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Genetic variability, character association and path coefficient analysis in China aster (*Callistephus chinensis*)

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ABSTRACT

Forty-two genotypes of China aster [*Callistephus chinensis* (L.) Nees] were evaluated in RBD with two replications for growth, flowering, yield and postharvest traits to determine the variability, heritability, genotypic and phenotypic coefficient of variation, correlation and path coefficient among 13 quantitative traits, based on which selection may be made. The study was carried out at the Division of Floriculture and Medicinal Crops, ICAR-Indian Institute of Horticultural Research, Hesaraghatta, Bengaluru during 2015–16 and 2016–17. Results revealed that magnitude of the phenotypic coefficient of variation (PCV) was higher than genotypic coefficient of variation (GCV) for all the traits. High (>20%) PCV and GCV was recorded for plant height, number of leaves per plant, plant spread, flower stalk length, 100 flower weight, number of flowers per plant and weight of flowers per plant. Heritability estimates ranged from 92.32% (number of leaves per plant) to 99.84% (100 flower weight). High heritability coupled with high genetic gain as per cent of mean was recorded for all the traits studied. The weight of flowers per plant was significant and positively correlated with all the economic traits, except for shelf life. Path coefficient analysis using correlation coefficients revealed that number of flowers per plant contributed highest positive direct effect on weight of flowers per plant, followed by weight of 100 flowers. Therefore, the selection on the basis of traits, viz. plant height, number of leaves per plant, plant spread, flower stalk length, 100 flower weight, number and weight of flowers per plant will be more effective for improvement of traits in breeding of China aster.

Key words: China aster, Correlation, Genetic variability, Heritability, Path coefficient

China aster [*Callistephus chinensis* (L.) Nees], belongs to family Asteraceae and is a native of China (Navalinskien *et al.* 2005). *Callistephus* is a monotypic genus, containing single species *C. chinensis* (Khangjarakpam *et al.* 2014) and having diploid (2n) chromosome number 18 (Huziwara 1954). It is one of the most popular flowering annual, commercially grown for cut flower and loose flower purpose, which are used in floral decoration, in bouquets and garlands.

The crop improvement depends on the extent of genetic variability available in the germplasm. This can be determined with the help of phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) which leads to the efficient selection of plants for breeding purpose. High heritability along with high genetic advance can be used for efficient selection (Johnson *et al.* 1955). Indirect selection will be helpful after studying the correlation coefficients between various desirable traits. To simplify the complex interactions among various traits, path coefficient analysis is highly effective method which reveals the direct and indirect causes of such interactions. Quantitative approaches have been used for studying various flowering characters in China aster (Negi *et al.* 1983, Khangjarakpam *et al.* 2015, Tirakannanavar *et al.* 2015). Therefore, the present study was carried out to determine the genotypic and phenotypic coefficient of variation, heritability, correlation coefficients and path coefficient analysis which would be helpful in formulating future breeding programmes in China aster.

MATERIALS AND METHODS

The present study was carried out in the Division of Floriculture and Medicinal Crops, ICAR-Indian Institute of Horticultural Research, Hesaraghatta Lake Post, Bengaluru during 2015–16 and 2016–17. The experimental site was located at 13°58' N Latitude, 78°E Longitude and at an elevation of 890 m amsl. The soil was red loamy with *p*H 7.35 and EC 0.26 dS/m. A total of 42 genotypes were evaluated for vegetative growth, flowering, yield and postharvest life in randomized complete block design with two replications. Twenty plants per replication were planted at a spacing of 30×30 cm under open field conditions. The recommended agronomical practices were adopted to raise the successful crop. Five uniformly grown plants were selected for recording biometrical observations, viz.

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plant height (cm), number of leaves per plant, plant spread (cm), number of branches per plant, days to first flowering, flower stalk length (cm), flower head diameter (cm), weight of 100 flowers (g), number of flowers per plant, weight of flowers per plant (g), duration of flowering (days), vase life (days) and shelf life (days). 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 Al-Jibouri *et al.* (1958) and Dewey and Lu (1959).

RESULTS AND DISCUSSION

Significant differences for growth, flowering, yield and postharvest traits among the genotypes were revealed by analysis of variance. The substantial improvement of this crop is possible due to the existence of wider variability among the genotypes.

Estimation of genetic parameters for growth, flowering, yield and postharvest traits

The amount of variation present in the China aster genotypes was estimated through GCV and PCV. Extent of variability was measured in terms of mean, 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 1. 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 Tirakannanavar *et al.* (2015), Rai *et al.* (2017) and Kumari *et al.* (2017) in China aster. High (>20%) PCV and GCV was recorded for plant height, number of leaves per plant, plant spread, flower stalk length, 100 flower weight, number of flowers per plant and weight of flowers per plant.

The genotypic coefficient of variation helps to measure genetic variability with regard to a character and, therefore, it is not possible to partition existing heritable variation in a population based solely on this estimate. Estimates of heritability in a broad sense give a measure of transmission of characters from one generation to another, thus, giving an idea about the heritable portion of variability which enables the plant breeder to isolate elite selections in the crop. Therefore, to know the existing heritable variations, genotypic coefficient of variation should be considered together with heritability estimates to get the best picture of the amount of advance to be expected from the selections (Burton 1952). However, Johnson *et al.* (1955) suggested that heritability estimates along with genetic gain are more helpful than the heritability value alone in predicting the result for selecting the best individual. Heritability and genetic advance increase efficiency of selection in a breeding programme by assessing influence of the environmental factors, and additive gene action. High heritability estimates with high genetic gain as per cent of mean was observed for all the traits studied. High heritability for all the traits has also been reported by Prakash *et al.* (2017) in Chrysanthemum. High heritability coupled with high genetic advance was also reported for leaf breadth in *gerbera* (Kumar *et al.* 2012), flower yield in African marigold (Panwar *et al.* 2013), number of leaves per plant, leaf area, number of cut flowers per plant in Chrysanthemum (Patil *et al.* 2019).

Phenotypic and genotypic correlation coefficients for various traits in China aster

Correlation coefficients among different traits had been worked out (Table 2). In general, the genotypic correlation coefficients were higher than phenotypic correlation coefficients. This may be due to the interaction of genotypes with the environment. These correlation coefficients provide a measure of association among traits. The significant

Table 1 Genetic parameters for various traits in China aster

Character	Mean ± SEm	Range	GCV (%)	PCV (%)	Heritability (%)	Genetic advance	Genetic gain (%)
Plant height (cm)	45.50 ± 0.66	8.20- 61.8	24.93	25.01	99.33	23.29	51.18
Number of leaves per plant	19.50 ± 0.86	9.20- 32.35	21.68	22.57	92.32	8.37	42.91
Plant spread (cm)	24.54 ± 0.72	8.75- 42.65	32.45	32.72	98.40	16.27	66.31
Number of branches per plant	12.08 ± 0.30	6.65- 17.60	19.68	19.99	96.91	4.82	39.90
Days to first flowering	66.71 ± 0.71	46.85- 100.15	16.89	16.95	99.20	23.11	34.65
Flower stalk length (cm)	35.62 ± 0.72	4.65- 49.10	29.32	29.37	99.65	21.47	60.28
Flower head diameter (cm)	5.39 ± 0.07	3.54- 6.74	15.91	16.01	98.82	1.76	32.58
100 flowers weight (g)	292.02 ± 2.66	105- 548.25	31.97	32.00	99.84	192.17	65.81
Number of flowers per plant	40.92 ± 0.46	7.35- 65.05	34.80	34.84	99.80	29.30	71.62
Weight of flowers per plant (g)	124.49 ± 2.06	7.71- 235.20	48.62	48.68	99.77	124.54	100.00
Duration of flowering (days)	24.92 ± 0.30	16.57- 34.40	19.49	19.57	99.23	9.97	40.00
Vase life (days)	7.06 ± 0.12	5.40- 9.50	14.16	14.37	97.10	2.03	28.74
Shelf life (days)	3.42 ± 0.08	2.35- 4.41	14.20	14.54	95.29	0.98	28.55

Table 2 Phenotypic (P) and genotypic (G) correlation coefficients for 13 traits in China aster

Character		Plant height (cm)	Number of leaves per plant	Plant spread (cm)	Number of branches per plant	Days for first flower opening	Flower stalk length (cm)	Flower head diameter (cm)	100 flowers weight (g)	Number of flowers per plant	Weight of flowers per plant (g)	Duration of flowering (days)	Vase life (days)	Shelf life (days)
Plant height (cm)	P	1.00												
	G	1.00												
Number of leaves per plant	P	0.47**	1.00											
	G	0.48**	1.00											
Plant spread (cm)	P	0.51**	0.62**	1.00										
	G	0.52**	0.63**	1.00										
Number of branches per plant	P	0.47**	0.53**	0.80**	1.00									
	G	0.47**	0.55**	0.81**	1.00									
Days for first flower opening	P	0.54**	0.76**	0.53**	0.46**	1.00								
	G	0.55**	0.79**	0.53**	0.47**	1.00								
Flower stalk length (cm)	P	0.92**	0.52**	0.61**	0.55**	0.49**	1.00							
	G	0.92**	0.54**	0.62**	0.56**	0.49**	1.00							
Flower head diameter (cm)	P	0.66**	0.51**	0.67**	0.61**	0.54**	0.65**	1.00						
	G	0.67**	0.53**	0.67**	0.62**	0.55**	0.66**	1.00						
100 flowers' weight (g)	P	0.54**	0.65**	0.70**	0.54**	0.56**	0.57**	0.75**	1.00					
	G	0.54**	0.67**	0.70**	0.55**	0.56**	0.57**	0.76**	1.00					
Number of flowers per plant	P	0.66**	0.36**	0.46**	0.50**	0.34**	0.78**	0.44**	0.38**	1.00				
	G	0.66**	0.38**	0.46**	0.51**	0.34**	0.78**	0.45**	0.38**	1.00				
Weight of flowers per plant (g)	P	0.64**	0.57**	0.63**	0.58**	0.51**	0.73**	0.66**	0.80**	0.83**	1.00			
	G	0.64**	0.59**	0.63**	0.59**	0.52**	0.73**	0.66**	0.80**	0.83**	1.00			
Duration of flowering (days)	P	0.45**	0.32**	0.61**	0.43**	0.52**	0.44**	0.38**	0.37**	0.43**	0.43**	1.00		
	G	0.46**	0.33**	0.61**	0.43**	0.53**	0.44**	0.38**	0.37**	0.43**	0.43**	1.00		
Vase life (days)	P	0.56**	0.20NS	0.24*	0.22*	0.48**	0.42**	0.35**	0.22*	0.25*	0.23*	0.32**	1.00	
	G	0.57**	0.23*	0.24*	0.24*	0.49**	0.43**	0.36**	0.22*	0.26*	0.23*	0.32**	1.00	
Shelf life (days)	P	0.15NS	0.28*	0.35**	0.37**	-0.03NS	0.17NS	0.15NS	0.25*	0.11NS	0.16NS	0.14NS	-0.14NS	1.00
	G	0.15NS	0.29**	0.36**	0.39**	-0.03NS	0.17NS	0.16NS	0.25*	0.11NS	0.16NS	0.15NS	-0.15NS	1.00

* Significant at (P=0.05), ** significant at (P=0.01) and NS non significant

Table 3 Path coefficient analysis for 12 traits in China aster

Character		Plant height (cm)	Number of leaves per plant	Plant spread (cm)	Number of branches per plant	Days for first flower opening	Flower stalk length (cm)	Flower head diameter (cm)	100 flowers' weight (g)	Number of flowers per plant	Duration of flowering (days)	Vase life (days)	Shelf life (days)
Plant height (cm)	P	-0.101	-0.028	-0.019	0.001	0.047	-0.054	-0.024	0.369	0.483	-0.022	-0.012	-0.003
	G	-0.138	-0.056	-0.018	0.001	0.077	-0.015	-0.029	0.377	0.483	-0.029	-0.014	-0.001
Number of leaves per plant	P	-0.047	-0.059	-0.023	0.002	0.066	-0.031	-0.019	0.440	0.265	-0.016	-0.004	-0.006
	G	-0.066	-0.117	-0.022	0.001	0.111	-0.009	-0.023	0.466	0.275	-0.021	-0.005	-0.003
Plant spread (cm)	P	-0.052	-0.036	-0.038	0.003	0.046	-0.036	-0.024	0.475	0.334	-0.030	-0.005	-0.008
	G	-0.071	-0.074	-0.034	0.001	0.075	-0.010	-0.029	0.488	0.337	-0.040	-0.006	-0.003
Number of branches per plant	P	-0.047	-0.032	-0.030	0.003	0.040	-0.032	-0.022	0.369	0.366	-0.021	-0.005	-0.008
	G	-0.065	-0.065	-0.028	0.002	0.066	-0.009	-0.027	0.382	0.371	-0.028	-0.006	-0.003
Days for first flower opening	P	-0.055	-0.045	-0.020	0.001	0.087	-0.029	-0.020	0.379	0.249	-0.026	-0.010	0.001
	G	-0.075	-0.092	-0.018	0.001	0.140	-0.008	-0.024	0.390	0.250	-0.034	-0.012	0.000
Flower stalk length (cm)	P	-0.092	-0.031	-0.023	0.002	0.042	-0.059	-0.024	0.385	0.567	-0.022	-0.009	-0.004
	G	-0.127	-0.063	-0.021	0.001	0.069	-0.016	-0.029	0.394	0.567	-0.028	-0.010	-0.002
Flower head diameter (cm)	P	-0.067	-0.030	-0.025	0.002	0.047	-0.038	-0.037	0.512	0.323	-0.019	-0.008	-0.003
	G	-0.092	-0.061	-0.023	0.001	0.077	-0.011	-0.044	0.525	0.325	-0.025	-0.008	-0.001
100 flowers' weight (g)	P	-0.055	-0.038	-0.026	0.002	0.048	-0.033	-0.028	0.681	0.280	-0.018	-0.005	-0.006
	G	-0.075	-0.078	-0.024	0.001	0.079	-0.009	-0.033	0.694	0.280	-0.024	-0.005	-0.002
Number of flowers per plant	P	-0.067	-0.021	-0.017	0.002	0.030	-0.046	-0.016	0.261	0.731	-0.021	-0.005	-0.003
	G	-0.092	-0.044	-0.016	0.001	0.048	-0.013	-0.019	0.267	0.729	-0.028	-0.006	-0.001
Duration of flowering (days)	P	-0.046	-0.019	-0.023	0.001	0.045	-0.026	-0.014	0.253	0.315	-0.049	-0.007	-0.003
	G	-0.063	-0.038	-0.021	0.001	0.074	-0.007	-0.017	0.259	0.315	-0.065	-0.008	-0.001
Vase life (days)	P	-0.057	-0.012	-0.009	0.001	0.041	-0.025	-0.013	0.148	0.185	-0.016	-0.021	0.003
	G	-0.079	-0.027	-0.008	0.000	0.069	-0.007	-0.015	0.152	0.188	-0.021	-0.024	0.001
Shelf life (days)	P	-0.015	-0.016	-0.013	0.001	-0.003	-0.010	-0.005	0.170	0.081	-0.007	0.003	-0.023
	G	-0.020	-0.034	-0.012	0.001	-0.004	-0.003	-0.007	0.177	0.080	-0.009	0.004	-0.009

and positive correlation (genotypic and phenotypic) was observed for all the characters with weight of flowers per plant except shelf life. A positive significant correlation of plant height was observed with all other traits except shelf life of flowers. Similar results have been reported by Tirakannanavar *et al.* (2015) and Rai *et al.* (2017) in China aster. The weight of flowers per plant was positively correlated with number of flowers per plant and weight of 100 flowers both at phenotypic and genotypic levels, respectively. There is least variation in the phenotypic and genotypic correlation among the important economic traits revealed that there is negligible environmental influence on the genotype. The results are in accordance with the findings of Khangjarakpan *et al.* (2015) and Rai *et al.* (2017) in China aster.

Similarly, plant spread, number of branches per plant, days for first flower opening, flower stalk length, flower head diameter, 100 flowers weight, number of flowers per plant, duration of flowering were significant and positively correlated with all the economic traits except with shelf life. Panwar *et al.* (2013) and Bharathi *et al.* (2014) in marigold and Rai *et al.* (2017) in China aster also reported similar results.

Path coefficient analysis for various traits in China aster

Path coefficient analysis measures the direct effect of one variable with other and allows separation of correlation coefficient into direct and indirect effects. The path coefficient analysis suggested by Dewey and Lu (1959) specifies the effective measure of the direct and indirect causes of association and depicts the relative importance of each factor involved in contributing to the flower yield per plant. This provides the actual information on contribution of the characters and thus forms the basis for selection of suitable characters to improve the yield. Considering weight of flowers per plant to be a dependent trait, phenotypic and genotypic coefficients of correlation between weight of flowers/plant and all other characters were further partitioned into direct and indirect effects (Table 3). It is evident that both phenotypic and genotypic correlations have direct and indirect effects. High positive direct effect on weight of flowers per plant was recorded for number of flowers per plant followed by 100 flowers weight. The days to first flower opening had low positive direct effect on flower yield per plant. However, at phenotypic and genotypic level, plant height observed least negative direct effect on flower yield per plant, whereas, number of leaves per plant, flower stalk length and duration of flowering observed negative effect on flower yield per plant. The results suggested that there had been change in both magnitude and direction. Similar results have been reported by Khangjarakpam (2015), Rai *et al.* (2017) and Naikwad *et al.* (2018) in China aster; Singh *et al.* (2014) and Choudhary *et al.* (2015) in marigold.

The present study revealed the existence of considerable variation among China aster genotypes and presence of highly heritable economic traits. Based on the information of genotypic and phenotypic correlations and path coefficients analysis, it is suggested that an ideal China aster genotype for getting higher flower yield per plant would possess more plant height, larger flower head diameter, longer stalk length, more weight of 100 flowers and more number of flowers per plant. Therefore, selection based on these attributes would results in genetic advance for flower yield per plant.

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