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Original Research Paper

Assessment of genetic variability, character association and path coefficient analysis in Chrysanthemum (*Dendranthema* x *grandiflora* Tzvelev)

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ABSTRACT

Thirty-one genotypes of chrysanthemum (*Dendranthema* x *grandiflora* Tzvelev) were evaluated for nine growth and flowering related traits to assess the genetic variability, correlation and path coefficient analysis. Significant differences among genotypes for all the growth and flowering related traits were observed through analysis of variance. The range of variation was high for number of leaves plant^{-1} (66.17-164.50) followed by number of flowers plant^{-1} (30.67-116.83). The magnitude of phenotypic coefficient of variation was higher than the genotypic coefficient of variation for all the characters studied. High (>20%) PCV and GCV was recorded for plant height, number of branches plant^{-1}, number of leaves plant^{-1}, days to bud initiation, days to first flower opening and number of flowers plant^{-1}. Heritability estimates ranged from 77.72% (days to optimum flowering) to 96.93% (number of flowers plant^{-1}). High heritability coupled with high genetic advance as *per cent* of mean was recorded for all the traits studied. Number of flowers plant^{-1} exhibited positive and highly significant correlation with number of branches and leaves plant^{-1}. Path coefficient analysis using correlation coefficients revealed that days to first flower opening (1.564) exhibited positive and very high direct effect, while,number of leaves plant^{-1} (0.347) and flower diameter (0.337) showed positive and high direct effect. Hence, genotypes with superior traits may be considered for further improvement.

Keywords : Chrysanthemum, correlation and path coefficient, genetic variability, heritability

INTRODUCTION

Chrysanthemum (*Dendranthema* x *grandiflora* Tzvelev) is popularly known as '*Guldaudi*' in India and 'Glory of the East' or 'Mum' in USA. It belongs to the family Asteraceae and native to Northern Hemisphere, chiefly Europe and Asia. It is one of the important floriculture crops in the world and ranks second next to rose. It is used as a cut flower, potted plant, and herbaceous perennial, and has been grown in garden for more than 2500 years (Vijayakumari *et al*., 2019). In India, small flowered chrysanthemum is used for making garlands, *venis*, *gajaras* and in religious offerings. There has been increase in the demand for potted chrysanthemum due to its suitability as potted plant in the last few years (Abrol *et al*., 2018). It is a short-day plant; critical photoperiod is ≥13.5 h for vegetative growth and ≤12 h for reproductive development (Cockshull, 1985).

Crop improvement depends on magnitude of genetic variability and its nature and association among key traits for efficient selection. The phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) helps in determining the amount of variability (Allard, 1960). Heritability estimates the relative influence of environment on expression of genotypes. Genetic advance gives an idea about the expected genetic changes, and for efficient selection, high heritability along with high genetic advance can be used (Johnson *et al*., 1955).

Studies on correlation coefficients between various desirable traits would be helpful in indirect selection of desirable traits for crop improvement. The path coefficient analysis is highly effective method to simplify the complex interactions among various traits which reveals the direct and indirect causes of such interactions. Thus, the present study was carried out to assess the genetic parameters of variability, correlation coefficients and path coefficient which would be of great significance in selection of parents for formulating appropriate breeding programme in chrysanthemum.

MATERIALS AND METHODS

The present study was carried out in the Division of Flower and Medicinal Crops, ICAR-Indian Institute of Horticultural Research, Bengaluru, during 2019-20 and 2020-21. The experimental site was geographically located at 13°58' N Latitude, 78°E Longitude and at an elevation of 890 meter above mean sea level. The experiment was carried out to evaluate thirty-one chrysanthemum genotypes for growth and flowering traits under naturally ventilated polyhouse in completely randomized design (CRD) with three replications. The 31 genotypes used as experimental material were A1 Collection, Appu, Arka Chandrakant, Arka Chankdrika, Arka Kirti, Arka Pink Star, Arka Usha Kiran, Arka Yellow Gold, Autumn Joy, Coffee, Fitonia, Flirt, Garden Beauty, Gulmohar, Heritage, Jublee, Marigold, Mayur, NBRI Little Kusum, Pachai Local, Pink Cloud, Ratlam Selection, Rekha, Shukla, Statesman, Sunil, Vasanthika, White Dolley, White Local, White Prolific and Winter Queen.

The plants of all genotypes were raised through terminal cuttings taken from healthy stock plants. After transplanting, plants were imposed with photoperiod of 15/9 hours for 30 days after transplanting and black in (dark conditions) until flower bud initiation. Uniform package of practices was followed throughout the experiment to ensure good growth. Five uniformly grown plants per replication were tagged for recording observations for various growth and flowering traits, *viz*., plant height (cm), number of branches per plant, number of leaves per plant, days to bud initiation, days to first flower opening, number of flowers per plant, optimum flowering, flower diameter (cm) and flowering duration (days). The collected data of both the years were pooled and analyzed statistically.

The analysis of variance for each character was carried out as suggested by Panse and Sukhatme (1985). 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 were calculated as per Al-Jibouri *et al*. (1958) and genotypic correlation coefficient was further partitioned into direct and indirect effect with the help of path coefficient analysis as elaborated by Dewey and Lu (1959).

RESULTS AND DISCUSSION

The analysis of variance revealed significant differences among the genotypes for various growth and flowering characters (Table 1). This infers that among the genotypes, wide range of variability exists and substantial improvement in this crop is possible through selection.

Estimation of genetic parameters for growth and flowering traits

The extent of variability *i.e*. mean, range, mean, and estimates of genetic parameters such as phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability (broad sense) and genetic advance, genetic advance as *per cent* of mean for various traits present in chrysanthemum genotypes studied are presented in Table 2.

The range of variation was high for number of leaves plant^{-1} (66.17-164.50) followed by number of flowers plant^{-1}(30.67-116.83) and days to first flower opening (31.00-88.33). The magnitude of phenotypic coefficient of variation was higher than the genotypic coefficient of variation for all the characters studied, however, difference among GCV and PCV was narrow. This indicates that phenotypic expression of genotypes may be genetically controlled and environment has slight influence, implying that phenotypic variability could be a reliable measure of genotypic variability. Similar results were also reported by Kumari *et al*. (2017) in China aster and Bennurmath *et al*. (2018) in Chrysanthemum. Higher

Table 1 : Analysis of variance (ANOVA) for morphological traits in chrysanthemum

Source of variation	DF	Plant height (cm)	Number of branches plant^{-1}	Number of leaves plant^{-1}	plant^{-1} bud initiation	Days to first flower opening	Days to optimum flowering	Flower diameter (cm)	Number of flowers plant^{-1}	Flowering duration (days)
Treatment	30	8,230.95	58.67 **	13,872.46 **	471.52 **	3,867.80 **	3,852.28 **	22.18 **	9,507.31 **	9,502.86 **
Error	62	0.25	12.81	10.19	1.00	4.74	6.02	4.22	0.08	5.29

Table 2 : Genetic parameters for various growth and flowering traits in chrysanthemum

Trait	Mean	Range		Coefficient of Variation (%)	GCV (%)	PCV (%)	Heritability (%)	Genetic Advance	Genetic advance as per cent mean
		Minimum	Maximum						
Plant height (cm)	59.09	26.92	103.27	7.93	31.12	32.12	93.90	36.71	62.12
Number of branches plant^{-1}	6.35	3.33	9.67	6.92	26.27	27.17	93.51	3.33	52.33
Number of leaves plant^{-1}	99.08	66.17	164.50	7.85	24.55	25.77	90.71	47.71	48.16
Days to bud initiation	21.06	11.17	32.00	7.20	20.85	22.06	89.34	8.55	40.60
Days to first flower opening	59.4	31.00	88.33	6.98	20.45	21.61	89.57	23.68	39.87
Days to optimum flowering	76.23	51.33	104.50	8.04	15.02	17.04	77.72	20.80	27.28
Number of flowers plant^{-1}	63.95	30.67	116.83	6.39	35.92	36.48	96.93	46.58	72.85
Flower diameter (cm)	5.34	3.67	6.90	7.63	18.51	20.02	85.46	1.88	35.24
Flowering duration (days)	44.43	31.17	61.17	8.02	16.41	18.27	80.71	13.49	30.37

GCV: genotypic coefficient of variation; PCV: phenotypic coefficient of variation

phenotypic and genotypic coefficients of variation were recorded for number of flowers plant^{-1}(36.48% and 35.92%), plant height (32.12% and 31.12%), number of branches plant^{-1}(27.17% and 26.27%), number of leaves plant^{-1} (25.77% and 24.55%), days to bud initiation (22.06% and 20.85%) and days to bud first flower opening (21.61% and 20.45%), respectively. For flower diameter, PCV estimates was found to be high (20.02%), and a moderate GCV (18.51%), while, days to optimum flowering (17.04% and 15.02%) and flowering duration (18.27% and 16.41%) showed moderate estimates of PCV and GCV, respectively. Similar results of higher estimates of PCV and GCV were reported in chrysanthemum (Telem *et al*., 2017 and Henny *et al*., 2021), gaillardia (Arulmani *et al*., 2015) and China aster (Rai *et al*., 2017, Bhargav *et al*., 2019 and Nataraj *et al*., 2021).

The genotypic coefficient of variation alone is not enough to measure the heritable variations present among the genotypes. To get the best picture of the amount of advance to be expected from the selections, it should be considered in conjunction with heritability estimates (Burton, 1952). However, for more reliable conclusions, heritability estimates along with genetic gain are more meaningful in predicting the best individual for selection than the heritability value alone (Johnson *et al*. 1955). The heritability estimates for all characters were high (>80%), ranging from 77.72% (days to optimum flowering) to 96.93% (number of flowers plant^{-1}). The genetic advance ranged from 1.88 (flower diameter) to 47.71 (number of leavesplant^{-1}). All the traits had genetic advance as per cent mean estimates of more than 20%, and ranged from 27.28% (days to optimum flowering) to 72.85% (number of flowers plant^{-1}). High values of heritability estimates supplemented with greater genetic gains are indicative of additive gene effects (Narayan *et al*., 1996); therefore, this offers ample scope for efficient selection. High heritability coupled with high expected genetic advance was observed for number of flowers per plant^{-1} and number of branches plant^{-1} (Telem *et al*., 2017), and flower diameter in chrysanthemum (Henny *et al*., 2021) and days to 50% flowering in China aster (Kumari *et al*., 2017 and Nataraj *et al*., 2021).

Phenotypic and genotypic correlation coefficients for various traits

Phenotypic and genotypic correlation analysis is the biometrical technique used to find out the nature and degree of association of traits, prevailing between highly heritable with most economic characters (Khangjarakpam *et al*., 2015). It gives better understanding of the contribution of trait to the genetic make-up of a crop and helps in making indirect

selection for improvement of economically important traits. The high positive correlation between the traits shows that selection for improvement of one character results in the improvement of the other and could be useful in developing an effective selection strategy.

Correlation coefficients among different traits have been worked out and presented in Table 3. In general, the genotypic correlation coefficients were higher than phenotypic correlation coefficients, which may be due to interaction of genotypes with the environment. In the present study, number of flowers per plant has been taken as dependent variable, whereas, remaining eight characters were considered as independent variables contributing towards number of flowers per plant.

The results of correlation coefficient revealed that the number of flowers plant^{-1}exhibited genotypic positive and highly significant correlation with number of branches plant^{-1} (0.415) and number of leaves plant^{-1}(0.392), therefore, there is a scope for direct selection of these characters for improvement in number of flowers plant^{-1}. A correlation study suggests that the genotype having higher number of flowers per plant would also possess a greater number of branches and number of leaves plant^{-1}. Significant and positive correlation of number of flowers per plant with plant height and number of branches in China aster (Sreenivasulu *et al.*, 2007) and chrysanthemum (Khangjarakpam *et al*., 2015 and Telem *et al*., 2017) have been reported.

Plant height exhibited positive and highly significant association with days to bud initiation (0.580), days to first flower opening (0.674), days to optimum flowering (0.599), flower diameter (0.510) and flowering duration (0.521). Positive significant correlation of plant height with flower size in chrysanthemum (Raghava *et al*., 1992) and with days to 50% flowering in China aster (Khangjarakpam *et al*. (2015) has been reported. This leads to the conclusion that the selection of taller plants results in early bud initiation, first flower opening, optimum flowering, maximum flower diameter and longer flowering duration. Therefore, direct selection of this character results in higher flower yield.

Table 3 : Genotypic and phenotypic correlation coefficients for various growth and flowering traits in chrysanthemum

Trait		Plant height (cm)	Number of branches plant^{-1}	Number of leaves plant^{-1}	Days to bud initiation	Days to first flower opening	Days to optimum flowering	Flower diameter (cm)	Flowering duration (days)	Number of flowers plant^{-1}
Plant height (cm)	G	1.000	-0.045	-0.118	0.580**	0.674**	0.599**	0.510**	0.521**	-0.008
	P	1.000	-0.021	-0.117	0.580**	0.663**	0.588**	0.492**	0.501**	-0.008
Number of branches plant^{-1}	G		1.000	0.255*	-0.224*	0.104	0.085	-0.083	0.075	0.415**
	P		1.000	0.094	-0.106	0.072	0.056	-0.026	0.038	0.190
Number of leaves plant^{-1}	G			1.000	-0.274*	0.026	0.044	-0.249*	-0.063	0.392**
	P			1.000	-0.271*	0.022	0.039	-0.242*	-0.061	0.387**
Days to bud initiation	G				1.000	0.621**	0.628**	0.419**	0.324*	-0.209*
	P				1.000	0.612**	0.617**	0.404**	0.311*	-0.208*
Days to first flower opening	G					1.000	0.985**	0.346**	0.584**	0.087
	P					1.000	0.969**	0.332*	0.558**	0.086
Days to optimum flowering	G						1.000	0.301*	0.571**	0.057
	P						1.000	0.30*	0.542**	0.056
Flower diameter (cm)	G							1.000	0.361**	0.112
	P							1.000	0.338**	0.110
Flower duration (days)	G								1.000	-0.010
	P								1.000	-0.009
No. of flowers plant^{-1}	G									1.000
	P									1.000

Correlation r value at 5% = 0.2038; 1% = 0.3357; *Significant at 5% ; **Significant at 1%

The number of branches per plant exhibited positive significant correlation with number of leaves plant^{-1}(0.255), however, it showed negative and significant correlation with number of days to bud initiation (-0.224). Number of leaves plant^{-1}exhibited negative significant correlation with days to bud initiation (-0.274) and flower diameter (-0.249). Days to bud initiation exhibited positive and highly significant correlation with days to first flower opening (0.621), days to optimum flowering (0.628) and flower diameter (0.419), while, positive significant correlation with flowering duration (0.324). However, it showed negative and significant correlation with number of flowers plant^{-1}(-0.209). These results are in close agreement with the findings obtained by Poornima *et al*. (2007) in China aster and Panwar *et al*. (2013) in African marigold.

The days to first flower opening exhibited positive and highly significant association with days to optimum flowering (0.985), flower diameter (0.346) and flowering duration (0.584). Days to optimum flowering showed positive and highly significant association with flowering duration (0.571), while, positive significant correlation with flower diameter (0.324). Flower diameter exhibited positive and highly significant correlation with flowering duration (0.361). These results are in close agreement with the findings of Telem *et al*. (2017) in chrysanthemum and Khangjarakpam *et al*. (2015) in China aster.

Path coefficient analysis for various traits

Path coefficient analysis divides the association between two traits into direct and indirect effects. Considering number of flowers plant^{-1} to be a dependent trait, phenotypic and genotypic coefficients of correlation between number of flowers plant^{-1} and all other characters were further partitioned into direct and indirect effects (Table 4). The residual effect is 0.29, due to the characters not considered for the study.

On portioning the phenotypic correlation into direct and indirect effects, maximum positive and high direct effect on number of flowers plant^{-1}was recorded for days to first flower opening (0.625) followed by number of leaves plant^{-1}(0.353). Positive and moderate direct effect on flower diameter (0.299) and positive and low direct effect on number of branches plant^{-1}(0.111) were also recorded. Kumar *et al*. (2012) observed highest direct positive effect of number of primary branches plant^{-1} on number of flowers per plant in chrysanthemum at the phenotypic level. The high negative direct effect was recorded for number of flowers plant^{-1} through days to optimum flowering (-0.372). The negative direct effect was moderate for

Table 4 : Path coefficient analysis for various growth and flowering traits in chrysanthemum

Trait		Plant height (cm)	Number of branches plant^{-1}	Number of leaves plant^{-1}	Days to bud initiation	Days to first flower opening	Days to optimum flowering	Flower diameter (cm)	Flowering duration (days)	Number of flowers plant^{-1}
Plant height (cm)	P	**-0.084**	0.002	0.010	-0.049	-0.056	-0.050	-0.041	-0.042	-0.008
	G	**-0.234**	0.010	0.028	-0.136	-0.158	-0.140	-0.120	-0.122	-0.008
Number of branches plant^{-1}	P	-0.002	**0.111**	0.011	-0.012	0.008	0.006	-0.003	0.004	0.190
	G	-0.012	**0.267**	0.068	-0.060	0.028	0.023	-0.022	0.020	0.415
Number of leaves plant^{-1}	P	-0.041	0.033	**0.353**	-0.096	0.008	0.014	-0.085	-0.021	0.387
	G	-0.041	0.089	**0.347**	-0.095	0.009	0.015	-0.087	-0.022	0.392
Days to bud initiation	P	-0.170	0.031	0.079	**-0.293**	-0.179	-0.180	-0.118	-0.091	-0.208
	G	-0.094	0.036	0.044	**-0.162**	-0.101	-0.102	-0.068	-0.053	-0.209
Days to optimum flowering	P	0.415	0.045	0.014	0.383	**0.625**	0.606	0.207	0.349	0.086
	G	1.053	0.162	0.040	0.972	**1.564**	1.541	0.541	0.913	0.087
Number of flowers plant^{-1}	P	-0.219	-0.021	-0.014	-0.229	-0.360	**-0.372**	-0.112	-0.201	0.056
	G	-0.794	-0.113	-0.059	-0.832	-1.306	**-1.326**	-0.430	-0.757	0.057
Flower diameter (cm)	P	0.147	-0.008	-0.072	0.121	0.099	0.090	**0.299**	0.101	0.110
	G	0.172	-0.028	-0.084	0.141	0.117	0.109	**0.337**	0.122	0.112
Flowering duration (days)	P	-0.054	-0.004	0.007	-0.033	-0.060	-0.058	-0.036	**-0.107**	-0.009
	G	-0.058	-0.008	0.007	-0.036	-0.065	-0.064	-0.040	**-0.111**	-0.010

days to bud initiation (-0.293), low for flowering duration (-0.107) and negligible for plant height (-0.084). Kumar *et al*. (2012) observed highest direct negative effect on number of flowers plant^{-1} via plant height at the phenotypic level.

At the genotypic level, very high positive and direct contribution was recorded for days to first flower opening (1.564), high for number of leaves plant^{-1} (0.347), and flower diameter (0.337) and moderate for number of branches plant^{-1} (0.267). Kumar *et al*. (2012) showed positive direct effect of day to flowering on number of flowers plant^{-1} in chrysanthemum. However, days to optimum flowering (-1.326) had very high negative direct effect, while, plant height (-0.234) had moderate negative direct effect on number of flowers per plant. Days to bud initiation (-0.162) and flowering duration (-0.111) recorded low negative direct effect. Kumar *et al*. (2012) also observed highest direct negative effect on number of flowers per plant via days to flower bud initiation followed by plant height at flower bud initiation stage in chrysanthemum.

CONCLUSION

The study provides the actual information on contribution of the characters and thus forms the basis for selection of suitable characters to improve the flower yield. It may be suggested for yield in terms of number of flowers per plant, direct selection of traits such as days to first flower opening, number of leaves per plant, flower diameter and number of branches per plant may be effective in selection of Chrysanthemum.

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