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Studies on Genetic Variability, Heritability, Correlation and Path Analysis in Chrysanthemum (*Dendranthema grandiflora* Tzvelev)

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ABSTRACT

The studies were conducted in the Division of Flower and Medicinal Crops, ICAR-Indian Institute of Horticultural Research, Bengaluru to evaluate twenty genotypes of chrysanthemum under naturally ventilated polyhouse during 2019–21. The experiments were laid out in CRD with three replications for growth and flowering traits to determine the variability, heritability, genotypic and phenotypic coefficient of variation, correlation and path coefficient among 9 quantitative traits. Results revealed that magnitude of the genotypic coefficient of variation (GCV) was higher than phenotypic coefficient of variation (PCV) for all the traits. High (>20%) PCV and GCV was recorded for number of flowers per plant, plant height, number of branches plant^{-1}, number of leaves plant^{-1}, flower diameter and days to bud initiation. Heritability estimates ranged from 82% (number of branches plant^{-1}) to 99% (plant height). High heritability coupled with high genetic gain as per cent of mean was recorded for all the traits studied. The number of flowers plant^{-1} exhibited positive and significant correlation with number of branches plant^{-1}, number of leaves plant^{-1}, days to bud initiation and days to optimum flowering. Path coefficient analysis using correlation coefficients revealed that days to optimum flowering, plant height and days to bud initiation contributed highest positive direct effect on number of flowers plant^{-1}. Therefore, the selection on the basis of traits *viz*., number of branches plant^{-1}, number of leaves plant^{-1}, days to bud initiation and days to optimum flowering will be more effective for improvement of traits in breeding of chrysanthemum.

KEYWORDS: Chrysanthemum, genetic variability, heritability, correlation, path coefficient

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Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

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1. INTRODUCTION

Chrysanthemum (*Dendranthema grandiflora* Tzvelev) is one of the most popular commercial flower crops grown for cut flower, loose flower and as pot mums belongs to the family Asteraceae. The flower crop is important as ornamental and medicinal (Song et al., 2008). It is native to East Asia (Ahasan et al., 2020) and has been grown in garden for more than 2500 years (Vijayakumari et al., 2019). It is globally the second economically most vital flower crop next to rose and one of the most significant ornamental species (Van Der Ploeg and Heuvelink, 2006). Owing to its trade value, it contributes a very large share of horticultural GDP and world flower trade (Spaargaren and Geest, 2018, Sun et al., 2010). In the United States, it is the number one dollar earner flower and the most reliable. In England, the popularity of chrysanthemum as exhibition flower is at its peak. In India, it is cultivated commercially in states like Karnataka, Tamilnadu, Maharashtra, Rajasthan, Madhya Pradesh and Bihar and its cultivation is popular around the cities like Delhi, Kolkata, Lucknow, Kanpur, Chennai and Bengaluru. In Karnataka, flowers are cultivated in an area of 24,660 ha with total production of 1,85,370 t (Anonymous, 2020).

Genetic diversity is used as source of genes in crop improvement for production of high yielding varieties and hybrids (Kumar, 2014). Access to diverse germplasm pool is crucial for the successful incorporation of novel traits in commercial ornamental crops (Anderson, 2006). Investigation, collection, evaluation, preservation and utilization of resources are important for the sustainable use of the germplasm available (Zhang and Dai, 2009). The characterization of germplasm is essential to provide information on the traits of accessions assuring the maximum utilization of the germplasm collection for the benefit of end user (Li, 2009, Dai et al., 2012). The magnitude of genetic variability in a gene pool is the pre-requisite for a breeding programme (Bhujbal et al., 2013). The knowledge of variability exists in a crop species has important significance to bring about the success in any hybridization programme (Panwar et al., 2013, Sahu and Sharma, 2014). Hence, for effective selection, a thorough study on genotypic and phenotypic variability is essential (Kumari et al., 2017). Correlation studies and further partitioning into various components of yield and other characters are rational approaches to understand the nature and magnitude of their relationship (Dey et al., 2021) as the breeders are always interested in the improvement of several economic characters including yield, the knowledge of correlation among the traits is important to have the idea of concurrent changes which would be brought about in other traits while making selection for one trait (Bennurmath et al., 2021). It is a well-known fact that there exists a complex association among different characters in the plant system. Knowledge of association of various characters should provide necessary information on indirect selection for improvement in flower yield (Henny et al., 2021). The association between two characters is generally through a complicated pathway involving various other attributes which may have direct or indirect effect on the resultant or end character (Lal et al., 2014). So, the direct contribution of the component characters to resultant character from the indirect effects due to the inter relationship of different characters can be determine with the help of path coefficient analysis. It is desirable for plant breeder to know the extent of relationship between yield and its various components, which will facilitate selection based on component traits (Prasad et al., 2011). Keeping in view the above facts, present investigation was undertaken with an objective to analyze and determine the traits having greater interrelationship with number of flowers per plant utilizing the correlation and path analysis and to help breeders in improvement of chrysanthemum.

2. MATERIALS AND METHODS

The present study was carried out in the Division of Flower and Medicinal Crops, ICAR-Indian Institute of Horticultural Research, Bengaluru for two years during 2019–20 and 2020–21. The experimental site was located at 13°58' N Latitude, 78°E longitude and at an elevation of 890 m above mean sea level. A total of 20 genotypes were evaluated for vegetative growth and flowering traits under naturally ventilated polyhouse in completely randomized design with three replications. The genotypes were imposed with photoperiod of 15/9 hours for 30 days after transplanting and black in (dark conditions) until flower bud initiation. The plants were pinched one month after transplanting in order to break their apical dominance so as to increase their lateral spread. After 40 days of transplanting, each plant was supported by 75–80 cm long bamboo stick to keep the plants erect. The recommended dose of fertilizer was applied to the plants and followed by spraying water soluble 19:19:19 N: P: K @ 0.2% twice in a week. Three uniformly grown plants per replication were selected for recording biometrical observations, viz. plant height (cm), number of branches per plant, number of leaves per plant, days to bud initiation, days to first flower opening, days to optimum flowering, flower diameter (cm), number of flowers per plant and flower duration (days). The pooled data were statistically analysed. The genotypic and phenotypic coefficients of variance were calculated as suggested by Burton and De vane (1953) and heritability (broad sense), genetic advance and genetic gain were calculated by the formula given by Johnson et al. (1955).

The correlations and path analysis were done by following method of Dewey and Lu (1959).

3. RESULTS AND DISCUSSION

Significant differences for growth and flowering among the genotypes were revealed by analysis of variance. The substantial improvement of this crop is possible because of the presence of broad variability among the genotypes.

3.1. Estimation of genetic parameters for growth and flowering

Analysis of variance for morphological traits in chrysanthemum is presented in Table 1 revealed that there were highly significant differences observed for different morphological traits such as plant height, number of branches per plant, number of leaves per plant, days to bud initiation, days to first flower opening, days to optimum flowering, flower diameter, number of flowers per plant and flowering duration.

Extent of variability was measured in terms of 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 2. The range of variation was high for number of leaves per plant (59.50–209.33) followed by number of flowers per plant (17.33–104.33). The magnitude of phenotypic coefficient of variation was higher than the genotypic coefficient of variation for all the characters studied, even though the difference was very less. This indicates the role of environment in expression of genotypes. Similar results were also reported by Kumari et al. (2017) in China aster, Satyanarayana et al. (2017) in *Hibiscus sabdariffa* L. High (>20%) PCV and GCV was recorded for number of flowers plant^{-1} (46.31%, 45.45%), plant height (32.14%, 32.02%), number of branches plant^{-1} (33.15%, 30.10%), number of leaves plant^{-1} (31.96%, 31.04%), flower diameter (26.10%, 24.88%) and days to bud initiation (26.08%, 25.03%), respectively. The heritability ranged from 82% in number of branches plant^{-1} to 99% in plant height. All the other traits had heritability estimates of more than 60%. The genetic advance as per cent of mean in different traits ranged from 28.23% (Days to optimum flowering) to 92.01% (Number of flowers plant^{-1}). All the other traits had high genetic advance as per cent of mean of more than 20%. It increases efficiency of selection in a breeding programme by assessing influence of the environmental factors. This has also been reported by Baskaran et al. (2016)

Table 1: Analysis of variance for morphological traits in chrysanthemum

Source of variation	DF	Plant height (cm)	No. of branches plant^{-1}	No. of leaves plant^{-1}	Days to bud initiation	Days to first flower opening	Days to optimum flowering	Flower diameter (cm)	No. of flowers plant^{-1}	Flowering duration (days)
Treatment	19	11,808.99**	160.87**	67,880.21**	1,829.81**	8,389.73**	7,448.68**	61.69**	33,428.04**	1,540.25**
Error	40	60.84	21.66	2,690.33	112.16	394.66	553.66	3.98	952.50	63.00
Total	59	11,869.83	182.54	70,570.54	1,941.98	8,784.40	8,002.35	65.68	34,380.54	1,603.250

Table 2: Genetic parameters for various traits in chrysanthemum

Trait	Range		Coefficient of Variation (%)	GCV (%)	PCV (%)	Heritability (%)	Genetic Advance	Genetic Advance as% mean
	Minimum	Maximum						
Plant height (cm)	26.38	70.77	2.73	32.02	32.14	99	29.54	65.82
Number of branches plant^{-1}	3.50	9.83	13.88	30.10	33.15	82	3.04	56.40
Number of leaves plant^{-1}	59.50	209.33	7.61	31.04	31.96	94	68.46	62.20
Days to bud initiation	11.67	34.33	7.32	25.03	26.08	92	11.06	49.56
Days to first flower opening	31.50	75.33	5.26	19.62	20.31	93	23.88	39.09
Days to optimum flowering	55.50	98.00	4.43	14.32	14.99	91	22.17	28.23
Flower diameter (cm)	1.77	6.02	7.87	24.88	26.10	90	2.01	48.94
Number of flowers plant^{-1}	17.33	104.33	8.90	45.45	46.31	96	48.71	92.01
Flowering duration (days)	23.17	40.83	3.85	16.22	16.67	94	10.33	32.55

GCV: Genotypic Coefficient of variation; PCV: Phenotypic coefficient of variation in chrysanthemum for flower disc diameter and number of flowers per plant, and for number of leaves per plant, number of cut flowers plant^{-1} in chrysanthemum (Baskaran et al. 2016). In chrysanthemum, the high heritability values and genetic advance as per cent of mean was observed in number of flowers per plant and flower diameter as suggested by Henny et al. (2021).

3.2. Phenotypic and genotypic correlation coefficients for various traits

Correlation coefficients among different traits have been analysed (Table 3). In general, the genotypic correlation coefficient was higher than phenotypic correlation coefficient. These correlation coefficients provide a measure of association among traits. In the present study,

Table 3: Phenotypic (P) and genotypic (G) correlation coefficient for 9 quantitative traits in chrysanthemum

Trait		Plant height	No. of branches plant^{-1}	No. of leaves plant^{-1}	Days to bud initiation	Days to first flower flowering	Days to optimum flowering	Flower duration	Flower diameter	No. of flowers plant^{-1}
Plant height (cm)	P	1.000	-0.137	-0.195	0.567**	0.545**	0.472**	0.411**	0.473**	0.028
	G	1.000	-0.154	-0.205	0.586**	0.573**	0.499**	0.425**	0.500**	0.031
No. of branches plant^{-1}	P		1.000	0.538**	0.206	0.024	0.161	0.264*	-0.291*	0.639**
	G		1.000	0.645**	0.217	0.042	0.213	0.302*	-0.37**	0.718**
No. of leaves plant^{-1}	P			1.000	0.342**	0.091	0.246	0.252	-0.058	0.731**
	G			1.000	0.369**	0.106	0.269*	0.259*	-0.049	0.770**
Days to bud initiation	P				1.000	0.693**	0.681**	0.535**	0.422**	0.375**
	G				1.000	0.744**	0.746**	0.580**	0.446**	0.394**
Days to first flower opening	P					1.000	0.953**	0.265*	0.274*	0.183
	G					1.000	0.979**	0.294*	0.284*	0.207
Days to optimum flowering	P						1.000	0.353**	0.229	0.281*
	G						1.000	0.391**	0.253	0.316*
Flowering duration (days)	P							1.000	0.214	0.211
	G							1.00	0.244	0.221
Flower diameter (cm)	P								1.000	0.058
	G								1.000	0.061

Correlation r value at 5%=0.2541, 1%=0.3300; *: Significant at (p=0.05); **: Significant at (p=0.01)

number of flowers per plant has been taken as dependent variable, whereas, remaining 8 characters were considered as independent variables contributing towards number of flowers per plant. The number of flowers per plant exhibited genotypic positive and highly significant correlation with number of branches per plant (0.718), number of leaves plant^{-1} (0.770) and days to bud initiation (0.394), whereas, genotypic positive significant association with days to optimum flowering (0.316). Days to optimum flowering exhibited positive and highly significant correlation with flower duration both at genotypic level (0.391) and phenotypic level (0.353). Plant height exhibited positive and highly significant association with days to bud initiation (0.586), days to first flower opening (0.573), flower duration (0.425), flower diameter (0.50) and days to optimum flowering (0.499). The number of branches plant^{-1} exhibited positive and highly significant association with number of leaves plant^{-1} (0.645). Number of leaves plant^{-1} showed positive and highly significant association with days to bud initiation (0.369), however, it showed positive significant correlation with flower duration (0.259) and days to optimum flowering (0.269). Days to bud initiation exhibited positive and highly significant correlation with days to first flower opening (0.744), flower duration (0.58), days to optimum flowering (0.746) and flower diameter (0.446). However, days to first flower opening exhibited positive and highly significant association with days to optimum flowering (0.979), whereas, positive and significant association with flower duration (0.294) and flower diameter (0.284). Our results are in close agreement with the findings obtained by Kumar and Patil (2003) and Poornima et al. (2007) in China aster and Panwar et al. (2013) in African marigold.

3.3. Path coefficient analysis for various traits

The data presented in Table 4 revealed that days to optimum flowering (3.22) exhibited positive and very high direct effect, while, plant height (0.392) and days to bud initiation (0.599) showed positive and high direct effect, whereas, days to first flower opening (-3.455) had negative and very high direct effect and flower duration (-0.639) had negative

Table 4: Path coefficient analysis for 9 quantitative traits in chrysanthemum

Trait		Plant height	No. of branches plant^{-1}	No. of leaves plant^{-1}	Days to bud initiation	Days to first flower flowering	Days to optimum flowering	Flower duration	Flower diameter	No. of flowers plant^{-1} (rG)
Plant height (cm)	P	0.182	-0.025	-0.035	0.103	0.099	0.086	0.075	0.086	0.028
	G	0.392	-0.060	-0.080	0.230	0.225	0.195	0.166	0.196	0.031
No. of branches plant^{-1}	P	0.065	0.475	0.256	0.098	0.011	0.076	0.125	-0.138	0.639
	G	0.028	0.185	0.119	0.040	0.007	0.039	0.056	-0.068	0.718
No. of leaves plant^{-1}	P	-0.124	0.342	0.636	0.217	0.058	0.156	0.160	-0.037	0.731
	G	0.036	0.114	0.176	0.065	0.018	0.047	0.045	-0.008	0.770
Days to bud initiation	P	-0.050	-0.018	-0.031	-0.091	-0.063	-0.062	-0.049	-0.038	0.375
	G	0.351	0.130	0.221	0.599	0.446	0.447	0.347	0.267	0.394
Days to first flower opening	P	0.024	0.010	0.037	0.285	0.411	0.392	0.109	0.113	0.183
	G	0.982	-0.145	-0.368	-2.572	-3.455	-3.383	-1.016	-0.982	0.207
Days to optimum flowering	P	-0.174	-0.059	-0.091	-0.252	-0.353	-0.370	-0.130	-0.085	0.280
	G	0.608	0.686	0.866	2.404	3.153	3.220	1.261	0.816	0.316
Flowering duration (days)	P	-0.049	-0.031	-0.030	-0.063	-0.042	-0.042	-0.119	-0.025	0.211
	G	-0.272	-0.193	-0.165	-0.371	-0.188	-0.250	-0.639	-0.156	0.221
Flower diameter (cm)	P	0.087	-0.053	-0.010	0.077	0.042	0.042	0.039	0.184	0.058
	G	-0.001	0.008	0.001	-0.001	-0.006	-0.006	-0.004	-0.156	0.061

Diagonal indicates direct effects; Residual effect=0.570; *: Significant at (p=0.05); **: Significant at (p=0.01)

and high direct effect. Number of branches plant^{-1} (0.185) and number of leaves plant^{-1} (0.176) recorded positive but low direct effect, whereas, flower diameter (-0.156) had negative and low direct effect towards number of flowers plant^{-1} at genotypic level. The residual effect is 0.570, due to the characters not considered for the study. This provides the actual information on contribution of the characters and thus forms the basis for selection of suitable characters to improve the yield. Similar results have been reported by Kumar et al. (2011) in chrysanthemum and Veluru et al. (2019) in china aster and number of flowers plant^{-1} (0.551) in chrysanthemum. From the present study, it may be suggested that yield in term of number of flowers plant^{-1} could be increased through selection of genotypes on the basis of number of branches plant^{-1}, number of leaves plant^{-1}, days to bud initiation and days to optimum flowering in chrysanthemum.

4. CONCLUSION

Correlations studies suggested that the genotype having higher number of flowers plant^{-1} would also possess a greater number of branches plant^{-1}, number of leaves plant^{-1}, days to bud initiation and days to optimum flowering. Days to optimum flowering, plant height (0.392) and days to bud initiation exhibited positive and high direct effect towards number of flowers plant^{-1}. Therefore, selection based on these attributes would result in genetic advance for the number of flowers plant^{-1}.

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