



## Genetic variability and trait association studies in gerbera (*Gerbera jamesonii*) for quantitative traits\*

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*Gerbera* (*Gerbera jamesonii* Bolus ex Hooker F.), family Asteraceae, is an important cut flower grown for domestic as well as for export market. It is used in floral arrangement, beds, border, pots and rock garden. Investigations have examined various gerbera flower traits using quantitative genetic approaches (Harding *et al.* 1990). Genotypic and phenotypic coefficients of variation are useful in detecting the amount of variability present in the genotypes. The main purpose of estimating heritability and the genetic parameters that compose the heritability estimate is to compare the expected gains from selection based on alternative selection strategies (Holland *et al.* 2003). Correlation analysis is a biometrical technique to find out the nature and degree of associations among various traits. Therefore, information on variability and heritability of plant characters and their association with yield and quality characters are very important. The present study was undertaken to ascertain the magnitude and extent of genetic variability, heritability, genetic advance, and the association of 19 quantitative traits in 17 genotypes of gerbera so as to identify the potential traits for selection.

The present study was carried out at the Research Farm of the Division of Horticulture, ICAR Research Complex for NEH Region, Umiam, Meghalaya during 2008–09. Experimental material consist of 17 genotypes of gerbera, viz. i. Daphne, ii. Diego, iii. Fenna, iv. Ice Queen, v. Jaffana, vi. Lieke, vii. Lion, viii. Lovely Disc, ix. Mayonaise, x. Pound Sterling, xi. Sienna, xii. Stanza, xiii. Soleil, xiv. Torbin, xv. Venicie, xvi. Wall Street and xvii. 68385. The experiment was planned under low cost polyhouse fabricated with UV

stabilized polyfilm (200 $\mu$ ) as a cladding material at the top and the sides with green colour shade net (50%). Tissue culture plants of all genotypes were planted at 30 cm  $\times$  30 cm spacing accommodating 9 plants/m<sup>2</sup>. Uniform cultural practices were followed to all the treatments. The data were recorded on four plants from each genotype in each replication for 19 characters, viz. i. number of leaves/plant, ii. leaf length (cm), iii. leaf breadth (cm), iv. plant spread (cm), v. number of suckers/plant/year, vi. days to bud burst, vii. days to first flower opening, viii. flower diameter (cm), ix. disc diameter (cm), x. stalk length (cm), xi. stalk diameter (mm), xii. fresh weight of stalk (g), xiii. fresh weight of flower head (g), xiv. number of flowers/plant/month, xv. durability of single flower (days), xvi. vase life (days), xvii. length of ray floret (cm), xviii. breadth of ray floret (cm) and xix. number of ray floret/flower head.

The phenotypic and genotypic co-efficient of variation were calculated using the procedure suggested by Singh and Choudhury (1985). Heritability in broad sense and genetic advance expressed in per cent of mean were calculated following the procedure suggested by Burton (1952).

The study revealed wide variations for all the characters indicating sufficient genetic variability to be exploited in a breeding programme (Table 1). In the present study, maximum values for genotypic (148.88) and phenotypic (153.02) variances was observed for days to bud burst, followed by days to first flower opening (140.45 and 142.79, respectively). The least genotypic (0.02) and phenotypic (0.02) variances was observed for breadth of ray florets. Estimates of phenotypic variance and genotypic variance had only a narrow difference for number of leaves/plant, flower diameter, disc diameter, suckers/plant/year, number of flowers/plant/month, stalk diameter, durability of single flower, vase life, ray floret length, ray floret breadth and leaf breadth indicating the fact that these characters are least influenced by environment. Phenotypic coefficient of variation was higher than genotypic coefficient of variation for the characters

\*Short note

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Table 1 Mean, range, variances, genotypic and phenotypic coefficient of variation, heritability and genetic advance for 19 traits in gerbera

Character	Mean	Range	G V	P V	G C V	P C V	Heritability (%)	Genetic Advance	Genetic Advance over mean (%)
Leaves/plant	13.26	9.5–16.66	3.48	4.08	14.06	15.22	85.42	3.29	24.81
Leaf length (cm)	32.71	25.04–45.83	29.69	35.59	16.65	18.23	83.44	9.37	28.64
Leaf breadth (cm)	10.52	7.25–13.87	3.40	3.56	17.52	17.92	95.56	3.63	34.50
Plant spread (cm)	42.16	36.26–51.26	15.55	17.37	9.35	9.88	89.55	7.28	17.26
Suckers/plant/year	3.47	2.49–5.00	0.50	0.52	20.43	20.85	96.07	1.41	40.63
Days to bud burst	118.62	99.58–135.66	148.88	153.02	10.28	10.42	97.29	24.46	20.62
Days to first flower opening	125.88	108.41–143.60	140.45	142.79	9.41	9.49	98.37	24.01	19.07
Flower diameter (cm)	10.40	9.44–11.10	0.24	0.27	4.78	5.04	89.84	0.92	8.84
Disc diameter (mm)	2.85	2.2–3.39	0.09	0.10	10.70	11.44	87.55	0.55	19.29
Stalk length (cm)	56.09	46.79–70.84	39.16	39.41	11.15	11.19	99.34	12.81	22.83
Stalk diameter (mm)	6.31	5.82–7.03	0.15	0.20	6.13	7.12	74.31	0.59	9.35
Fresh weight of stalk (g)	19.17	12.47–27.72	10.85	13.80	17.18	19.37	78.64	5.34	27.85
Fresh weight of flower head (g)	9.56	6.13–12.57	2.38	3.13	16.13	18.50	76.02	2.42	25.31
Number of flowers/plant/month	2.87	2.29–3.69	0.18	0.18	14.65	14.89	96.87	0.84	29.26
Durability of single flower (days)	7.58	5.4–10	1.30	1.37	15.05	15.47	94.64	2.23	29.41
Vase life (days)	8.23	6.22–10.17	1.19	1.23	13.26	13.50	96.52	2.17	26.36
Length of ray floret (cm)	4.51	4.01–5.13	0.11	0.11	7.44	7.51	98.16	0.68	15.07
Breadth of ray floret (cm)	1.18	0.93–1.49	0.02	0.02	14.00	14.19	97.34	0.33	27.96
Number of ray floret/flower	61.43	54.33–69.66	20.86	32.50	7.43	9.28	64.20	6.04	9.83

G V, Genotypic variance; P V, phenotypic variance; GCV, genotypic coefficient of variation; PCV, phenotypic coefficient of variation

studied which indicated greater genotype and environment interaction. Specifically, for the number of flowers/plant PCV and GCV were worked out to be 14.89 and 14.65, respectively. This facilitates for direct selection for improving the performance of specific traits. Similar results were also reported by Nair and Shiva (2003). High (>20%) phenotypic and genotypic coefficient of variation were observed for number of suckers/plant/year, indicating high genetic variability in this trait. It was moderate (10–20%) for leaves/plant, leaf length, leaf breadth, days to bud burst, disc diameter, stalk length, fresh weight of stalk, fresh weight of flower head, number of flowers/plant/month, durability of single flower, vase-life and ray floret breadth. However, plant spread, days to first flower opening, flower diameter, stalk diameter, ray floret length, number of ray floret/flower head showed low (<10%) phenotypic and genotypic coefficient of variation suggesting that these genotypes possessed less variability for the these traits. GCV helps in the measurement of the range of genetic diversity in a character and provide means to compare the genetic variability in the quantitative characters. Burton (1952) has suggested that GCV together with heritability estimates would give the best picture of the amount of advancement to be achieved through selection. The heritable portion of variability was thus determined with the help of broad sense heritability estimates.

In the present study, heritability estimates were ranged from 64.20% (number of ray florets/flower head) to 99.34 (stalk length). The magnitude of heritability in broad sense was high for all the characters. Such high heritability estimates have been found to be helpful in making selection of superior genotypes on the basis of phenotypic performance with respect to the quantitative traits. High heritability was observed for all the traits under study. Nair and Shiva (2003) and Chobe *et al.* (2010) also reported high heritability for most of the quantitative traits in gerbera. High heritability associated with high genetic advance proves more useful for efficient improvement of a character through selection. In the present study, high heritability estimates with high genetic advance was observed for the traits like leaf breadth and number of suckers/plant/year, indicating the possible role of additive gene action. Maji and Dastidar (2005) also reported number of clumps/plant is likely to be controlled by additive genes. High heritability with medium genetic advance as per cent of mean was observed for number of leaves/plant, leaf length, days to bud burst, stalk length, fresh weight of stalk, fresh weight of flower head, number of flowers/plant/month, durability of single flower, vase life and breadth of ray floret indicating presence of dominant and epistatic gene effects inferring that these characters could be improved through hybridization. Plant height, days to first flower opening,

Table 2 Estimates of phenotypic ( $r_p$ ) and genotypic ( $r_g$ ) correlation among 19 quantitative traits in gerbera

Character	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16	X17	X18	X19
X1	1.00	0.15	0.19	0.09	0.35*	-0.28	-0.28	0.14	0.31*	-0.18	-0.37	-0.12	0.16	0.32*	-0.12	0.00	-0.13	-0.16	-0.17
$r_p$																			
X2	1.00	1.00	0.13	0.12	0.38*	-0.32	-0.29	0.19	0.40*	-0.19	-0.44	-0.14	0.23	0.36*	-0.10	0.01	-0.15	-0.19	-0.03
$r_g$																			
X3	1.00	1.00	0.75*	0.31*	0.06	-0.55	-0.58	-0.04	0.51*	0.55*	0.14	0.35*	0.14	0.26	0.08	0.29*	0.07	0.30*	0.12
$r_p$																			
X4	1.00	1.00	0.81*	0.35*	0.05	-0.60	-0.64	-0.04	0.58*	0.61*	0.23	0.49*	0.21	0.31*	0.10	0.33*	-0.01	0.32*	0.17
$r_g$																			
X5	1.00	1.00	1.00	0.21	0.08	-0.67	-0.66	-0.01	0.59*	0.22	0.16	0.36*	0.21	0.52*	0.35*	0.08	-0.12	0.15	0.13
$r_p$																			
X6	1.00	1.00	1.00	0.23	0.09	-0.68	-0.68	-0.01	0.64*	0.22	0.20	0.43*	0.28*	0.53*	0.38*	0.07	-0.14	0.15	0.15
$r_g$																			
X7	1.00	1.00	1.00	1.00	0.11	-0.23	-0.23	0.10	-0.14	0.35*	0.11	-0.02	0.28*	0.26	-0.04	0.43*	0.05	-0.26	-0.09
$r_p$																			
X8	1.00	1.00	1.00	1.00	0.12	-0.25	-0.23	0.12	-0.19	0.37*	0.12	-0.03	0.31*	0.28*	-0.06	0.46*	0.05	-0.28	-0.22
$r_g$																			
X9	1.00	1.00	1.00	1.00	1.00	-0.07	-0.13	0.00	0.08	0.05	-0.23	0.08	-0.10	0.36*	0.30*	0.06	-0.35	0.06	-0.31
$r_p$																			
X10	1.00	1.00	1.00	1.00	1.00	0.98*	-0.09	-0.09	-0.39	-0.07	-0.05	-0.17	-0.29	-0.50	-0.40	-0.31	-0.05	-0.04	-0.14
$r_g$																			
X11	1.00	1.00	1.00	1.00	1.00	1.00	0.10	-0.07	-0.40	-0.07	-0.08	-0.19	-0.32	-0.51	-0.05	-0.31	-0.05	-0.03	-0.02
$r_p$																			
X12	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-0.06	-0.38	-0.11	-0.08	-0.21	-0.28	-0.49	-0.05	-0.30	-0.04	-0.09	-0.14
$r_g$																			
X13	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-0.06	-0.42	-0.11	-0.09	-0.23	-0.30	-0.50	-0.04	-0.31	-0.04	-0.09	-0.16
$r_p$																			
X14	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.31*	0.31*	0.26	-0.13	0.34*	-0.17	0.36*	-0.03	0.45*	-0.28	0.09
$r_g$																			
X15	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.32*	0.33*	0.26	-0.13	0.43*	-0.17	0.37*	-0.04	0.47*	-0.30	0.15
$r_p$																			
X16	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.23	0.13	0.33*	0.26	0.25	0.28*	0.08	0.06	0.13	0.04
$r_g$																			
X17	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.24	0.14	0.41*	0.38*	0.26	0.30*	0.08	0.05	0.13	-0.04
$r_p$																			
X18	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.21	0.22	0.09	-0.00	0.13	0.23	0.45*	0.32*	0.03
$r_g$																			
X19	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.26	0.25	0.09	-0.00	0.14	0.23	0.46*	0.33*	0.05
$r_p$																			
X20	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.33*	0.43*	-0.23	0.28*	0.28*	0.31*	-0.18	0.28*
$r_g$																			
X21	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.47*	0.70*	-0.25	0.32*	0.34*	0.34*	-0.18	0.30*
$r_p$																			
X22	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.33*	0.25	0.11	0.05	-0.01	0.05	0.22
$r_g$																			
X23	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.34*	0.29*	0.12	0.38*	-0.01	0.06	0.37*
$r_p$																			
X24	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-0.01	0.12	0.23	0.08	-0.63	0.20
$r_g$																			
X25	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-0.03	0.13	0.25	0.09	-0.72	0.44*
$r_p$																			
X26	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.14	0.24	-0.04	0.24	-0.23
$r_g$																			
X27	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.15	0.24	-0.04	0.24	-0.03
$r_p$																			
X28	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.04	0.08	0.04	0.15
$r_g$																			
X29	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.05	0.09	0.06	0.18
$r_p$																			
X30	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.22	0.06	-0.07
$r_g$																			
X31	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.22	0.06	-0.08
$r_p$																			
X32	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.32*	0.13
$r_g$																			
X33	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.32*	0.16
$r_p$																			
X34	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.32*	0.16
$r_g$																			
X35	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-0.11
$r_p$																			
X36	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-0.16
$r_g$																			
X37	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
$r_p$																			

\*significant at 5% level of probability

X1 leaves/plant, X2 leaf length (cm), X3 leaf breadth (cm), X4 plant spread (cm), X5 suckers/plant/ year, X6 days to bud burst, X7 days to first flower opening, X8 flower diameter (cm), X9 disc diameter (cm), X10 stalk length (cm), X11 stalk diameter (cm), X12 fresh weight of stalk (g), X13 fresh weight of flower head (g), X14 number of flowers/plant/month, X15 durability of single flower (days), X16 vase life (days),

flower diameter, disc diameter, stalk diameter, length of ray floret and number of ray florets/flower head has low estimates of genetic advance as per cent of mean but high heritability indicating contribution of non-additive gene effect on the expression. These characters demand selection with adequate progeny testing for improvement.

All possible phenotypic and genotypic correlation studies were carried out to reveal the nature of relationship between various growth and flowering related characters. The correlation involving flower yield along with flower diameter, stalk length, stalk thickness, early flowering and vase life deserves special attention as these characters are of primary interest in gerbera breeding. In the present investigation, the estimates of genotypic correlation in general were higher than the phenotypic correlations, indicating the presence of inherent association between various characters (Table 2). Anuradha and Gowda (2002) and Magar *et al.* (2010) have also reported higher genotypic correlation coefficient than phenotypic correlation coefficient among the various traits in gerbera. The study showed positive and significant correlation of number of leaves/plant with number of suckers/plant/year, disc diameter and number of flowers/plant/month both at genotypic and phenotypic level. Significant and positive correlation of number of leaves/plant with number of flowers/plant/year reveals that cut flower production can be increased by selecting for number of leaves as reported by Anuradha and Gowda (2002), and Nair and Shiva (2003). Positive and significant correlation was observed between leaf length and plant spread, disc diameter, stalk length, fresh weight of stalk, ray floret breadth and vase life at both genotypic and phenotypic levels. Positive and significant correlation was observed between leaf breadth and disc diameter, fresh weight of stalk, number of flowers/plant/month, durability of single flower at both levels. Plant spread was significant and positively correlated with stalk length, fresh weight of flower head and vase life at both at genotypic and phenotypic levels, and with number of flowers/plant/month at genotypic level only. Suckers/plant/year were found significant positive correlation with durability of single flower and durability of single flower at both genotypic and phenotypic levels. Days to bud burst were significant and positively correlated with days to first flower opening at phenotypic only.

Flower diameter was significant and positively correlated with disc diameter, stalk length, fresh weight of flower head, durability of single flower, length of ray floret at both genotypic and phenotypic levels. Flower quality characters like stalk length and durability of flowers can be improved simultaneous with the improvement in flower diameter. Significantly positive correlation was found between stalk length and length of ray floret and breadth of ray floret both at genotypic and phenotypic levels. Positive and significant correlation was observed between stalk diameter and fresh weight of stalk, fresh weight of flower head, durability of

single flower, vase-life, length of ray floret and number of ray floret/flower both at genotypic and phenotypic levels. Significant and positive correlation was found between fresh weight of stalk and fresh weight of flower head both at genotypic and phenotypic levels, while it was positively correlated with number of flowers/plant/month, number of ray floret/flower and vase life at genotypic level only. Number of flowers/plant/month, durability of single flower and breadth of ray floret found independent with other quantitative characters under study. Significant and positive correlation was observed between length of ray floret and breadth of ray floret both at genotypic and phenotypic levels.

### SUMMARY

A study was conducted during 2008–09 to estimate the variability, heritability, genetic advance and correlation in 17 genotypes of gerbera for 19 quantitative traits. The phenotypic coefficient of variation was found higher than genotypic coefficient of variation for all the traits under study. High (>20%) phenotypic and genotypic coefficient of variation were observed for number of suckers/plant/year. Leaf breadth and number of suckers/plant/year showed high heritability (95.56% and 96.07%, respectively) coupled with high genetic advance as per cent of mean, indicating presence of additive gene action indicated scope of improving these characters through selection. Flower diameter was significant and positively correlated with disc diameter, stalk length, fresh weight of flower head, durability of single flower, and ray floret length both at genotypic and phenotypic levels.

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