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Research Note

Genetic variability, heritability and genetic advance in chrysanthemum (*Dendranthema grandiflora*) genotypes evaluated for loose flower production

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Abstract
Twenty-five genotypes of chrysanthemum were evaluated for loose flower yield under open field conditions in a Completely Randomized Block Design during the year 2023-24 to ascertain their genetic variability, heritability and genetic advance for various quantitative and qualitative qualities that can be used to choose parents. Analysis of variance exhibited noteworthy variation in the genetic potential of the genotypes for every trait under study. The magnitude of phenotypic coefficient of variation (PCV) for each trait was discovered to be higher than the genotypic coefficient of variation (GCV), which demonstrated an interaction between the genotype and environment. High (>20%) PCV and GCV were noticed for all the traits evaluated in the present study. Heritability estimates ranged from a low 29.78% (stem diameter) to as high as 99.968% (flower diameter). High heritability (>60%) was noted for each of the characteristics except stem diameter. All of the growth, flowering and yield examined, estimates of high heritability combined with high genetic advance as a percentage of mean (GAM) was found, suggesting that potential significance of additive gene action among the genotypes.

Keywords: Chrysanthemum, Genetic variability (GCV, PCV), Heritability, Genetic advance (GAM)

Chrysanthemum (*Dendranthema grandiflora),* a member of the Asteraceae family, is indigenous to Europe and Asia and encompasses annuals, herbaceous perennials, and sub-shrubs. Among its varieties, Chrysanthemum morifolium (syn. Dendranthema grandiflora) stands out as a key player in the floral industry, often referred to as the “Queen of the East” or “Autumn Queen.” It ranks just behind roses and carnations in global cut flower trade and is one of the top five commercially cultivated flower crops in India. Known for its beauty and versatility, chrysanthemum also symbolizes royalty in Japan. The demand for chrysanthemums is steadily increasing due to their diverse forms, sizes, colors, and impressive shelf life. The crop exhibits considerable variation in plant height and growth habit, making it increasingly popular as both a cut flower and a pot plant, although loose flowers are particularly in demand in India.

Performance of chrysanthemum genotypes varies significantly based on local climate, growing conditions, and other environmental factors. Genetic improvement efforts have led to the development of around a thousand varieties, but there remains a need to focus on enhancing this crop further. Identifying specific cultivars suited to different agroclimatic conditions is essential for optimizing production.

To achieve high yield and quality, a thorough understanding of genetic variability within germplasm is crucial. Flower yield, influenced by multiple genes and environmental factors, requires careful assessment of genetic material. Breeding programs benefit from analyzing phenotypic and genotypic coefficients of variation, which inform breeders about the potential for selection based on genetic traits.

Key genetic factors, including heritability, genetic advancement, and coefficients of variation, are critical for successful breeding. These criteria enable breeders to assess the transmission of traits across generations and the performance of cultivars under varying conditions. A comprehensive understanding of these elements is vital for developing improved chrysanthemum varieties that meet market demands.

The present experiment was carried out to investigate the genetic variability, heritability and genetic advancement of different chrysanthemum (*Dendranthema grandiflora*) genotypes obtained from All India Coordinated Research Project on Floriculture, Horticultural Research Station, Sri Konda Laxman Telangana State Horticultural University, Rajendranagar, Hyderabad, Telangana. The experiment comprised of 25 genotypes of chrysanthemum such as Rupanjali, BC-611, HYDC-31, Basanthi, DFR-C-4, Rajahmundry, Lalima, Winter Queen, Local Button, Poornima Yellow, Chandrika, Agnipath, PAU-B-107, Decoction Yellow, Rajat, Halvid, Pusa Centenary, Aparajitha, Paragon Yellow, Gouri, HYDC-2, Sugandha Yellow, HYDC-30, CO-3 and Meera. The genotypes were evaluated in a Randomized Block Design (RBD) with two replications during *Kharif and Rabi* - 2023 at the College of Horticulture, Dr. Y.S.R. Horticultural University, Venkataramannagudem, West Godavari District of Andhra Pradesh. The plants were planted 45 cm apart by 30 cm apart, and all recommended cultivation methods were adopted. In order to record thorough observations and the data for all quantitative and qualitative traits, five competitive plants were randomly tagged in each replication of each treatment. The characters included plant height (cm), plant spread (cm), number of primary and secondary branches, stem diameter (mm), number of leaves, leaf length and width (cm), number of days to first flower bud appearance (d), number of days to 50% flowering (d), number of days to harvest the flowers (d), number of flowers per plant, yield of flowers per plant (g), yield of flowers per plot (kg), yield of flowers per hectare (q/ha), flower diameter (cm), single flower weight (g), shelf life. Analysis of variance was performed on the mean values and estimates of genotypic and phenotypic coefficients of variation (Burton and Devane, 1953) were used to calculate the broad sense heritability, which was expressed as a percentage based on the ratio of genotypic variance to phenotypic variance. Genetic advance as percentage of mean was calculated as per the formula proposed by Robinson *et al.* (1949) and categorized according to Johnson *et al.* (1955). Additionally, investigations on the genetic components for growth, flowering, yield, and quality indicators were carried out.

The genotypes differed significantly (P=0.05) for each of the vegetative growth, physiological, floral, yield and quality traits, according to the analysis of variance for various quantitative traits. The genotypic and phenotypic coefficients of variation, broad sense heritability, genetic advance, genetic advance as a percentage of mean and genetic advance (GCV and PCV) among other genetic factors were analyzed in order to determine the amount of variation causative to genetic factors. The analyzed data (**Table 1**) indicated that there was a significant degree of variability for each attribute in the present study.

High estimates of PCV and GCV (>20%) were noticed respectively for the characters like plant height (26.30% and 26.02%), plant spread (20.43%), number of primary branches (62.86% and 62.65%), number of secondary branches (43.41% and 36.36%), number of leaves per plant (44.70% and 44.34%), leaf length (33.70% and 33.39%), leaf width (31.10% and 30.27%). Kumar and Dewan (2017) noticed greatest difference in the phenotype and genotype for the characters like number of leaves (699.74% and 699.70%) and leaf area (90.62% and 64.87%). Number of branches at 105 days after transplanting exhibited maximum phenotypic coefficient of variation (55.51%). Leaf breadth (18.97%) exhibited lowest genotypic coefficient of variation but number of branches (55.41%) exhibited highest variation.

Moderate estimates of PCV and GCV (10-20%) were noticed for the characters like stem diameter (19.53% and 10.66%). Moderate estimates of GCV (10-20%) was recorded for the traits like plant spread (19.41%).

High heritability (>60%) associated with highest genetic advance (>20%) as per cent of mean was observed respectively for the characters such as plant height (97.9% and 53.03%), plant spread (90.21% and 37.97%), number of primary (99.63% and 128.63%) and secondary branches (70.15% and 62.74%), number of leaves per plant (98.37% and 90.58%), leaf length (98.17% and 68.16%) and width (94.71% and 60.69%). Stem diameter (29.78% and 11.98%) was found with low heritability (<40%) associated with moderate genetic advance (10-20%) as per cent of mean. The present results were found in close concurrence with the earlier results published by Hebbal *et al.* (2018) who revealed that magnitude of phenotypic coefficient of variation (PCV) for each attribute was found to be greater than the genotypic coefficient of variation (GCV) in the results they obtained,

Table 1. Estimates of Variability, Heritability and Genetic Advance as percent of mean for the traits evaluated in the genotypes of Chrysanthemum

Parameter	General Mean	Variance		Coefficient of variation (%)		Heritability (%) (Broad Sense)	Genetic advance @ 5%	GAM @ 5%
		Genotypic (r_g)	Phenotypic (r_p)	GCV	PCV			
Plant height (cm)	31.60	67.60	69.05	26.02	26.30	97.90	16.76	53.03
Plant spread (cm)	31.47	37.33	41.38	19.41	20.43	90.21	11.95	37.97
Number of primary branches per plant	2.09	1.71	1.72	62.65	62.86	99.33	2.69	128.63
Number of secondary branches per plant	7.83	8.09	11.54	36.36	43.41	70.15	4.91	62.74
Stem diameter (mm)	5.57	0.35	1.18	10.66	19.53	29.78	0.67	11.98
Number of leaves per plant	92.51	1682.08	1710.00	44.34	44.70	98.37	83.80	90.58
Leaf length (cm)	4.80	2.57	2.62	33.39	33.70	98.17	3.27	68.16
Leaf width (cm)	2.74	0.69	0.72	30.27	31.10	94.71	1.66	60.69
Number of days to first flower bud appearance (d)	84.46	56.64	58.43	8.91	9.05	96.93	15.26	18.07
Number of days to 50% flowering (d)	121.86	126.46	128.84	9.22	9.31	98.15	22.95	18.83
Number of days to harvest the flowers (d)	108.28	234.10	235.82	14.13	14.18	99.27	31.40	29.00
Number of flowers per plant	59.14	1095.00	1105.05	55.94	56.94	99.09	67.85	114.72
Yield of flowers per plant (g)	80.38	1025.46	1051.71	39.83	40.34	97.50	65.13	81.03
Yield of flowers per plot (kg)	1.92	0.59	0.60	39.85	40.35	97.50	1.56	81.06
Yield of flowers per hectare (q/ha)	33.49	178.03	182.59	39.83	40.34	97.51	27.14	81.03
Flower diameter (cm)	3.96	0.90	0.90	23.92	23.96	99.68	1.95	49.21
Single flower weight (g)	1.57	0.61	0.61	49.49	49.59	99.59	1.60	101.74
Shelf life	3.71	2.26	2.34	41.78	42.46	96.82	3.05	84.69

demonstrating an interaction between the genotype and environment. They observed high (>20%) heritability estimates of PCV and GCV for the characters like number of secondary branches (45.76% and 33.97%), number of leaves (71.92% and 70.95%) and stem girth (23.29% and 22.6%). Bennurmath *et al.* (2022) noticed that number of flowers per plant, plant height, number of branches per plant, number of leaves per plant, flower diameter and days to bud initiation were found to have high (>20%) PCV and GCV values. Estimates of heritability varied from 99% (plant height) to 82% (number of branches per plant).

Moderate range of heritability estimates were identified for the characters like number of secondary branches per plant (55.10%). The traits like plant height (77.7%), number of primary branches (64.3%), number of secondary branches (55.1%), number of leaves (97.3%), and stem girth (94.2%) exhibited high heritability (>60%). Relatively small variation existed between the genotypic and phenotypic coefficients of variation, which suggested that genetic variability contributed very little to overall variability. These variations suggested that chrysanthemum's short flowering period is more genetically controlled than the environment or genetic variability's contribution to total variance. These results were in accordance with the earlier findings noticed by Kore (2014) in Chinese aster and Sathian (2015) in chrysanthemum. Based on the analysis of these results, it could be concluded that the traits like plant height, plant spread, number of primary branches, number of secondary branches, number of leaves per plant, leaf length, leaf width can be used in chrysanthemum breeding programme to make the best use of the variability that is now present. Similar findings were also reported by Janakiram and Rao (1991) in African marigold and Shiragur (2009) in chrysanthemum. In the present study, every trait examined pertaining to flowering, yield and quality measures, exhibited high estimates of heritability combined with high genetic advance as a percentage of mean (GAM) which suggested the potential significance of additive gene action. For every characteristic under investigation in the present study exhibited significant genetic gain in the percentage of mean associated with high heritability. The findings of Misra *et al.* (1987), Choudhary (1987) and Srinivas (1993) were found in close concurrence with the present results.

Floral parameters: High estimates of PCV and GCV (>20%) were noticed respectively for the characters like number of flowers per plant (56.94% and 55.94%), yield of flowers per plant (40.34% and 39.83%), yield of flowers per plot (40.35% and 39.85%), yield of flowers per hectare (40.34% and 39.83%), flower diameter (23.96% and 23.92%), single flower weight (49.59% and 49.49%), shelf life (42.46% and 41.78%). Moderate estimates of

PCV and GCV (10-20%) were noticed respectively for the characters like number of days to harvest the flowers (14.18% and 14.13%). Low estimates of PCV and GCV (<10%) were noticed respectively for the characters like number of days to first flower bud appearance (9.05% and 8.91%), number of days to 50% flowering (9.31% and 9.22%).

High heritability (>60%) associated with highest genetic advance (>20%) as per cent of mean was observed respectively for the characters like number of days to harvest flowers (99.27% and 29.00%), number of flowers per plant (99.09% and 114.72%), yield of flowers per plant (97.50% and 81.03%), yield of flowers per plot (97.50% and 81.06%), yield of flowers per hectare (97.51% and 81.03%), flower diameter (99.68% and 49.21%), single flower weight (99.59% and 101.74%), shelf life (96.82% and 84.69%). The present results were found in close concurrence with the earlier findings of Hebbal *et al.* (2018) who revealed that the magnitude of phenotypic coefficient of variation (PCV) for each trait was found to be greater than the genotypic coefficient of variation (GCV), demonstrating an interaction between the genotype and environment. Number of days to flower bud initiation and number of days to first flower bud appearance exhibited high (>20%) PCV and GCV. Further, they reported that range of heritability estimates were as high as 99.74% for number of days to flower bud initiation. All traits, *viz.,* number of days to flower bud initiation (99.74%), number of days to first flower bud appearance (99.43%), number of days to 50% flowering (99.60%), duration of flowering (96.02%), number of flowers per plant (95.9%), flower yield per plant (89.9%), flower yield per hectare (89.90%), individual flower weight (95.40%), weight of 100 flowers (95.30%), flower diameter (95.30%) and shelf life (94.20%) exhibited high heritability (>60%). Relatively small variation existed between the genotypic and phenotypic coefficients of variation, which suggested that genetic variability contributes very little to overall variability. Similar kind of findings were also reported by Janakiram and Rao (1991) in African marigold and Shiragur (2009) in chrysanthemum. All the vegetative growth, floral, yield and quality measures examined, exhibited high estimates of heritability combined with high genetic advance as percentage of mean (GAM), which suggested the potential significance of additive gene action. Barigidad *et al.* (1992) proposed that additive gene effects were the cause of the high estimates of broad-sense heritability and genetic advancement seen for the number of branches, leaves, leaf area, and flowers/ plant. Sirohi and Behera (2000) showed Characteristics such as disc diameter and number of flowers per plant were found to have higher PCV and GCV estimates, followed by number of branches. Disc diameter, number of petals per plant, number of branches per plant, and yield per plant all showed strong heritability and high genetic advancement. Talukdar *et al.* (2003) concluded that the estimations of GCVs and PCVs made it evident that among growth features, the greatest genetic variation was found in the number of leaves, followed by the number of primary branches per plant, stem thickness, and plant height. The greatest genetic diversity across flower characteristics was evidently seen in GCVs and PCVs for the number of flowers per plant, followed by dry weight and the number of ray florets, and Sathian (2015) also reported similar results in marigold All characters, with the exception of stem girth and leaf count, showed slight discrepancies between genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV). Other characteristics, such as plant height, number of leaves, leaf length, leaf width, 50% flowering, flower diameter, and flower output per plot, showed high heritability in conjunction with genetic advancement.

Kumar and Dewan (2017) reported that dry weight of flower had the highest phenotypic coefficient of variation (89.73%) followed by number of flowers per spray per plant (78.10%), whereas shelf life of flower recorded lowest (19.71%). Dry weight of flower recorded the highest genotypic coefficient of variation (89.17%) followed by number of flowers per spray per plant (78.08%) and leaf breadth (18.97%). Number of flowers per spray per plant recorded highest genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) which indicated that this trait is genetically controlled. Therefore, it is safe to assume that these characters will be chosen for continued development. Every character under investigation, depicted that phenotypic coefficient of variation (PCV) exceeded the genotypic coefficient of variation (GCV) which suggested the influence of environment on genotype expression. Sheela *et al.* (2005) reported similar kind of results in heliconia. Highest heritability was found for the characters like number of leaves (99.98%), number of flowers per spray per plant (99.98%) followed by duration of flowering (99.97%) and number of days to bud initiation (99.95%). Kumar *et al.* (2015) also observed high estimations of heritability in a wide sense for number of flowers per plant, flower diameter and plant height in chrysanthemum.

Bennurmath *et al.* (2022) reported that number of flowers per plant, plant height, number of branches per plant, number of leaves per plant, flower diameter and number of days to bud initiation were found to have high (>20%) PCV and GCV values. Estimates of heritability for varied from 99% (plant height) to 82% (number of branches per plant). For every characteristic under investigation, significant genetic gain in percentage of mean was observed associated with high heritability.

Baskaran *et al.* (2004) reported low coefficients of variation in both genotype and phenotype respectively regarding the characters like number of days taken for 50% flowering (11.97% and 15.43%), number of days taken for flowering from bud initiation (11.97% and 15.43%), flower diameter (33.13% and 34.28%), number of sprays per plant (26.88% and 42.09%), yield per plant (44.05% and 46.06%). Further, results of Srinivas (1993), Choudhary (1987), and Misra *et al.* (1987) in Dahlia were found in concurrence with the present results. Chaugule (1985) observed lower values for the genotypic and phenotypic coefficients of variation with regard to the duration of flowering in chrysanthemum.

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