



Character association and path analysis of quantitative traits among marigold (*Tagetes* sp.) genotypes

BIBIN POULOSE¹, AJAYA PALIWAL², MAMTA BOHRA³, PARUL PUNETHA⁴,
PANKAJ BAHUGUNA⁵ and NAMITA⁶

*Veer Chandra Singh Garhwal University of Horticulture and Forestry, Bharsar,
Uttarakhand 246 123, India*

Received: 3 February 2020; Accepted: 3 July 2020

ABSTRACT

The path-coefficient analysis provides information about direct and indirect effect of other morphological characteristics on flower yield per plant, hence this investigation was undertaken to study the effects of various quantitative traits among marigold (*Tagetes* sp.) genotypes. The genetic variability and heritability in 21 genotypes of marigold confirmed that there is a colossal difference between the genotypes for yield and other 17 traits. The number of ray florets/ flower showed high heritability (99.95) together with high genetic advance (255.77) followed by fresh weight of flower and yield per plant. The study revealed that the PCV is more in comparison with GCV for all the traits which indicates, the contribution of the environment in the expression of traits. Correlation analysis between yield and yield attributing traits in marigold genotypes revealed high positive correlation of flower yield per plant at both phenotypic and genotypic levels with traits like plant height, plant spread, number of primary branches per plant, stem diameter, number of leaves per plant, fresh weight of flower, flower diameter, number of ray florets per flower and flowering duration. Path analysis revealed that the characters like fresh weight of flower and number of flowers per plant are important characters affecting flower yield since they had high direct positive effect. The magnitude of genetic divergence of marigold collected from four different states of India showed the presence of wide genetic diversity. Characters of maximum association with yield have been identified and a selection programme based on the above traits shall be highly effective in improving flower yield of marigold.

Key words: Correlation, Heritability, Marigold, Path analysis, Variability

Marigold (*Tagetes* sp.), a native of South America, is one of the most important ornamental crops grown in India, which belongs to the family Asteraceae (Kaplan 1960). In India, marigold ranks first in the production of loose flowers, followed by chrysanthemum, jasmine, tuberose and crossandra (Anonymous 2014). Among 33 species of the genus *Tagetes*, *T. erecta* (African marigold) and *T. patula* (French marigold) are grown commercially for loose flower production. *T. erecta* is about 90 cm tall hardy annual, flower colour varies from lemon yellow to yellow, golden yellow or orange. Whereas, *T. patula* is compact and about 30 cm tall, flower colour varies from yellow to mahogany-red. Marigold

gained popularity among growers due to its easy culture, wider adaptability, short duration nature, free blooming habit and longer flowering period. It is commonly grown as loose flowers and highly suitable for cultivation under different agro-climatic conditions. Marigold is commonly used for bedding purpose, herbaceous border, decoration and in landscaping owing to its wide range of attractive colors, shape, size and having good keeping quality. Besides this, its leaves and flowers are important for their medicinal value (Tripathy and Gupta 1991), used as a source of pigment for poultry feed and food colourant (Sreekala *et al.* 2002).

Knowledge regarding variability, heritability, genetic advances, genotypic and phenotypic coefficient of variations is essential in a good breeding programme. Coefficient of variation enables a valuable comparison of variation of several characteristics of plants belonging to the same population as well as comparison of the same trait as expressed in different populations (Namita *et al.* 2008). Heritability estimates give information about transmission of characters from one generation to other as the efficiency in selection depends on the heritable portion of the variability, helps the plant breeders in separating the elite selection in the crop. In any crop improvement programme, an understanding

¹Research Scholar (e mail: bibinnilgris@gmail.com),

³Assistant Professor (e mail: mbohragbptu@gmail.com), ⁴Assistant Professor (e mail: parulpunetha@gmail.com), Department of Floriculture and Landscape Architecture, ²Assistant Professor (e mail: ajay.paliwal@gmail.com), Department of Crop Improvement,

⁵Assistant Professor (e mail: pankajbahuguna@rocketmail.com), Department of Basic & Social Sciences, ⁶Senior Scientist (e mail: namitabanyaliari@gmail.com), Division of Floriculture and Landscaping, ICAR-IARI, New Delhi.

of the association between yield and its component traits is imperative. Thus, correlation coefficient based on heritable part of the value provides an efficient basis for selection (Karuppaiah and Kumar 2010). Information on genetic association of characters of marigold is helpful in selection process of breeding. Correlation coefficient helps in selection of a particular trait in breeding programme. Correlation studies alone will not be able to give the exact direct and indirect effects of each of the traits in the yield. In such case the path co-efficient analysis is useful tool for the separation of direct and indirect effects of the component characters in the yield.

MATERIALS AND METHODS

The present investigation was carried out in Department of Floriculture and Landscape Architecture, College of Horticulture, Veer Chandra Singh Garhwali Uttarakhand University of Horticulture and Forestry, Bharsar during 2015-17. Twelve genotypes of African marigold and eight genotypes of French marigold were collected from four different states of India namely, Kerala, Tamil Nadu, Karnataka and Uttarakhand and used as experimental material. The salient features of different genotypes are given in Table 1. The genotypes of marigold were categorized

as per Namita *et al.* (2011). This experiment was laid out in Randomized Block Design with three replications. The seedlings were transplanted at three to four leaf stages during the month of March in raised beds of size 1.1×1 m² at spacing of 40 cm $\times$ 30 cm. Five plants were randomly selected and tagged for recording the observations. The vegetative traits such as plant height (cm), plant spread (cm²), number of primary branches per plant, number of leaves per plant, leaf area (cm²), stem diameter (cm); flowering parameters such as, number of days to first flower bud initiation, number of days to first flower bud opening, number of days for 50 % flowering, flowering duration (days), flower diameter (cm), number of flowers per plant, number of ray florets per flower, fresh weight of the flower (g), number of flowers for $\frac{1}{2}$ meter garland, yield per plant (g) as well as quality parameters such as vase life (days) and shelf life (days) were studied and the data were subjected to statistical analysis as per the procedure described by Gomez and Gomez (1983) for Randomized Complete Block Design. The coefficients of variation were calculated by the formula given by Burton (1952). Heritability in 'broad sense' was calculated by the ratio between genotypic variance to whole phenotypic variance and expressed in percentage (Allard 1960). The expected genetic advance was obtained by

Table 1 Salient features of the genotypes

Genotype	Source/Place of Collection	Plant height	Maturity (Flowering)	Flower form	Flower diameter	Flower colour
Palani Local-1 (AM)	Palani (Tamil Nadu)	Tall	Late	Double	Medium	Light yellow
Palani Local-2 (AM)	Palani (Tamil Nadu)	Tall	Mid season	Double	Medium	Orange
Coimbatore Local (AM)	TNAU, Coimbatore (Tamil Nadu)	Tall	Early	Double	Medium	Yellow orange
Theni Local -1 (AM)	Theni (Tamil Nadu)	Tall	Early	Semi double	Medium	Yellow orange
Theni Local 2 (AM)	Theni (Tamil Nadu)	Tall	Mid season	Single	Medium	orange
Nilgiri Local (AM)	Nilgiri (Tamil Nadu)	Tall	Mid season	Semi double	Medium	Orange
Kotdwara Local-1 (AM)	Kotdwara (Uttarakhand)	Tall	Late	Semi double	Medium	Yellow green
Kotdwara Local-2 (FM)	Kotdwara (Uttarakhand)	Small	Mid season	Single	Small	Dark purple red
Srinagar Local (AM)	Srinagar (Uttarakhand)	Tall	Early	Double	Medium	Orange red
BC-1 (FM)	Bharsar (Uttarakhand)	Tall	Mid season	Single	Small	Red
BC-2 (FM)	Bharsar (Uttarakhand)	Medium	Late	Single	Small	Yellow orange
BC-3 (FM)	Bharsar (Uttarakhand)	Small	Late	Single	Small	Dark purple red
BC-4 (FM)	Bharsar (Uttarakhand)	Medium	Late	Single	Small	Orange red
BC-5 (FM)	Bharsar (Uttarakhand)	Small	Late	Single	Small	Dark purple red
BC-6 (FM)	Bharsar (Uttarakhand)	Medium	Mid season	Single	Small	Red
Haridwar Local (FM)	Haridwar (Uttarakhand)	Tall	Late	Single	Small	Yellow
Pusa Basanti Gaiinda (AM)	IARI, New Delhi	Tall	Mid season	Semi double	Medium	Yellow
Pusa Narangi Gaiinda (AM)	IARI, New Delhi	Tall	Early	Semi double	Medium	Orange red
Pusa Arpita (FM)	IARI, New Delhi	Tall	Mid season	Semi double	Medium	Orange red
Wayanad Local (AM)	Wayanad (Kerala)	Tall	Mid season	Semi double	Medium	Yellow orange
Mysore Local (AM)	Mysore (Karnataka)	Tall	Late	Semi double	Medium	Orange

AM-African Marigold ; FM-French Marigold. Plant height (dwarf, 0–50 cm; medium: 51–65 cm; tall, >65 cm); Maturity (early flowering, 0–60 days; mid season flowering, 61–80 days; late flowering, >80 days); Flower diameter (small: 0–5.00 cm; medium, 6–9 cm; large, >9 cm), (Namita *et al.* 2011)

using the method of Johnson *et al.* (1955). Genotypic and phenotypic correlations are calculated as per the formulae given by Al-Jibouri *et al.* (1958). The direct and indirect paths were obtained by following Dewey and Lu (1959).

RESULTS AND DISCUSSION

Variability analysis

Mean performance of the genotypes and variability are the most important factors which influence the selection in a good breeding programme. Variability helps in the process of selection (Vishnupriya *et al.* 2015). The variation is a result of both environmental as well as genetic variation. Table 2 shows mean, range, PCV, GCV, heritability and genetic advance analyzed for 15 traits. The trait yield per plant shows the highest mean value (412.55) with the range of 94.10 to 731.00 followed by number of leaves per plant, number of ray florets per flower and plant height. The lowest mean value was exhibited by the trait stem diameter (1.53) with the range of 0.96 to 2.1 followed by flower diameter and fresh weight of flower. The estimate of phenotypic coefficient of variation for the characters was higher than that of the genotypic coefficient of variation. This effect is in line with Singh and Singh (2010). The value of genotypic coefficients of variation ranged between 7.58 (Leaf area) and 124.21 (Number of ray florets/flower). The study revealed that phenotypic coefficient of variation ranged between 8.47 (Leaf area) and 124.26 (Number of ray florets/flower). The heritability exhibited was high in case of the entire characters studied which is in confirmation with findings of Namita *et al.* (2008). Heritability ranged

from 73.16 (flowering duration) to 99.95 (plant height). The highest heritability was observed in case of plant height (99.95) followed by number of ray floret/flower (99.94) and number of days for first flower bud initiation (99.73) whereas the lowest value was obtained for flowering duration (73.16). Johnson *et al.* (1955) reported that the heritability values together with estimates of the genetic advance can be extra useful and secure than heritability values alone. Among the many characters studied, flower yield/plant and stem diameter (cm) confirmed high (416.96) and low (0.62) genetic advance, respectively. Genetic advance in percentage (genetic gain) is high in case of the number of ray florets per flower (255.77) followed by fresh weight of flower (146.96) and flower yield/plant (110.10), whereas lowest in the case of leaf area (cm²) with the value of (13.99). Highest GCV and PCV values was exhibited by number of ray floret/flower (124.21, 124.26) followed by fresh weight of flower (71.67, 72.00) and number of flowers/plant (40.66, 41.85) respectively.

Heritability together with genetic advance is useful standards in predicting the resultant effects for selection of superior genotypes (Johnson *et al.* 1995). In this study, high heritability (99.95) together with high genetic advance (255.77) is exhibited by number of ray florets/flower followed by fresh weight of flower and yield per plant. These outcomes are in line with Singh and Singh (2010); Karuppaiah and Kumar (2011) and Anuja and Jahnvi (2012b) in marigold. Similar results of high heritability along with high genetic advance on fresh weight of flower were also reported by Singh *et al.* (2014) and Panwar *et al.* (2013) in African marigold.

Table 2 Variability, heritability and genetic advance of the quantitative traits

Character	Mean	Range	Coefficient of variation		Heritability	Genetic advance	Genetic advance % means
			GCV (%)	PCV (%)			
Plant height (cm)	102.04	34.37-169.71	39.69	39.70	99.94	85.40	81.73
Plant spread(cm)	51.21	34.33-68.10	16.37	16.89	94.00	17.28	32.70
Number of leaves/plant	377.03	197.92-556.14	23.96	24.23	97.83	182.66	48.82
Number of primary branches/plant	18.19	9.15-27.23	25.85	26.62	94.01	8.13	51.73
Stem diameter(cm)	1.53	0.96-2.1	20.94	21.59	94.01	0.62	41.82
Leaf area (cm ²)	29.46	28.71-30.21	7.58	8.47	80.15	3.55	13.99
Number of days for first flower bud initiation	59.90	28.71-91.10	33.31	33.36	99.73	42.83	68.55
Number of days for first flower bud opening	72.00	43.00-101.00	25.03	25.21	98.55	38.00	51.18
Number of days for 50% flowering	88.1	61.00-115.2	18.74	19.27	94.66	34.25	37.56
Number of flowers/plant	89.00	36.30-141.70	40.66	41.85	94.39	56.73	81.37
Flower diameter (cm)	5.79	2.78-8.81	28.75	29.01	98.27	3.22	58.71
Fresh weight of flower (g)	9.15	1.80-16.50	71.67	72.00	99.10	9.73	146.96
Flowering duration (days)	48.16	37.82-58.50	14.35	16.75	73.16	11.52	25.29
Number of ray florets/flower	208.23	5.00-411.46	124.21	124.26	99.95	279.10	255.77
Yield/plant (g)	412.55	94.10-731.00	53.86	54.27	98.50	416.97	110.10

Character association of quantitative traits

The genotypic and phenotypic correlation for different characters and their inter relation between each other is presented in the Table 3. Flower yield is a quantitative character and the expression of which depends upon the interaction of various characters. Yield per plant showed significant and positive correlation at both phenotypic and genotypic levels with plant height (0.670, 0.675), plant spread (0.512, 0.529), number of primary branches per plant (0.771, 0.792), number of leaves per plant (0.645, 0.656), stem diameter (0.339, 0.353), fresh weight of flower (0.788, 0.794), flower diameter (0.707, 0.715), number of ray florets per flower (0.447, 0.450) and flowering duration (0.504, 0.592), respectively. Yield per plant showed significant negative correlation between number of days for 50% flowering (-0.509, -0.525), number of days for first flower bud initiation (-0.650, -0.654) and number of days for first flower bud opening (-0.573, -0.576) at both phenotypic and genotypic level respectively. The phenotypic and genotypic correlation (Table 3 and 4) revealed that the genotypic correlations for all the traits are higher than the phenotypic correlation. Similar results were obtained by Namita *et al.* (2009). This is due to the strong association between the characters and the phenotypic expression which is, minimum under the environment. The results obtained indicate that there is strong association between the morphological traits and the yield. A positive relationship between the favourable characters will help the breeder in simultaneous improvement of both the characters.

Association of plant height (cm), plant spread (cm), number of primary branches per plant, number of leaves per plant, stem diameter (cm), fresh weight of the flower (g), flower diameter (cm), number of ray florets per flower and flower yield per plant are in positive direction with flower yield and the selection of these characters will be helpful in improvement of yield. Similar results were obtained by Panwar *et al.* (2014); Singh *et al.* (2014) and; Bharathi and Jawaharlal (2014) in African marigold, Namita *et al.* (2009) in African and French marigold. Yield per plant showed negative and significant correlation with number of days for 50% flowering, number of days for first flower bud initiation and number of days for first flower bud opening. Similar results were obtained by Karuppaiah and Kumar (2010) in African marigold. Similar results were also obtained by Anuja and Jahn timer (2012a).

It is evident from the correlation studies that the characters, *viz.* plant height, plant spread, number of primary branches per plant, number of leaves per plant, stem diameter, flower diameter, fresh weight of flower, flowering duration and number of ray florets per flower need to be given more importance for selection during breeding for higher flower yield in African marigold.

Path analysis

Path analysis is used in partitioning the total correlation coefficient into direct and indirect effects, which helps us in measuring the relative importance of casual factors

individually (Namita *et al.* 2009). In the present study the total yield per plant is a dependent variable and the rest of the 14 characters are independent variables. Table 4 showed the direct and indirect effects of the characters on yield per plant. Table 4 revealed that the maximum direct positive effect on the yield per plant was contributed by fresh weight of the flower (1.220, 0.644) followed by number of flowers per plant (0.282, 0.538) at both genotypic and phenotypic levels, respectively. Traits which contributes to the direct positive effects also includes number of primary branches per plant (0.207, 0.181), followed by plant height (0.140, 0.059). Fresh weight of the flower contributed very high positive and indirect effect towards flower yield per plant at genotypic level through flower diameter (1.147), number of ray florets per flower (0.937), number of primary branches per plant (0.868), plant height (0.860), flowering duration (0.703), number of leaves per plant (0.671), plant spread (0.586), and stem diameter (0.482); low positive and indirect effect through leaf area (0.149). Its high negative indirect effect on flower yield per plant through number of days for first flower bud initiation (-0.905) followed by number of days for 50% flowering (-0.793), number of flowers per plant (-0.620) and number of days for first flower bud opening (-0.442). Regarding indirect effects at phenotypic level (Table 4), it was observed that the fresh weight of the flower had the highest positive indirect effect via flower diameter (0.601) followed by the number of ray floret (0.492), plant height (0.451), number of primary branches per plant (0.443), number of leaves per plant (0.348), flowering duration (0.320), plant spread (0.300) and moderate positive and indirect effect via stem diameter (0.246).

Fresh weight of flower contributed negligible positive and indirect effect via stem diameter (0.079). The classification of direct and indirect effect is carried out based on Bharathi *et al.* (2014). Both weight per flower and number of flower per plant showed a very high direct effect on yield at both phenotypic and genotypic levels (Table 4) and their correlation was also positive with yield. This indicates that these traits were important yield components and the effective improvement in yield could be achieved through selection based on these characters. These findings were in accordance with Anuja and Jahn timer (2012a) in French marigold, Bharathi *et al.* (2014) in African marigold, Kanwar and Saha (2009) in French marigold, Karuppaiah and Kumar (2010) in African marigold. Significant association and direct effects were observed for various yield attributing traits that provide the opportunity to maximally improve the yield through its contributing traits in a sustainable way. On the basis of path analysis it may be concluded that the characters like fresh weight of flower and number of flowers per plant are important characters affecting flower yield since they have high direct positive effect and these characters should be given more importance in the further crop improvement programme.

The above study unambiguously revealed that the selection of characters based on correlation, path analysis may helpful in increasing the success of breeding

Table 3 Phenotypic and genotypic correlation of different traits of marigold

Character	CV	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	P	0.505**	0.599**	0.512**	-0.146	0.377**	0.701**	-0.461**	-0.539**	-0.479**	0.764**	0.484**	-0.341**	0.374**	0.670**
	G	0.523**	0.616**	0.517**	-0.158	0.389**	0.705**	-0.473**	-0.540**	-0.482**	0.772**	0.485**	-0.350**	0.438**	0.675**
2	P		0.466**	0.316*	-0.008	0.399**	0.466**	-0.334**	-0.439**	-0.384**	0.442**	0.261*	-0.025	0.249*	0.512**
	G		0.514**	0.339**	-0.022	0.426**	0.480**	-0.351**	-0.452**	-0.395**	0.450**	0.268*	-0.031	0.297*	0.529**
3	P			0.744**	-0.054	0.432**	0.688**	-0.540**	-0.636**	-0.585**	0.659**	0.530**	-0.156	0.385**	0.771**
	G			0.748**	-0.060	0.465**	0.712**	-0.581**	-0.655**	-0.607**	0.691**	0.547**	-0.168	0.458**	0.792**
4	P				0.076	0.162	0.540**	-0.536**	-0.591**	-0.532**	0.455**	0.430**	-0.064	0.415**	0.645**
	G				0.084	0.171	0.550**	-0.558**	-0.598**	-0.540**	0.466**	0.435**	-0.065	0.463**	0.656**
5	P					-0.056	0.122	-0.086	-0.132	-0.136	0.049	0.376**	-0.268*	0.194	-0.142
	G					-0.075	0.122	-0.100	-0.149	-0.156	0.035	0.418**	-0.315*	0.217	-0.178
6	P						0.381**	-0.468**	-0.422**	-0.446**	0.450**	0.306*	-0.152	0.006	0.339**
	G						0.395**	-0.487**	-0.435**	-0.462**	0.470**	0.319**	-0.164	0.042	0.353**
7	P							-0.631**	-0.737**	-0.686**	0.932**	0.764**	-0.487**	0.497**	0.788**
	G							-0.650**	-0.742**	-0.694**	0.940**	0.768**	-0.508**	0.576**	0.794**
8	P								0.910**	0.956**	-0.537**	-0.390**	0.196	-0.338**	-0.509**
	G								0.933**	0.980**	-0.557**	-0.401**	0.201	-0.421**	-0.525**
9	P									0.969**	-0.653**	-0.503**	0.194	-0.624**	-0.650**
	G									0.974**	-0.661**	-0.504**	0.202	-0.733**	-0.654**
10	P										-0.611**	-0.439**	0.189	-0.483**	-0.573**
	G										-0.619**	-0.442**	0.201	-0.581**	-0.576**
11	P											0.719**	-0.604**	0.453**	0.707**
	G											0.725**	-0.633**	0.539**	0.715**
12	P												-0.604**	0.414**	0.447**
	G												-0.623**	0.482**	0.450**
14	P													-0.074	0.033
	G													-0.080	0.020
15	P														0.504**
	G														0.592**

*, **Significant at 5 % and 1 % level respectively. G—Genotypic correlation, P—Phenotypic correlation. 1. Plant height (cm), 2. Plant spread (cm), 3. Number of primary branches per plant, 4. Number of leaves per plant, 5. Leaf area (cm²), 6. Stem diameter (cm), 7. Fresh weight of the flower (g), 8. Number of days for 50% flowering, 9. Number of days for first flower bud initiation, 10. Number of days for first flower bud opening, 11. Flower diameter (cm), 12. Number of ray florets per flower, 13. Number of flowers per plant, 14. Flowering duration (days), 15. Yield per plant (g).

Table 4 Direct (bold) and indirect effects of different traits on yield per plant in marigold at genotypic and phenotypic level

Character	CV	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	G	0.140	-0.018	0.127	0.089	0.022	0.058	0.860	-0.225	-0.309	0.329	-0.313	-0.095	-0.099	0.108	0.675**
	P	0.059	-0.013	0.108	0.046	0.004	-0.008	0.451	0.014	0.183	-0.218	0.282	-0.047	-0.183	-0.008	0.670**
2	G	0.073	-0.035	0.106	0.059	0.003	0.064	0.586	-0.167	-0.258	0.269	-0.183	-0.052	-0.009	0.073	0.529**
	P	0.030	-0.026	0.084	0.028	0.000	-0.008	0.300	0.010	0.149	-0.175	0.163	-0.025	-0.013	-0.006	0.512**
3	G	0.086	-0.018	0.207	0.130	0.008	0.070	0.868	-0.276	-0.374	0.414	-0.280	-0.107	-0.047	0.113	0.792**
	P	0.036	-0.012	0.181	0.066	0.002	-0.009	0.443	0.016	0.216	-0.267	0.243	-0.052	-0.084	-0.009	0.771**
4	G	0.072	-0.012	0.155	0.173	-0.012	0.026	0.671	-0.265	-0.342	0.368	-0.189	-0.085	-0.018	0.114	0.656**
	P	0.030	-0.008	0.134	0.089	-0.002	-0.003	0.348	0.016	0.201	-0.242	0.168	-0.042	-0.034	-0.009	0.645**
5	G	-0.022	0.001	-0.012	0.015	-0.138	-0.011	0.149	-0.048	-0.085	0.106	-0.014	-0.082	-0.089	0.053	-0.178
	P	-0.009	0.000	-0.010	0.007	-0.029	0.001	0.079	0.003	0.045	-0.062	0.018	-0.037	-0.144	-0.004	-0.142
6	G	0.054	-0.015	0.096	0.030	0.010	0.150	0.482	-0.232	-0.249	0.315	-0.191	-0.062	-0.046	0.010	0.353**
	P	0.022	-0.010	0.078	0.014	0.002	-0.021	0.246	0.014	0.143	-0.203	0.166	-0.030	-0.082	0.000	0.339**
7	G	0.099	-0.017	0.147	0.095	-0.017	0.059	1.220	-0.309	-0.424	0.474	-0.381	-0.150	-0.143	0.141	0.794**
	P	0.042	-0.012	0.124	0.048	-0.004	-0.008	0.644	0.019	0.250	-0.312	0.344	-0.074	-0.262	-0.011	0.788**
8	G	-0.066	0.012	-0.120	-0.097	0.014	-0.073	-0.793	0.476	0.534	-0.668	0.226	0.078	0.057	-0.103	-0.525**
	P	-0.027	0.009	-0.098	-0.048	0.002	0.010	-0.406	-0.030	-0.309	0.436	-0.198	0.038	0.106	0.008	-0.509**
9	G	-0.076	0.016	-0.135	-0.103	0.021	-0.065	-0.905	0.444	0.572	-0.664	0.268	0.098	0.057	-0.180	-0.654**
	P	-0.032	0.011	-0.115	-0.053	0.004	0.009	-0.475	-0.027	-0.339	0.442	-0.241	0.049	0.104	0.014	-0.650**
10	G	-0.068	0.014	-0.125	-0.093	0.022	-0.069	-0.847	0.466	0.557	-0.682	0.251	0.086	0.057	-0.143	-0.576**
	P	-0.028	0.010	-0.106	-0.047	0.004	0.009	-0.442	-0.029	-0.329	0.456	-0.226	0.043	0.102	0.011	-0.573**
11	G	0.108	-0.016	0.143	0.081	-0.005	0.071	1.147	-0.265	-0.378	0.422	-0.406	-0.142	-0.179	0.133	0.715**
	P	0.045	-0.012	0.119	0.041	-0.001	-0.009	0.601	0.016	0.222	-0.278	0.369	-0.070	-0.325	-0.010	0.707**
12	G	0.068	-0.009	0.113	0.075	-0.058	0.048	0.937	-0.191	-0.288	0.301	-0.294	-0.195	-0.176	0.119	0.450**
	P	0.029	-0.007	0.096	0.038	-0.011	-0.006	0.492	0.012	0.171	-0.200	0.265	-0.097	-0.325	-0.009	0.447**
13	G	-0.049	0.001	-0.035	-0.011	0.044	-0.025	-0.620	0.096	0.115	-0.137	0.257	0.122	0.282	-0.020	0.020
	P	-0.020	0.001	-0.028	-0.006	0.008	0.003	-0.314	-0.006	-0.066	0.086	-0.223	0.059	0.538	0.002	0.033
14	G	0.061	-0.010	0.095	0.080	-0.030	0.006	0.703	-0.200	-0.419	0.396	-0.219	-0.094	-0.022	0.246	0.592**
	P	0.022	-0.007	0.070	0.037	-0.006	0.000	0.320	0.010	0.212	-0.220	0.167	-0.040	-0.040	-0.022	0.504**

Genotypic residual effect=0.0574, Phenotypic residual effect =0.0418. *, **=Significant at 5 % and 1 % level respectively. G—1 Genotypic effect, P—Phenotypic effect. 1. Plant height (cm), 2. Plant spread (cm), 3. Number of primary branches per plant, 4. Number of leaves per plant, 5. Leaf area (cm²), 6. Stem diameter (cm), 7. Fresh weight of the flower (g), 8. Number of days for 50% flowering, 9. Number of days for first flower bud initiation, 10. Number of days for first flower bud opening, 11. Flower diameter (cm), 12. Number of ray florets per flower, 13. Number of flowers per plant, 14. Flowering duration (days), 15. Yield per plant (g).

programme. An exploitable amount divergence among the genotypes which when grouped in to heterotic pools with the help of cluster analysis can save time, effort and money of breeders working for the improvement of marigold as more genetic divergence is positively associated with the increased amount of heterosis

REFERENCES

- Al-Jabouri RA, Miller P A and Robinson H F. 1958. Genotypic and environmental variance in upland cotton cross of interspecific origin. *Agronomy Journal* **50**: 633–7.
- Allard R W. 1960. *Principles of Plant Breeding*. John Wiley and Sons Inc., New York. USA, pp 82-98.
- Anonymous. 2014. Indian Horticulture Database-2014, Ministry of Agriculture, Government of India.
- Anuja S and Jahnvi K. 2012. Correlation and path co-efficient analysis in French marigold. *Asian Journal of Horticulture* **7**(2): 269–71.
- Anuja S and Jahnvi K. 2012. Variability, heritability and genetic advance studies in French marigold (*Tagetes spatula* L.). *Asian Journal of Horticulture* **7**: 362–4.
- Bharathi U T and Jawaharlal M. 2014. Correlation and path analysis in African marigold (*Tagetes erecta* L.). *Bioscan* **9**(4): 1673–6.
- Burton G W. 1952. Quantitative inheritance in grasses. *Proceedings of 6th International. Grassland Congress* **1**: 277–83.
- Dewey D R and Lu K G. 1959. A correlation and path analysis of yield components of crested wheat grass seed production. *Agronomy Journal* **15**: 513–8.
- Gomez K A and Gomez A A. 1983. *Statistical Procedures for Agricultural Research*, pp 357-427. John Wiley and Sons Inc., New York.
- Johnson H W, Robinson H F and Comstock R L. 1995. Estimates of genetic and environmental variability in soybean. *Agronomy Journal* **47**: 314–28.
- Kanwar P and Saha T N. 2009. Character association and path analysis studies in French marigold. *Annals of Horticulture* **2**(1): 39–42.
- Kaplan L. 1960. Historical and ethanobotanical aspects of domestication of tagetes. *Economic Botany* **11**: 200–2.
- Karuppaiah P and Kumar P S. 2010. Correlation and path analysis in African marigold (*Tagetes erecta* L.). *Electronic Journal of Plant Breeding*. **1**(2): 217–20
- Karuppaiah P and Kumar P S. 2011. Variability, heritability and genetic advance for yield, yield attributes and xanthophylls content in African marigold (*Tagetes erecta* L.). *Crop Research* **41**(1,2& 3): 117–9.
- Namita, Kanwar P S, Raju D V S and Prasad K V. 2008. Studies on genetic variability, heritability and genetic advance in French marigold (*Tagetes patula*) genotypes. *Journal of Ornamental Horticulture* **12**: 30–4.
- Namita, Kanwar P S, Bharadwaj C, Prasad K V and Raju D V S. 2009. Studies on character association and path analysis of quantitative traits among parental lines of marigold (*Tagetes erecta* and *T. patula*) and their interspecific F₁ hybrids. *Indian Journal of Horticulture* **66**(3): 348–52.
- Panwar S, Singh K P, Janakiram T and Namita. 2013. Genetic variability, heritability and genetic advance in African marigold (*Tagetes erecta* L.) genotypes. *Progressive Horticulture* **45**: 135–40.
- Panwar S, Singh K P, Namita, Janakiram T and Bharadwaj C. 2014. Character association and path coefficient analysis in African marigold (*Tagetes erecta* L.). *Vegetos* **27**(1): 26–32.
- Singh K P, Raju D V S, Namita, Janakiram T. 2014. Determination of genetic variation for vegetative and floral traits in African marigold (*Tagetes erecta*). *Indian Journal of Agricultural Sciences* **84**(9): 1057–62.
- Singh A K and Singh D. 2010. Genetic variability, heritability and genetic advance in marigold. *Indian Journal of Horticulture* **67**: 132–6.
- Sreekala C, Raghava S P S, Misra R L and Maini S B. 2002. Path analysis for total carotenoid yield in African marigold. *Journal of Ornamental Horticulture* **5**(2) : 8–10.
- Tripathy A K and Gupta K K. 1991. Plant phenolics of *Tagetes erecta*. *Fitoterapea*. **62**(1): 91–2.
- Vishnupriya A K, Jawaharlal M and Manivannan N. 2015. Variability studies in African marigold (*Tagetes erecta* L.). *Bioscan* **10**: 407–9.