.178	0.017	0.033	0.017	0.127	-0.045	-0.021	0.218	-0.012	-0.011	-0.001
G	14.424	**-42.520**	0.605	-0.340	20.034	15.924	-14.522	9.745	-0.386	0.299	-1.523	-0.785	-0.579	0.197
p	-0.017	0.751	-0.004	-0.035	-0.246	0.045	0.040	-0.068	-0.009	0.004	0.056	-0.008	-0.002	-0.002
G	-0.600	1.355	**-18.992**	-1.321	8.873	-26.592	17.227	16.093	3.972	1.490	-0.053	-0.080	-2.559	0.996
p	0.002	-0.015	0.181	-0.097	-0.078	-0.062	-0.034	-0.152	0.110	-0.010	0.013	-0.002	-0.003	-0.001
G	14.491	-2.666	-4.619	**-5.430**	4.645	-1.228	4.840	-4.505	2.092	0.736	-6.290	-1.044	-1.785	0.393
p	-0.016	0.044	0.030	-0.596	-0.050	0.001	-0.015	0.021	0.079	-0.003	0.200	-0.011	-0.008	-0.002
G	-1.261	-33.973	-6.721	-1.006	**25.074**	2.442	-9.540	23.170	1.311	1.256	-0.536	-0.367	-0.230	0.460
p	0.003	0.551	0.042	-0.089	-0.335	0.003	0.023	-0.179	0.048	-0.002	0.028	-0.005	-0.001	-0.005
G	12.841	-18.697	13.946	0.184	1.691	**36.214**	-26.775	-10.368	-2.698	-2.466	-1.290	-1.268	-0.780	-0.130
p	-0.015	0.295	-0.097	-0.007	-0.010	0.114	0.062	0.081	-0.099	0.026	0.039	-0.015	-0.004	0.001
G	7.371	-20.580	10.904	0.876	7.972	32.316	**-30.005**	-2.100	-2.767	0.893	-3.041	-0.931	-0.338	-0.047
p	-0.011	0.352	-0.072	0.105	-0.089	0.082	0.086	-0.015	-0.081	0.002	0.095	-0.011	-0.002	0.000
G	20.406	14.637	10.796	-0.864	-20.521	13.262	-2.226	**-28.311**	-2.735	-3.347	-0.487	0.345	-0.939	0.217
p	-0.018	-0.134	-0.072	-0.033	0.159	0.024	-0.003	0.379	-0.088	0.006	-0.049	0.003	0.000	0.000
G	11.614	-3.600	16.555	2.493	-7.212	21.441	-18.221	-16.989	**-4.557**	-1.504	0.043	0.127	0.469	-0.297
p	-0.013	0.037	-0.105	0.248	0.080	0.050	0.037	0.176	-0.190	0.024	-0.015	0.000	0.004	0.002
G	8.382	-2.074	-4.623	-0.654	5.148	-14.593	-4.378	15.486	1.120	**6.120**	-10.281	0.278	0.200	-0.064
p	-0.009	-0.025	0.015	-0.015	-0.006	-0.024	-0.001	-0.018	0.038	-0.122	0.178	0.003	0.000	0.000
G	22.629	-5.205	-0.080	-2.745	1.079	3.755	-7.333	-1.109	0.016	5.056	**-12.443**	**-1.425**	-1.401	0.705
p	-0.028	0.104	0.006	-0.295	-0.023	0.011	0.020	-0.046	0.007	-0.054	0.405	-0.017	-0.006	0.002
G	15.179	-14.291	-0.651	-2.426	3.942	19.652	-11.961	4.184	0.249	-0.728	-7.587	**-2.337**	-2.324	-0.727
p	-0.020	0.195	0.011	-0.211	-0.047	0.051	0.030	-0.041	0.002	0.011	0.219	-0.032	-0.008	0.003
G	34.525	-7.304	-14.412	-2.875	1.709	8.378	-3.012	-7.880	0.634	-0.362	-5.169	-1.610	**-3.372**	0.760
p	-0.025	0.076	0.026	-0.216	-0.021	0.020	0.006	-0.003	0.036	-0.002	0.105	-0.012	-0.023	-0.006
G	11.050	-5.772	-13.059	-1.476	7.972	-3.249	0.970	-4.247	0.933	-0.269	6.061	1.174	-1.769	**1.448**
p	-0.006	0.104	0.018	-0.074	-0.115	-0.007	0.003	0.014	0.036	-0.002	-0.052	0.008	-0.010	-0.013

E. Hierarchical cluster analysis

Multivariate hierarchical clustering had been established an efficient approach to provide a good index of degree of diversity. The main aim of clustering of genotypes was selection of desirable genotypes for to improve the breeding program of the crop. By the application of multivariate hierarchical clustering as per Ward's method while considering flowering traits, 10 genotypes were grouped into three distinct clusters (Fig. 2). Atlanta and Golianth formed the first cluster of varieties followed by cluster of Brillance with White House while remaining six varieties formed the last bigger group. Number of flowers in February month had portioned the studied flowering traits in two broad groups at the first point of classification (Fig. 3). Disc diameter, dry flowers weight, fresh flowers weight, days to first flower along with shelf life of considered varieties separated from other traits. These traits were further grouped by fresh flowers weight into days to first flower with shelf life in one sub group while disc diameter, dry flowers weight in other group at second node of classification.

F. Biplot analysis based on PC1 and PC2

Approximately 46.6% of total variations among flowering traits of Gebera varieties had been accounted by first two significant principal components of the present study (Table 4). Nearly 26.4 % of variations accounted by first whereas 22.4% by second principal components in biplot analysis. Dry flower weight, fresh flower weight, shelf life, disc diameter, stalk length contributed more in first component while number of flowers in March month, stalk diameter, shelf life, number of ray floret per flower augmented more in second principal component. Varieties Rosalin, Intense, White house observed major contributor for the first whereas White house, Golianth, Dana Ellen were for second component. Performance of Golianth, White house, Roosalin would be unstable type as compared to Silvester, Ankus, Stanza as placed near to the origin of biplot analysis in the present study based on flowering traits (Fig. 4). The principal component analysis generated eigen values of each principal component axes of varieties with the first axes totally accounted for the variation among the varieties (Table 4).

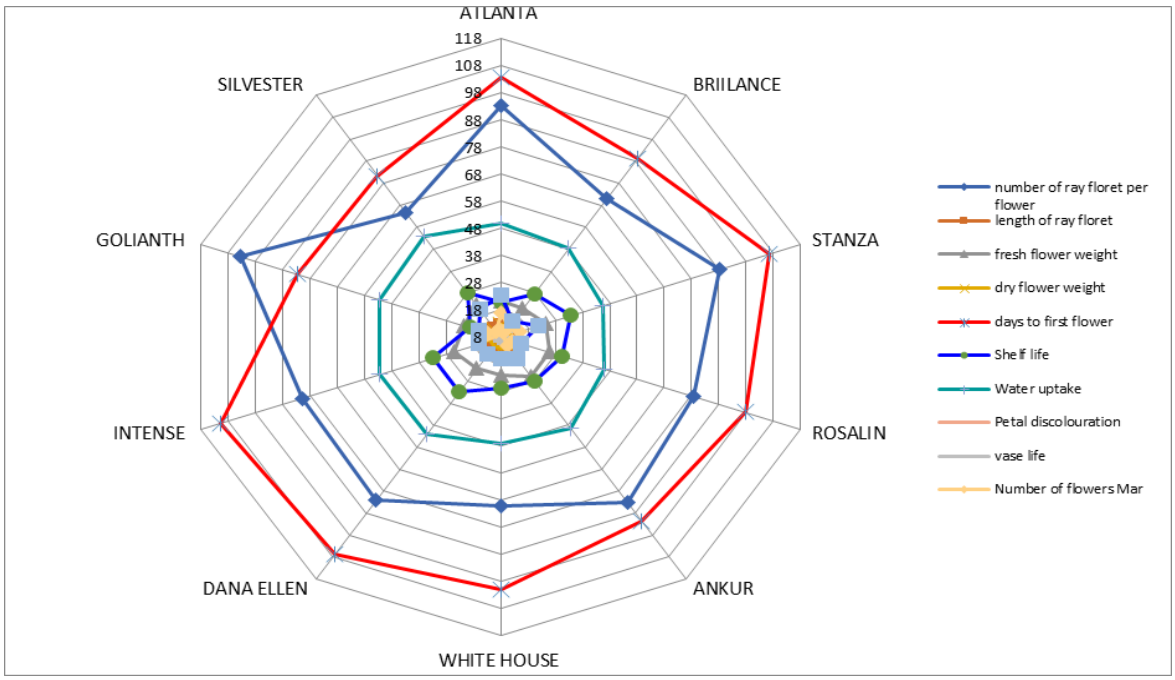

Fig. 1. Degree of variation in flowering traits for Gebera varieties.

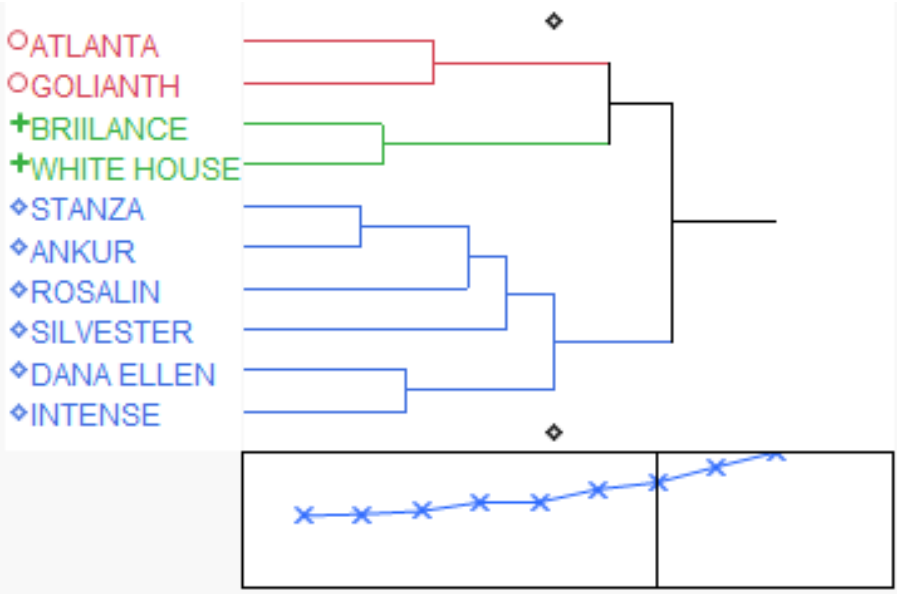

Fig. 2. Multivariate hierarchical clustering of varieties based vegetative traits.

Table 4: Loadings of traits and genotypes towards the first and second principal components in Biplot analysis.

Traits	Principal Component 1	Principal Component 2	Genotypes	Principal Component 1	Principal Component 2
Stalk length	0.3023	-0.2408	Atlanta	-0.3216	-0.3444
Flower diameter	0.2674	-0.2196	Briilance	-0.3482	0.0772
Stalk diameter	-0.2940	-0.3564	Stanza	0.1599	0.0359
Disc diameter	0.3097	0.0443	Rosalin	0.5220	-0.0319
Number of ray floret per flower	-0.0001	-0.3579	Ankur	0.1662	0.0504
Length of ray floret	0.0314	-0.3054	White house	-0.4043	0.6202
Dry flower weight	0.4113	0.0101	Dana Ellen	0.0552	0.3153
Days to first flower	0.1879	0.2268	Intense	0.4718	-0.0009
Shelf life	0.3375	0.3225	Golianth	-0.2378	-0.6119
Water uptake	-0.0394	-0.2061	Silvester	-0.0632	-0.1100
Petal discolouration	0.1920	-0.3119	% share of factors (48.61%)	26.24%	22.37%
Vase life	0.2727	-0.2801			
Number of flowers (March)	0.1296	-0.3688			
Number of flowers (February)	-0.0756	-0.1710			
Fresh flower weight	0.4473	0.0669			

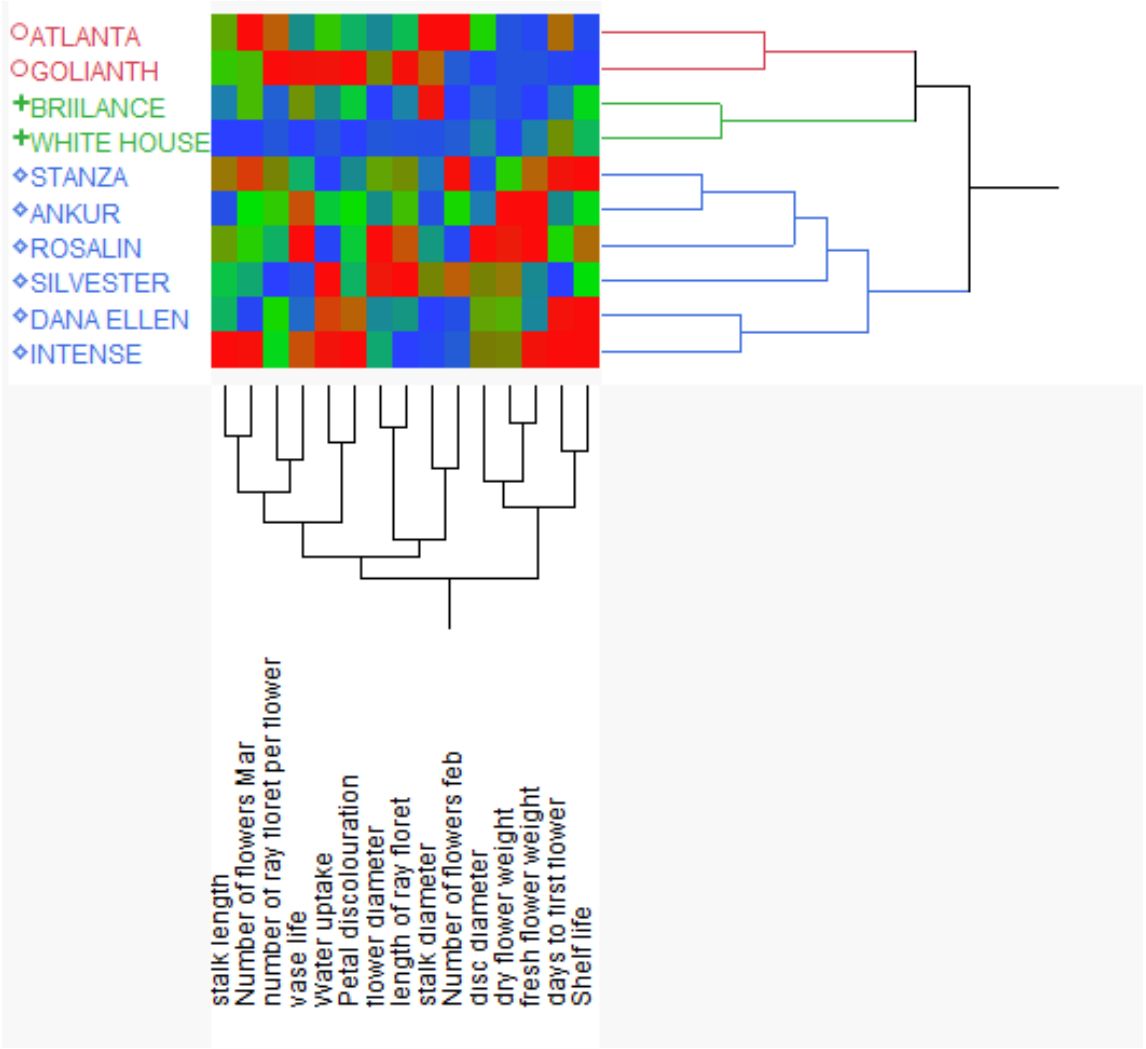

Fig. 3. Two way Multivariate hierarchical clustering as per Ward's method.

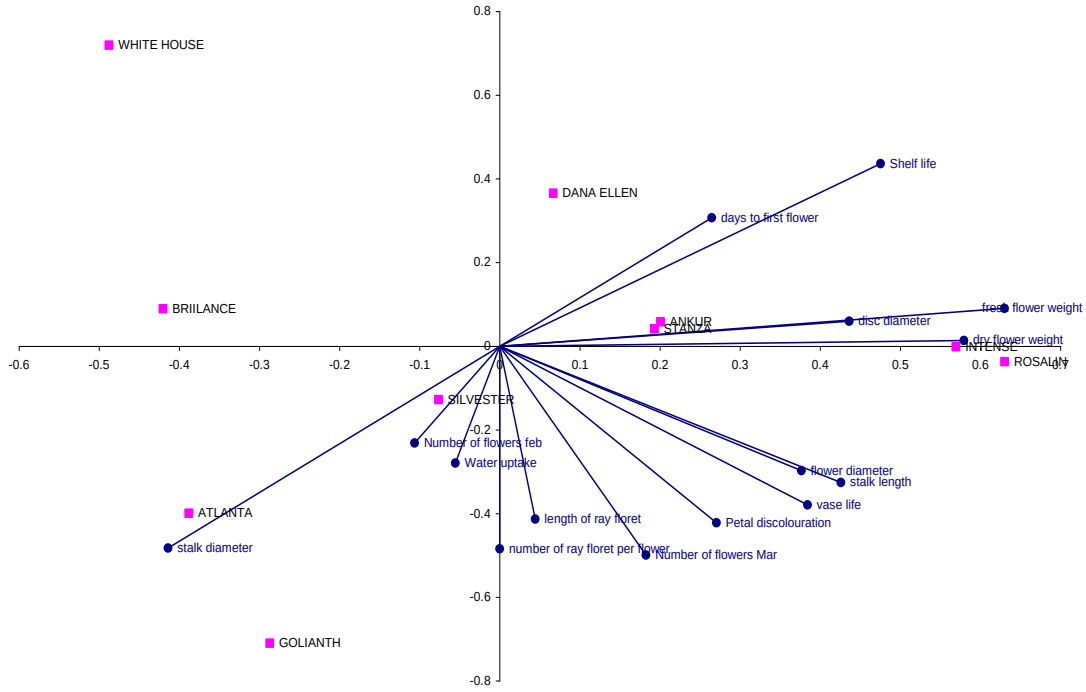

Fig. 4. Association among vegetative traits vs varieties by biplot analysis.

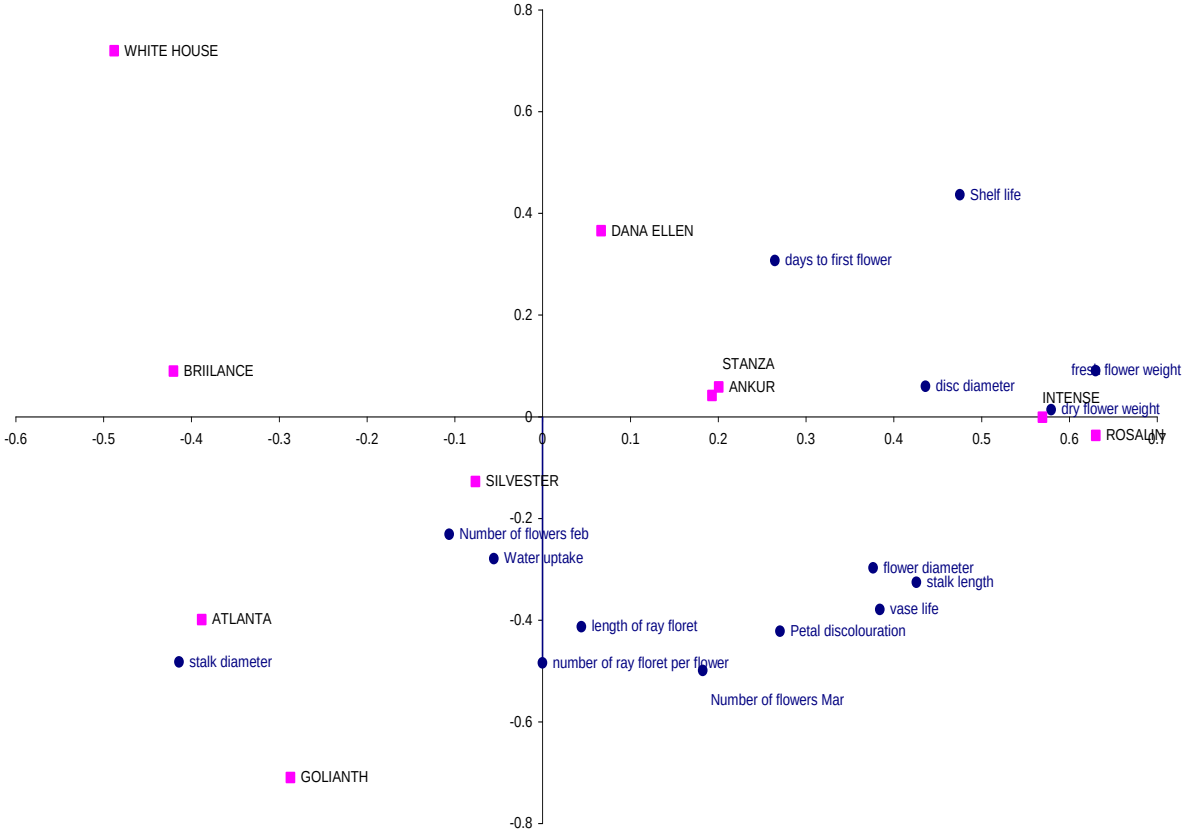

Fig. 5. Clustering of vegetative traits and varieties based on PC1 and PC2.

The distribution pattern of varieties in the biplot revealed that considerable variability existed in the studied genotypes. Number of flowers in February month had association with water uptake and Stalk diameter as observed in first quadrant. Petal discolourization had expressed direct association with numbers of Flowers in March, length of ray floret, number of ray floret per flower one side and with vase life, stalk length, flower diameter on other side in second quadrant of the biplot graphical analysis. Fresh flower weight had exhibited close association with dry flower weight and disc diameter. Similarly tight direct relation of shelf life was observed with days to first flower. Stalk diameter has expressed straight line angle with days to first flower weight and obtuse angles with shelf life. Number of ray floret had maintained ninety degree angle with dry flower weight, length of ray floret with shelf life, Number of flowers in March month with days to first flower. Number of Flowers in February month had showed right angles with flower diameter and stalk length in the present study.

Number of flowers in February month had clubbed with water uptake and number of ray floret per flower leaves in first cluster whereas length of ray floret joined hands with number of flowers in March month in second cluster based on first two principal components. Next adjacent cluster consisted of flower diameter, stalk length, case life and petal discolourization. Next quadrant found the cluster of dry flower weight with disc diameter and fresh flower weight. Shelf life formed the last cluster with days to first flower in current study (Fig. 5).

CONCLUSIONS

Earlier opening of first flower was observed in variety Ankur followed by Golianth, maximum flower diameter was recorded in Rosalin, while the minimum was recorded in Brilliance. The maximum number of ray florets expressed by Rosalin and minimum was recorded in Dana Ellen. Rosalin showed maximum length of ray floret while minimum was expressed in Dana Ellen. The maximum and minimum shelf life of flowers was recorded in Ankur and Golianth respectively. The maximum fresh weight found for Rosalin followed by Stanza, Golianth, Ankur, while minimum was for White House. The highest heritability was recorded fresh flower weight, length of ray floret, stalk length, shelf life, and flower diameter. Flower diameter had maintained positive with number of ray florets per flower, fresh flower weight, dry flower weight and negative with days to first flower, Stalk diameter had expressed negative relationship with shelf life, length of ray floret, dry flowers weight and positive with number of flowers in March as well as with February month. The multivariate clustering observed Atlanta and Golianth formed the first cluster of varieties followed by cluster of Brillance with White House while remaining six varieties formed the last bigger group. Biplot analysis found that Stalk diameter has expressed straight line angle with days to first flower weight and obtuse angles with shelf life.

FUTURE SCOPE

The stalk diameter has expressed not significant associate with days to first flower weight and shelf life under multivariate biplot analysis while considered principal components of flowering traits. Further Bleedings n Gerbera would consider this association among traits.

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Conflict of Interest. Authors declare no conflict of interest for this publication.

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