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Character Association And Path Co-Efficient Analysis In Marigold

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ABSTRACT
An investigation was carried out with 20 genotypes of marigold to assess association of yield components and their direct and indirect effects on flower yield. All the quantitative traits had a significant correlation (genotypic and phenotypic) coefficient with flower yield per plant except stalk length. Perceptibly the genotypic correlation coefficients were generally higher than the corresponding phenotypic correlation coefficients. Results of correlation coefficient analysis indicated that the flower yield per plant was found to be significantly and positively correlated with number of flowers per plant, flower size, number of secondary branches per plant, fresh weight of plant, number of buds per plant, days taken to first flowering, duration of flowering and fresh weight of flower. Stalk length showed a negative association with flower yield per plant. The highest direct positive effect on number of flowers per plant was exhibited by number of buds per plant followed by number of secondary branches per plant and plant spread. Thus, the present study indicated that number of secondary branches per plant, dry weight of plant, and higher stalk length are important characters in deciding the flower yield per plant. Hence these characters may be considered as selection indices in marigold improvement programme.
Key words : Correlation coefficient, Marigold, Path coefficient analysis, Yield components

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INTRODUCTION

Among loose flowers, marigold is one of the most important commercial flower crop grown world over and are valued for their spectacular flowers, attractive colours, shape, size and good keeping quality. It is native to the South and Central America, especially Mexico, where it is being utilized in traditional medicine as well as for ornamental purpose (19). In India, marigold ranks first among the loose flowers followed by chrysanthemum, jasmine, tuberose and crossandra (12). Genus *Tagetes* consists of 33 species, out of these species, *Tagetes erecta L.*, commonly called African marigold, and *Tagetes patula L.* popular as French marigold are of great horticultural importance and is grown commercially for exquisite blooms. Both the species of marigold are suitable for garden display and grown commercially for use as cut flowers and loose flowers. Apart from the great demand for loose flowers during festival seasons, industrial uses of carotenoids extracted from flowers are being used commercially in pharmaceuticals, food supplements, animal feed additives and colorants in food and cosmetics. Many multinational companies are being involved for extraction of carotenoid pigments from the flower petals. To improve the yield through selection of better varieties, knowledge of the nature of association of flower yield and its components is very essential. Correlation coefficient is the significant selection parameter in plant breeding. It is used to find out the degree (strength) and direction of relationship between two or more variables. In plant breeding, correlation coefficient analysis measures

the mutual relationship between various plant characters and determines the component character, on which, selection can be based for genetic improvement in yield, which is a very complex phenomenon. It is not only polygenic in nature but is also affected by environment. Hence, selection of the superior plants
based on yield performance as such is usually not very effective. For selecting superior genotypes, the breeder has to choose from the material on the basis of its phenotypic expression. For most of the traits, the knowledge about degree of phenotypic and genotypic correlation of the traits is important. Simple correlation coefficient indicates association between any two characters but does not give a complete picture of complex relationship. Therefore, it is essential to have path coefficient analysis in order to get clear picture of association among characters, as it splits the correlation coefficient into the measure of direct and indirect effects of a set of independent variables (characters) on the dependant variable through other component traits. With this background information, a study on correlation and path coefficient analysis was undertaken in marigold.

MATERIAL AND METHODS

The experiment was conducted at Citrus Research Station, Tirupati from November, 2016-17 and September, 2017-18. The soil of the experimental field is red loamy with ph 6.4. The region lies in Seshachalam hill ranges dominated by sedimentary rocky-hilly terrain It receives an average rainfall of 900- 1000 mm with tropical conditions and remains almost free from frost. During summers the temperature touches the mark of 42-45 degrees centigrade, whereas during winters it falls to 18- 20^{o}C. The source of planting material is from Indian Institute of Horticultural Research, Namdhari Seeds and Indus Seeds Bangalore.

The materials utilized for the present study consisted of 20 genotypes of African marigold (*Tagetes erecta J).* Raised nursery beds of size 3.0 x 1.0 m were first prepared and drenched with captan (0.01%). Seeds of different genotypes were sown in lines. The nursery beds were watered daily twice for first 10 days and daily once for the remaining period. The seedlings were ready for transplanting at 28-30 days after sowing. One month old, healthy, vigorous and uniform seedlings were selected and transplanted in 60 beds during September. The plot size was kept 3 x 3 mt and in each plot consisted of 30 plants and they were transplanted at a spacing of at a spacing of 30 x 30 cm in beds of at a depth of 6-8 cm in three replications. All the fertilizer and protection measures were carried out as per the recommendations. Five plants were selected in each replication of each genotype for taking observations after discarding the border plants at both the ends. Observations were recorded on growth, flowering and yield characters on five randomly selected plants. The pooled data of both the years were analyzed as suggested by (2) for correlation coefficient and direct and indirect effects on the growth and flowering traits on number of flowers/pant were assessed by the path coefficient analysis after the method suggested by (7,23).

RESULTS AND DISCUSSION

The genotypic and phenotypic correlation coefficients were computed in all possible combinations for 15 quantitative characters and are presented in Tables 1 and 2. In the present study, the magnitude of correlation coefficient at genotypic level was found higher than the corresponding correlation at phenotypic level. It indicates that there is a strong inherent association between various characters under studied. It is mainly due to genetic and environmental sources of variation which affected the trait through different physiological mechanisms (8), pleiotropy, linkage and environmental effects being more common in experimental and breeding populations of cross fertilized one and in the population derived from crosses between inbred lines (1). Similar results were noticed in the earlier studies conducted by [3, 20, 21) in marigold and in gladiolus (4), who observed higher genotypic correlation than the corresponding phenotypic correlation coefficients for most of the characters studied.

The statistically significant and positive correlation (genotypic and phenotypic) was observed in most of the characters with flower yield per plant except stem diameter, stalk length and number of primary branches per plant, dry weight of plant, days taken for first flower opening, duration of flowering. The flower yield per plant exhibited highly significant and positive correlation with fresh weight of flower followed by dry weight of flower, flower

diameter, number of secondary branches per plant, fresh weight of stem, plant spread, stalk length, plant height. Similar findings have also been reported by [12, 16, 21] in marigold. Significantly genotypic correlation between other characters and flower yield suggested that the genes which influence these characters will tend to influence the character under study [6].

Plant height showed highly significant and positive correlation with dry weight of plant followed by plant spread, stalk length, number of flowers per plant, number of flowers per plant, fresh weight of stem however non significant and negative correlation was observed with duration of flowering at both genotypic and phenotypic level. High significant and positive correlation between plant height and dry weight of plant was observed in gerbera (22). These results are in agreement with the findings in gerbera (14) and in gladiolus [5].

Plant spread expressed highly significant and positive association with dry weight of flower followed by dry weight of flower, fresh weight of flower, number of flowers per plant, stalk length. It was also reported [18] that plant spread was significant and positive correlated with number of flower per plant, flower weight, flower size, duration of flowering and flower yield. Similar results were also obtained by [20] in French marigold and [12] in African marigold.

Table 1: Genotypic correlation coefficients among various characters in marigold

Traits	X_{-1}	X_{-2}	X_{-3}	X_{-4}	X_{-5}	X_{-6}	X_{-7}	X_{-8}	X_{-9}	X_{-10}	X_{-11}	X_{-12}	X_{-13}	X_{-14}	X_{-15}
X_{-1}	1.000	0.672**	0.252	0.650**	0.163	0.485*	0.577**	0.708**	0.177	-0.137	0.638**	0.328	0.141	0.407	0.483*
X_{-2}		1.000	0.201	0.459*	-0.143	0.292	0.185	0.321	0.247	0.133	0.484*	0.566**	0.402	0.586**	0.572**
X_{-3}			1.000	0.480*	0.309	0.073	0.441	0.626**	0.370	-0.416	0.398	0.292	0.273	0.436	0.193
X_{-4}				1.000	0.186	0.342	0.444*	0.702**	0.162	-0.071	0.660**	-0.011	0.018	0.102	0.142
X_{-5}					1.000	0.141	0.343	0.171	0.112	-0.383	-0.090	0.179	0.342	0.158	0.145
X_{-6}						1.000	0.652**	0.542*	-0.092	0.268	0.742**	0.303	0.185	0.342	0.627**
X_{-7}							1.000	0.844**	0.311	0.183	0.528*	0.458*	0.390	0.535*	0.596**
X_{-8}								1.000	0.285	-0.076	0.759**	0.249	0.134	0.414	0.419
X_{-9}									1.000	-0.010	0.038	0.452*	0.483*	0.526*	0.354
X_{-10}										1.000	0.029	0.268	0.262	0.116	0.317

X-11											1.000	0.202	-0.023	0.341	0.485*
X-12												1.000	0.835**	0.900**	0.901**
X-13													1.000	0.774**	0.674**
X-14														1.000	0.844**
X-15															1.000

*significant at 5% level, ** significant at 1% level

Where,

X-$_1$: Plant height (cm); X-$_5$: No of primary branches per plant; X-$_9$: Days taken to first flower opening X-$_{13}$: Flower diameter (cm)

X-$_2$: Plant spread (cm); X-$_6$: No of secondary branches per plant; X-$_{10}$: Duration of floweringX-$_{14}$: Dry weight of flower (g)

X-$_3$: Stem diameter (cm); X-$_7$: Fresh weight of stem (g); X-$_{11}$: No of flowers per plantX-$_{15}$: Flower yeild per plant (g)

X-$_4$: Stalk length (cm); X-$_8$: Dry weight of plant (g) X-$_{12}$: Fresh weight of flower (g)

Table 2: Phenotypic correlation coefficients among various characters in marigold

Traits	X-$_1$	X-$_2$	X-$_3$	X-$_4$	X-$_5$	X-$_6$	X-$_7$	X-$_8$	X-$_9$	X-$_{10}$	X-$_{11}$	X-$_{12}$	X-$_{13}$	X-$_{14}$	X-$_{15}$
X-$_1$	1.000	0.669**	0.251	0.650**	0.162	0.484*	0.576**	0.707**	0.174	-0.137	0.634**	0.327	0.140	0.406	0.483*
X-$_2$		1.000	0.201	0.457*	-0.143	0.290	0.185	0.320	0.243	0.133	0.482*	0.564**	0.401	0.582**	0.571**
X-$_3$			1.000	0.477*	0.308	0.072	0.439	0.622**	0.360	-0.413	0.395	0.290	0.269	0.430	0.192
X-$_4$				1.000	0.186	0.341	0.443	0.702**	0.160	-0.071	0.657**	-0.011	0.017	0.102	0.141
X-$_5$					1.000	0.140	0.341	0.170	0.111	-0.382	-0.088	0.178	0.341	0.156	0.145

X-6						1.000								
X-7							1.000							
X-8								1.000						
X-9									1.000					
X-10										1.000				
X-11											1.000			
X-12												1.000		
X-13													1.000	
X-14														1.000
X-15														

0.625**	0.595**	0.418	0.350	0.317	0.482*	0.900**	0.672**	0.842**	1.000
0.341	0.534*	0.412	0.517*	0.117	0.338	0.896**	0.770**	1.000	
0.183	0.390	0.133	0.476*	0.262	-0.022	0.833**	1.000		
0.301	0.458*	0.248	0.442	0.267	0.201	1.000			
0.740**	0.525*	0.755**	0.035	0.029	1.000				
0.267	0.183	-0.076	-0.010	1.000					
-0.092	0.307	0.281	1.000						
0.541*	0.842**	1.000							
0.650**	1.000								
1.000									

*significant at 5% level, ** significant at 1% level

Where,

X_{-1}: Plant height (cm) , X_{-5}: No of primary branches per plant, X_{-9}: Days taken to first flower opening, X_{-13}: Flower diameter (cm)

X_{-2}: Plant spread (cm), X_{-6}: No of secondary branches per plant, X_{-10}: Duration of floweringX_{-14}: Dry weight of flower (g)

X_{-3}: Stem diameter (cm), X_{-7}: Fresh weight of stem (g), X_{-11}: No of flowers per plant, X_{-15}: Flower yield per plant (g)

X_{-4}: Stalk length (cm), X_{-8}: Dry weight of plant (g), X_{-12}: Fresh weight of flower (g

Table 3. Direct (diagonal) and indirect (above and below diagonal) effects of fifteen characters on number of flowers per plant in marigold at genotypic level

Traits	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	r_g
X_1	**0.011**	-0.259	-0.039	0.313	-0.020	0.476	-0.610	0.668	0.008	-0.003	0.369	-0.061	0.157	-0.372	0.638**
X_2	0.008	**-0.386**	-0.031	0.221	0.018	0.286	-0.195	0.302	0.011	0.003	0.636	-0.175	0.226	-0.440	0.484*
X_3	0.003	-0.077	**-0.153**	0.231	-0.039	0.071	-0.466	0.590	0.017	-0.008	0.328	-0.118	0.168	-0.149	0.398
X_4	0.007	-0.177	-0.074	**0.481**	-0.023	0.335	-0.469	0.662	0.007	-0.001	-0.013	-0.008	0.039	-0.109	0.660**
X_5	0.002	0.055	-0.047	0.089	**-0.125**	0.139	-0.363	0.161	0.005	-0.007	0.201	-0.148	0.061	-0.112	-0.090
X_6	0.005	-0.113	-0.011	0.165	-0.018	**0.981**	-0.690	0.511	-0.004	0.005	0.341	-0.080	0.132	-0.482	0.742**
X_7	0.006	-0.071	-0.068	0.214	-0.043	0.640	**-1.057**	0.796	0.014	0.003	0.515	-0.169	0.206	-0.458	0.528*
X_8	0.008	-0.124	-0.096	0.338	-0.021	0.532	-0.892	**0.943**	0.013	-0.001	0.280	-0.058	0.159	-0.322	0.759**
X_9	0.002	-0.095	-0.057	0.078	-0.014	-0.090	-0.329	0.269	**0.046**	0.000	0.508	-0.209	0.202	-0.272	0.038
X_{10}	-0.002	-0.051	0.064	-0.034	0.048	0.263	-0.194	-0.072	-0.001	**0.019**	0.301	-0.114	0.045	-0.244	0.029
X_{11}	0.004	-0.218	-0.045	-0.005	-0.022	0.297	-0.485	0.235	0.021	0.005	**1.125**	-0.362	0.347	-0.693	0.202
X_{12}	0.002	-0.155	-0.042	0.009	-0.043	0.181	-0.413	0.126	0.022	0.005	0.939	**-0.434**	0.298	-0.518	-0.023
X_{13}	0.005	-0.226	-0.067	0.049	-0.020	0.336	-0.566	0.390	0.024	0.002	1.013	-0.336	**0.385**	-0.649	0.341
X_{14}	0.005	-0.221	-0.030	0.068	-0.018	0.615	-0.630	0.395	0.016	0.006	1.013	-0.292	0.325	**-0.769**	0.485*

*significant at 5% level,** significant at 1% level,Residual effect: 0.169

Where,

X_1: Plant height (cm) , X_5: No of primary branches per plant X_9: Days taken to first flower opening X_{13}: Dry weight of flower (g)

X_2: Plant spread (cm), X_6: No of secondary branches per plant, X_{10}: Duration of flowering X_{14}: Flower yeild per plant (g)

X_3: Stem diameter (cm) X_7: Fresh weight of stem (g), X_{11}: Fresh weight of flower (g) r_g : correlation with no of flowers per plant
X_4: Stalk length (cm) X_8: Dry weight of plant (g), X_{12}: Flower Diameter (cm)

The number of secondary branches per plant had highly significant and positive correlation with number of flowers per plant, fresh weight of stem, dry weight of plant, days taken to first flowering opening and duration of flowering, whereas it showed negative correlation with flower diameter. The results are in accordance with the findings of (16, 17) in marigold. Fresh weight of stem expressed a highly significant and positive correlation with all the characters except days taken to first flower opening, duration of flowering, flower diameter which is non significant and positive. Duration of flowering had non significant and positive association with number of flowers, fresh weight of flower, flower diameter and dry weight of flower. Similar results were obtained in marigold where duration of flowering showed significant and positive correlation with flower yield and harvest index [18].
Number of flowers per plant exhibited significantly higher genotypic and phenotypic relationship with flower yield per plant, whereas non significant and negative correlation was observed with flower diameter. Similar results were also obtained in gerbera [14] and in marigold [11, 18].
Flower diameter showed highly significant and positive correlation with fresh weight of flower followed by dry weight of flower and flower yield per plant. It was observed in African marigold that significant and positive correlation of flower head weight and flower yield per plant with flower head diameter [11]. Correlation coefficient between two characters may not give a complete picture of complex characters, which is controlled by many traits either directly or indirectly. A better picture of the contribution of each component building up the total genetic architecture of a complex character may be obtained through the analysis of causal schemes. Hence, in such a situation, path coefficient analysis devised by [23] had been useful in partitioning direct and indirect causes of association, which allows a detailed examination of specific forces acting to produce a given correlation and measures the relative importance of each causal character.
In present study, path coefficient analysis was computed both at genotypic levels for all the characters. Path coefficient analysis was carried out by taking number of flower per plant as dependent variable to partition correlation coefficients into direct and indirect effects in order to determine the contribution of different characters towards the number of flowers per plant. The data on direct and indirect effects of various characters along with their genotypic correlation coefficient with number of flowers per plant are presented in Table 3.
The critical evaluation of path coefficient analysis both at genotypic level, in which diagonal values represented direct effects, indicates that the number of buds per plant had the highest direct and positive effect on number of flowers per plant. Traits which contribute positive direct effects on number of flowers per plant, included number of flowers per plant, number of secondary branches per plant, dry weight of plant, stalk length, flower diameter at genotypic level . Similar results were reported in African marigold [16] where number of buds per plant, plant height, plant spread and number of branches exhibited high indirect on number of flowers per plant, The results are in accordance with the findings of in gladiolus [4].
Though plant spread, stem diameter, stalk length, number of primary branches per plant, fresh weight of stem, fresh weight of flower, dry weight of flower exhibited negative direct effects on number of flowers per plant at genotypic level, The residual effect of the genotypic path analysis was low (0.169) indicating that the characters considered for path analysis were appropriate. These findings are in line with those of [10, 18] in marigold.

CONCLUSION

Based on the information of genotypic path coefficients analysis, it is suggested that the an ideal genotypes marigold for getting higher number of flowers per plant and flower yield per plant would be that possess more number of secondary branches per plant, dry weight of plant and higher stalk length. Hence these characters may be considered as selection indices in marigold breeding programme.

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