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CHARACTER ASSOCIATION AND PATH ANALYSIS IN CHRYSANTHEMUM (*Dendranthema grandiflora* TZVELEV.)

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ABSTRACT

Correlation and path analysis was carried out for 20 genotypes of chrysanthemum under naturally-ventilated polyhouse in completely randomized design during 2019-20 and 2020-21 to indicate the relationship amongst variables and to provide direct and indirect contribution of different quantitative traits. In majority of the characters, genotypic correlation coefficient was found to be higher in magnitude than phenotypic correlation coefficient, indicating a strong inherent association among various characters but their phenotypic expression was impeded by the influence of environmental factors. Days to optimum flowering exhibited significantly positive and high correlation with plant height (0.499), days to bud initiation (0.746), days to first flower opening (0.979), flowering duration (0.391), whereas significantly positive association was observed with number of leaves per plant (0.269) and number of flowers per plant (0.316). The results of path analysis indicated that the days to optimum flowering showed positive and direct effect on days to first flower opening and number of branches per plant, suggesting that these characters can be chosen for further improvement in the breeding programme.

Keywords: Chrysanthemum, Correlation, Path coefficient

Chrysanthemum (family Asteraceae) is one of the commercially important flower crops grown for cut flower as well as pot plant. Due to wide range of flower colour and form, the flower has earned tremendous popularity. The large flower genotypes are generally used for cut flower production, whereas small flowering are grown as pot plant and loose flower production (Kumar *et al*., 2015). Chrysanthemum is a short day plant with flowering controlled by relative length of the day and night. The flowering period under traditional culture is short and varies depending on the geographical location of growing area. So, programmed flowering is essential for year round availability of flowers. The character days to optimum flowering is complex and is the result of interrelationship of various components. Therefore, information on direct and indirect effect of these components is of great importance. Study of such components contributing to optimum flowering may provide a solid ground for year round cultivation. A variety may perform well only in a particular environment and therefore the genetic potentialities of different genotypes and their interaction with environmental condition are to be established and according to their performance, selection of genotypes with best growth and flowering traits needs to be done (Kumar *et al*., 2011). Correlation and path coefficient analysis furnishes information regarding the nature and magnitude of various associations and helps in the measurement of direct influence of one variable on others. The presence and magnitude of genetic variability in a gene pool is the prerequisite of a breeding programme (Bhujpal *et al.,* 2013). It is important to know the direct and indirect effects of other traits on days to optimum flowering are desirable for selecting suitable genotypes for improving the yield. Therefore, present investigations were carried out to generate such information.

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MATERIALS AND METHODS

The experimental material of the present study comprised of 20 genotypes such as Arka Pink Star, Arka Kirti, Arka Yellow Gold, Arka Chandrika, Arka Chandrakant, NBRI Little Kusum, Autumn Joy, Garden Beauty, Rekha, Roopanjali, White Dolley, Kargil, Lalpari, Punjab Gold, Winter Queen, Red Stone, Marigold, Pusa Anmol, and Vijay Kiran. These genotypes were evaluated under different photoperiods for photo insensitivity in chrysanthemum. These genotypes were grown in pot culture under naturally ventilated polyhouse of Division of Flower and Medicinal Crops, ICAR-Indian Institute of Horticultural Research, Bengaluru during 2019-20 and 2020-21 in a completely randomized design with three replications. The cuttings were prepared on 12th July, 2019 (2019-20) and on 1st June, 2020 (2020-21). The well decomposed farmyard manure, red soil, sand and cocopeat at a ratio of 1:1:1:0.5 were used as potting media. The well rooted cuttings were transplanted in 8 inch pots (one plant/pot) on 5th August, 2019 (2019-

20) and on 23rd June, 2020 (2020-21) under naturally ventilated polyhouse and all the recommended practices were followed in the month of August-October. The genotypes were imposed with photoperiod of 15/9 hours for 30 days after transplanting on 20th August to 19th September, 2019 (2019-20) and on 8th July to 10th August, 2020 (2020-21) and black in (dark conditions) was followed on 20th September, 2019 (2019-20) and on 11th August, 2020 (2020-21) until flowering. The observations were recorded on five randomly selected plants of each genotype in all replications on nine quantitative characters such as plant height, number of branches/plant, number of leaves/plant, days to bud initiation, days to first flower opening, days to optimum flowering, number of flowers/plant, flower diameter and flowering duration. Data recorded for both the years were pooled and analysed statistically using OPSTAT software. Mean values were subjected to analysis of variance, genotypic and phenotypic coefficients of variation were estimated based on estimate of genotypic and phenotypic variance (Burton and Devane,1953), broad sense heritability was calculated as ratio of genotypic variance to phenotypic variance and expressed in percentage, genetic advance was calculated using formula given by Robinson *et al.* (1949), genetic advance as per cent over mean was worked out and categorized as suggested by Johnson *et al.* (1955).

RESULTS AND DISCUSSION

Genotypic and phenotypic correlation

The correlation coefficients (genotypic and phenotypic) between different characters in Chrysanthemum are presented in Table 1. In majority of the characters, genotypic correlation coefficient was found to be higher in magnitude than phenotypic correlation coefficient, indicating a strong inherent association among various characters but their phenotypic expression was impeded by the influence of environmental factors.

At genotypic level, plant height exhibited positive and highly significant association with days to bud initiation (0.586), days to first flower opening (0.573), flowering duration (0.425) and flower diameter (0.50). Number of branches per plant exhibited positive and highly significant association with number of leaves per plant (0.645), number of flowers per plant (0.718), however, it showed negative and highly significant correlation with the flower diameter (-0.37), whereas positive significant correlation with flowering duration (0.302). Number of leaves per plant showed positive and highly significant association with the days to bud initiation (0.369) and number of flowers per plant (0.77), however, it showed positive significant correlation with flowering duration (0.259). Days to bud initiation exhibited positive and highly significant correlation with days to first flower opening (0.744), flowering duration

Table 1. Phenotypic (P) and genotypic (G) correlation coefficients for 9 quantitative traits in chrysanthemum

Trait		Plant height (cm)	Number of branches/ plant	Number of leaves/ plant	Days to bud initiation	Days to first flower flowering	Flowering duration (days)	Number of flowers/ plant	Flower diameter (cm)	Days to optimum flowering
Plant height (cm)	P	**1.00**	-0.137	-0.195	0.567**	0.545**	0.411**	0.028	0.473**	0.472**
	G	**1.00**	-0.154	-0.205	0.586**	0.573**	0.425**	0.031	0.500**	0.499**
Number of branches/ plant	P		**1.00**	0.538**	0.206	0.024	0.264*	0.639**	-0.291*	0.161
	G		**1.00**	0.645**	0.217	0.042	0.302*	0.718**	-0.37**	0.213
Number of leaves/ plant	P			**1.00**	0.342**	0.091	0.252	0.731**	-0.058	0.246
	G			**1.00**	0.369**	0.106	0.259*	0.770**	-0.049	0.269*
Days to bud initiation	P				**1.00**	0.693**	0.535**	0.375**	0.422**	0.681**
	G				**1.00**	0.744**	0.580**	0.394**	0.446**	0.746**
Days to first flower opening	P					**1.00**	0.265*	0.183	0.274*	0.953**
	G					**1.00**	0.294*	0.207	0.284*	0.979**
Flowering duration (days)	P						**1.00**	0.211	0.214	0.353**
	G						**1.00**	0.221	0.244	0.391**
Number of flowers/ plant	P							**1.00**	0.058	0.280*
	G							**1.00**	0.061	0.316*
Flower diameter (cm)	P								**1.00**	0.229
	G								**1.00**	0.253
Correlation r =>	5% = 0.2541			1% = 0.3300			* Significant at 5% ** Significant at 1%			

(0.58), number of flowers per plant (0.394) and flower diameter (0.446). Days to first flower opening exhibited positive significant association with flowering duration (0.294) and flower diameter (0.284). Days to optimum flowering exhibited positive and highly significant correlation with plant height (0.499), days to bud initiation (0.746), days to first flower opening (0.979) and flowering duration (0.391), whereas positive significant association with number of leaves per plant (0.269) and number of flowers per plant (0.316).

At phenotypic level, plant height also exhibited positive and highly significant association days to bud initiation (0.567), days to first flower opening (0.545), flowering duration (0.411) and flower diameter (0.473). Number of branches per plant also showed positive and highly significant correlation with number of leaves per plant (0.538), number of flowers per plant (0.639), whereas, the correlation was significantly positive with flowering duration (0.264), however, it was significantly negative with flower diameter (-0.291). Number of leaves per plant exhibited positive and highly significant association with days to bud initiation (0.342) and number of flowers per plant (0.731). Days to bud initiation showed positive and highly significant correlation with days to first flower opening (0.693), flowering duration (0.535), number of flowers per plant (0.375) and flower diameter (0.422) at phenotypic level. Days to first flower opening showed positive significant correlation with flowering duration (0.265) and flower diameter (0.274). Days to optimum flowering exhibited positive and highly correlation with plant height (0.472), days to bud initiation (0.681), days to first flower opening (0.953) and flower duration (0.353), whereas positive significant association was recorded with number of flowers per plant (0.28). Present results are in partial agreement with Deengra *et al*. (2010) in sun flower, Kumar *et al*. (2011), Hebbal *et al*. (2018) and Bindhushree *et al.* (2019) in Chrysanthemum. Kumar and Patil (2003) and Poornima *et al.* (2007) also found the similar results in China aster.

Path coefficient analysis

The correlation coefficient would only indicate the relationship of independent variable with the dependent variable without specifying cause and effect relationship. Using path coefficient analysis, it is possible to resolve the correlations, which will provide direct and indirect contribution of different quantitative traits. The genotypic path coefficient analysis was done for days to optimum flowering. The data pertaining to the phenotypic and genotypic path coefficients for following characters are presented in Table 2. The path coefficient analysis for days to optimum flowering was performed with a set of eight independent characters, *viz*., plant height, number of branches per plant, number of leaves per plant, days to bud initiation, days to first flower opening, flowering duration, number of flowers per plant and flower diameter. In the present investigation, the residual effect of path analysis for genotypic coefficient was observed as 0.224. At phenotypic level, days to

Table 2. Path coefficient analysis for 9 quantitative traits in chrysanthemum

Trait		Plant height	Number of branches/ plant	Number of leaves/ plant	Days to bud initiation	Days to first flower flowering	Flowering Duration (days)	Number of flowers/ plant	Flower diameter (cm)	Days to optimum flowering (rG)
Plant height (cm)	P	**-0.012**	0.001	0.002	-0.007	-0.006	-0.005	-0.004	-0.005	0.472
	G	**-0.030**	0.004	0.006	-0.018	-0.017	-0.013	-0.001	-0.015	0.499
Number of branches/ plant	P	0.013	**0.094**	0.051	0.019	0.002	0.025	0.060	-0.027	0.161
	G	0.034	**0.223**	0.144	0.048	0.009	0.067	0.160	-0.082	0.213
Number of leaves / plant	P	-0.032	0.090	**0.168**	0.057	0.015	0.042	0.123	-0.009	0.246
	G	0.038	0.121	**0.188**	0.069	0.020	0.048	0.144	-0.009	0.269
Days to bud initiation	P	-0.077	-0.028	-0.046	**-0.136**	-0.094	-0.073	-0.051	-0.057	0.681
	G	-0.137	-0.050	-0.086	**-0.234**	-0.174	-0.135	-0.092	-0.104	0.746
Days to first flower opening	P	0.051	0.025	0.093	0.701	**1.012**	0.268	0.186	0.277	0.953
	G	0.634	0.046	0.117	0.823	**1.105**	0.325	0.229	0.314	0.979
Flowering duration (days)	P	0.041	0.026	0.025	0.054	0.026	**0.101**	0.021	0.021	0.353
	G	0.042	0.030	0.026	0.058	0.029	**0.100**	0.022	0.024	0.391
Number of flowers/ plant	P	-0.001	-0.039	-0.045	-0.023	-0.011	-0.013	**-0.061**	-0.003	0.280
	G	-0.048	-0.111	-0.120	-0.061	-0.032	-0.033	**0.008**	0.136	0.316
Flower diameter (cm)	P	0.016	-0.010	-0.002	0.014	0.009	0.007	0.002	**0.034**	0.229
	G	0.068	-0.050	-0.006	0.060	0.038	0.033	0.008	**0.136**	0.253

Diagonal indicates direct effects; rG genotypic correlation with days to optimum flowering @ characters; Residual effect= 0.2240
*Significant at 5% **Significant at 1%

first flower opening (1.012) exhibited positive and very high direct effect, while number of leaves per plant (0.168), flowering duration (0.101) showed positive and low direct effect, whereas days to bud initiation (-0.136) had negative and low direct effect. Number of branches per plant (0.094) and flower diameter (0.034) recorded positive but negligible direct effect, whereas plant height (-0.012) and number of flowers per plant (-0.061) had negative and negligible direct effect towards days to optimum flowering.

Direct effect of biometrical traits on days to optimum flowering

At genotypic level, among the nine characters, days to first flower opening (1.105) exhibited positive and very high direct effect, whereas number of branches per plant (0.223) showed positive and moderate direct effect, whereas, days to bud initiation (-0.234) had negative and moderate effect. Number of leaves per plant (0.188), flower duration (0.10) and flower diameter (0.136) recorded positive but low direct effect. Number of flowers per plant (0.008) recorded positive and negligible direct effect, whereas, plant height (-0.03) had negative and negligible direct effect towards days to optimum flowering.

Indirect effect of biometrical traits on days to optimum flowering

The characters which had shown direct very high and high positive and negative effect on optimum flowering in path coefficient analysis were selected and their indirect effect *via* different traits is furnished. Plant height, flowering duration and flower diameter influenced negligible indirect effect on optimum flowering. Number of branches per plant had positive and low indirect effect on optimum flowering through number of leaves per plant (0.144). Their indirect effects through other traits are negligible. Number of leaves per plant influenced low positive indirect effect on optimum flowering through number of branches per plant (0.121), whereas all other traits are negligible. Days to bud initiation influenced low negative indirect effect on optimum flowering through plant height (-0.137), days to first flower opening (-0.174), flower duration (-0.135) and flower diameter (-0.104), whereas its indirect effects through other traits are negligible. Days to first flower opening influenced high and positive indirect effect on optimum flowering through plant height (0.634), days to bud initiation (0.823) and flower diameter (0.314). However, there was positive moderate indirect effect *via* flowering duration (0.325) and number of flower per plant (0.229), however, positive and low indirect effect through number of leaves per plant (0.117) was observed. Its indirect effect through other traits is negligible. Number of flowers per plant had positive and low indirect effect on optimum flowering through flower diameter (0.136), whereas negative and low indirect effect *via* number of branches per plant (-0.111) and number of leaves per plant (-0.12). The present findings are in close conformity with the reports of Sirohi and Behera (1999) and Kumar *et al*. (2011) in chrysanthemum and Katwate *et al*. (2002) in gladiolus. The results are in conformity with observation made by Hebbal *et al*. (2018) and Bindhushree *et al*. (2019) in chrysanthemum.

To conclude, days to optimum flowering showed highly significant and positive correlation with plant height, days to bud initiation, days to first flower opening and flowering duration, however, it was significant and positively correlated with number of leaves and flowers per plant, both at phenotypic and genotypic level. In path analysis, days to first flower opening exhibited positive and very high direct effect towards days to optimum flowering both at genotypic and phenotypic level.

Authors' contribution

Conceptualization and designing of the research work (PB, RK); Execution of field/lab experiments and data collections (PB, RK, AG), Analysis of data and interpretation (PB, VR, DMV, SN); Preparation of manuscript (PB, RK).

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