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# Association and path analysis in marigold (*Tagetes* spp.) genotypes under drought stress conditions

**Aparna Srinivasan, M Kannan, R Ravikesavan, P Jeyakumar and S Subramaniam**

**Abstract**
Thirty-two genotypes of marigold were collected and used for evaluating of correlation co-efficient and path analysis. Based on correlation and path coefficient analyses of 12 characters, results revealed that selection should be primarily, based on the component characters which exhibited significant positive correlation with yield and also had either direct or indirect effect on yield. In the present study, results strongly confirmed the reliability of the characters *viz*., number of branches per plant, number of flowers per plant, shoot fresh weight, root fresh weight, root-shoot ratio and single flower weight as they have a high direct effect on yield per plant and also possess strong positive and significant association with yield which aids in breeding of marigold genotypes that can tolerate drought stress and simultaneously perform well in terms of flower yield under drought stress conditions. Thus, the above characters should be given a prime importance during selection in marigold breeding programme.

**Keywords:** Correlation, direct effect, indirect effect, yield, marigold

## Introduction
Marigold (*Tagetes* spp.) gained popularity among the growers due to its easy culture, wide adaptability, different colour, shape, size and good keeping quality with a short duration. It is used for making garlands, wreaths and religious offerings, ideal for garden display and has a medicinal property as it is an excellent and important source of carotenes, xanthophyll's, lutein and zea-xanthin (Hojnik *et al*., 2008) [8]. Such a flower with aesthetic and medicinal use is definitely to be evaluated for its commercial use for availing its benefit even during stressful conditions.

The success of selection depends on the choice of selection criteria for improving flower yield in which studies on correlation will provide information regarding the association among various traits and offers opportunity for selecting genotypes that have desirable traits simultaneously (Ali *et al.,* 2009) [1]. Adequate knowledge about the magnitude and degree of association between yield and other yield attributes would assist the breeder to understand the strength of correlated traits that would help in the decision process for the simultaneous improvement of more than one trait in breeding program (Singh and Singh, 2009 and Karrupaiah and Kumar, 2010) [9, 18]. Less research has been done towards the genetic improvement of this plant for economic characters such as number of flowers per plant, number of branches per plant, single flower weight and most importantly flower yield under drought stress situation. Further, these economic characters are not only polygenic ally controlled but also considerably influenced by the fluctuating environmental conditions. Hence, an attempt was made to study correlation and path analysis in 32 genotypes of marigold under control (100% FC) and drought stress treatment (50% FC).

## Materials and Methods
The present experiment was carried out at the Department of Floriculture and Landscaping, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore during 2016. The plant material consists of thirty-two marigold genotypes collected from various sources as mentioned in Table 1. The experiments were laid out in Factorial completely randomised design (FCRD) under pot culture conditions inside a playhouse using two treatments *viz.,* 100 per cent field capacity (well-watered) and 50 per cent field capacity (water-stressed). Thirty-two marigold genotypes were assessed for their relationship between yield and yield component traits.

**Table 1:** List of thirty-two genotypes of marigold used in the study

| S. No. | Accession No. | Source |
|---|---|---|
| 1. | IIHRMG - 32 | IIHR, Bengaluru |
| 2. | IIHRMG – 38 | |
| 3. | IIHRMG – 24 | |
| 4. | IIHRMG - 21 | |
| 5. | IIHRMG - 49 | |
| 6. | IIHRMG -109 | |
| 7. | IIHRMG - 37 | |
| 8. | IIHRMG - 99 | |
| 9. | Hisar Jafri-2 | CCHSAU, Hisar |
| 10. | Hisar local | |
| 11. | Pusa Narangi Gainda | IARI, New Delhi |
| 12. | Pusa Basanti Gainda | |
| 13. | Pusa Arpita | |
| 14. | Nilakottai Local | HC & RI, Periyakulam |
| 15. | Thovalai Local Yellow | HC & RI, Coimbatore |
| 16. | Sathyamangalam Local | |
| 17. | Thovalai Local orange | |
| 18. | Dharmapuri Local | HC & RI, Coimbatore |
| 19. | Sambalpur Local | |
| 20. | Belgaum Local orange | |
| 21. | Belgaum Local yellow | |
| 22 | Siracole orange | |
| 23. | Siracole yellow | |
| 24. | Coimbatore Local orange | |
| 25. | Coimbatore local dwarf | |
| 26. | MDU-1 | |
| 27. | Mudigree Local | |
| 28. | Coimbatore Local yellow | |
| 29. | Punjab Local | |
| 30. | Cracker jack mix | |
| 31 | Synthite hybrid | |
| 32 | AVT | |

Observations were recorded on plant height (cm), days to first flowering, number of flowers per plant, number of branches per plant, shoot fresh and dry weight (g), root fresh and dry weight (g), root-shoot ratio, root length (cm), single flower weight (g) and flower yield per plant. The data was statistically analyzed and correlation coefficient analysis for yield and yield components was performed utilizing the formula suggested by Al-jibouri *et al.* (1958) [2]. And path coefficient analysis was carried out according to Dewey and Lu, (1959) [6].

## Results and Discussion

### Correlation of fruit yield other attributes

Yield is a complex trait associated with a number of component traits. It is the prime concern of the plant breeder and is the ultimate factor on which selection programmes are to be thought of. All changes in yield must be accompanied by changes in one or more characters. However, all changes in the components need not be expressed by changes in yield which is because of varying degrees of positive and negative correlations between yield and its components and among themselves. Besides favourable association of characters with yield, an inter-association of characters would simplify the selection programme. The knowledge of the nature and magnitude of interrelationships among yield and its components is necessary for the simultaneous improvement of the characters and yield improvement (Doku and Ghana, 1970) [7]. An understanding of the interdependence will be useful in evolving efficient selection and breeding strategies for simultaneous improvement of all positively related characters, minimizing the negative effects and for maximizing the synergistic effects. Hence, it is important to know the association between yield and its components in developing of high yielding and drought tolerance of marigold genotypes.

In the present investigation, results indicated a fairly strong inherent association between the characters which is presented in Table 2 and 3. However, at 100% FC, positive and significant association of yield with plant height, number of flowers/plant, number of branches/plant, shoot fresh and dry weight, root fresh and dry weight, root-shoot ratio and single flower weight. At 50% FC, yield showed positive and significant correlation with plant height, number of flowers/plant, number of branches/plant, shoot fresh and dry weight, and root fresh and dry weight and root-shoot ratio. The results are in line with the earlier findings of Karuppaiah *et al.* (2004) [10], Mathad *et al.* (2005) [12], Kavitha and Anburani (2010) [11], Bharathi *et al*. (2014) [4], Panwar *et al.* (2014) [14], Patel *et al.* (2018) [15] for plant height; number of flowers per plant, number of branches per plant, fresh weight per flower.

**Table 2:** Genotypic correlation coefficients of different characters at control (100% FC)

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 0.367* | 0.358* | 0.319 | 0.907** | 0.901** | 0.782** | 0.781** | -0.227 | 0.417* | 0.377* | 0.390* |
| 2 | | 1 | -0.151 | -0.250 | 0.247 | 0.236 | 0.097 | 0.096 | -0.296 | -0.042 | 0.111 | -0.130 |
| 3 | | | 1 | 0.577** | 0.220 | 0.219 | 0.393* | 0.393* | 0.315 | 0.327 | 0.123 | 0.618** |
| 4 | | | | 1 | 0.359* | 0.353* | 0.486** | 0.484** | 0.263 | 0.647** | 0.559** | 0.896** |
| 5 | | | | | 1 | 0.996** | 0.802** | 0.801** | -0.306 | 0.456** | 0.370* | 0.390* |
| 6 | | | | | | 1 | 0.786** | 0.786** | -0.324 | 0.444* | 0.332 | 0.365* |
| 7 | | | | | | | 1 | 1.000** | 0.316 | 0.698** | 0.413* | 0.531** |
| 8 | | | | | | | | 1 | 0.318 | 0.698** | 0.413* | 0.530** |
| 9 | | | | | | | | | 1 | 0.393 | 0.063 | 0.263 |
| 10 | | | | | | | | | | 1 | 0.628** | 0.674** |
| 11 | | | | | | | | | | | 1 | 0.726** |
| 12 | | | | | | | | | | | | 1 |

* Significant at 1% level and ** significance at 5% level

**Table 3:** Genotypic correlation coefficients of different characters at control (50% FC)

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 0.326 | 0.479** | 0.552** | 0.891** | 0.76** | 0.756** | 0.755** | -0.309 | 0.333 | 0.398* | 0.492** |
| 2 | | 1 | -0.115 | -0.005 | 0.068 | -0.098 | 0.020* | 0.021 | -0.139 | -0.189 | -0.039 | -0.053 |
| 3 | | | 1 | 0.878** | 0.456** | 0.473** | 0.652** | 0.652** | 0.264 | 0.705** | 0.486** | 0.935** |
| 4 | | | | 1 | 0.436* | 0.416* | 0.599** | 0.599** | 0.195 | 0.58** | 0.475** | 0.827** |
| 5 | | | | | 1 | 0.943** | 0.805** | 0.804** | -0.378* | 0.413* | 0.411* | 0.472** |
| 6 | | | | | | 1 | 0.856** | 0.855** | -0.213 | 0.536** | 0.535** | 0.500** |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 | | | | | | | 1 | 1.001** | 0.215 | 0.664** | 0.634** | 0.683** |
| 8 | | | | | | | | 1 | 0.217 | 0.663** | 0.634** | 0.682** |
| 9 | | | | | | | | | 1 | 0.275 | 0.221 | 0.247 |
| 10 | | | | | | | | | | 1 | 0.731** | 0.821** |
| 11 | | | | | | | | | | | 1 | 0.679** |
| 12 | | | | | | | | | | | | 1 |

* Significant at 1% level and ** significance at 5% level Residual effect =

| | | | | | |
|---|---|---|---|---|---|
| 1 | Plant height (cm) | 2 | Days to first flowering | 3 | Number of flowers/plant |
| 4 | Number of branches/plant | 5 | Shoot fresh weight (g) | 6 | Shoot dry weight (g) |
| 7 | Root fresh weight (g) | 8 | Root dry weight (g) | 9 | Root length (cm) |
| 10 | Root: Shoot ratio | 11 | Single flower weight (g) | 12 | Flower yield (g) |

**Correlation among yield attributes**

At 100% FC, inter-correlation among the yield attributes revealed that plant height exhibited positive significant association with number of flowers/plant, shoot fresh weight, shoot dry weight, root fresh weight, root dry weigh, single flower weight. These results indicated that as the plant height increases, characters such as number of flowers/plant, shoot fresh weight, shoot dry weight, root fresh weight, root dry weight and single flower weight would also increase. At 100% FC, number of flowers per plant showed positive significant association with number of branches per plant and root fresh and dry weight. Number of branches/plant exhibited positive significant association with shoot fresh and dry weight, root fresh and dry weight, root- shoot ratio and single flower weight. Positive and significant association was also recorded between shoot fresh weight with shoot dry weight, root fresh and dry weight, root- shoot ratio and single flower weight.

Significant and positive association was observed for root fresh weight with root dry weight, root length and single flower weight; root dry weight with root-shoot ratio and single flower weight. However, root length showed no association with any of the traits studied but, root-shoot ratio was positive and significantly correlated with root- shoot ratio and single flower weight. This suggested the importance of root in achieving higher yield under water-limiting environment.

At 50% FC, intercorrelation among yield attributes revealed that plant height were positively and significantly associated with number of flowers/plant, number of branches/plant, shoot fresh weigh, shoot dry weight, root fresh weight, root dry weight, single flower weight; days to first flowering with root fresh weight. Positive and significant correlation was observed for number of flowers/plant with number of branches/plant, shoot fresh weight, shoot dry weight, root fresh weight, root dry weight; number of branches/plant with shoot fresh weight, shoot dry weight, root fresh weight, root dry weight, root- shoot ratio, single flower weight; shoot fresh weight with shoot dry weight, root fresh weight, root dry weight, root- shoot ratio and single flower weight while negative and significant association with root length. There is also positive and significant association between shoot dry weight, root fresh weight, root dry weight, root- shoot ratio and single flower weight. The present results is in consonance with the findings of Namita (2008) [13], Singh and Saha (2009) [20], Raghuvanshi and Sharma (2011) [16], Anuja and Jahnavi (2012) [3], Panwar *et al*. (2014) [14] and Vishnupriya *et al.* (2015) [23] for days to first flowering, number of flowers per plant, number of branches per plant and single flower weight.

**Path coefficient analysis**

Path coefficient analysis provides a thorough understanding of contribution of various characters by partitioning the correlation coefficient into components of direct and indirect effects. As yield is influenced by many factors, selection based on correlation may be misleading because it measures only the mutual association between two variables, whereas path coefficient analysis specifically measures the relative importance of different yield components. To find out the direct and indirect effects and to measure the relative importance of causal factors, path coefficient analysis is useful, which permits critical examination of the specific forces acting to produce a given correlation.

Path-coefficient analysis at phenotypic level was carried out for 12 selected traits, with yield as a dependent variable. The path-coefficient analysis at 100% FC and 50% FC for different component characters is presented in Table 4 and 5. In the present investigation, at control (100% FC), among all the twelve characters, number of branches per plant exerted very high positive and significant direct effect upon flower yield per plant followed by single flower weight. The number of branches per plant showed positive and significant indirect effect through number of flowers per plant, number of branches per plant, shoot fresh weigh, root fresh weight, root length, root-shoot ratio and single flower weight. The findings of the present study are in agreement with those of Singh *et al*. (2014) [21].

**Table 4:** Direct (diagonal) and indirect effects (off diagonal) of different characters on flower yield at 100% FC

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 22 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | -0.215 | 0.009 | 0.126 | 0.174 | 2.402 | -2.071 | 0.132 | -0.230 | -0.042 | 0.050 | 0.103 | 0.390* |
| 2 | -0.079 | 0.023 | -0.053 | -0.137 | 0.654 | -0.542 | 0.016 | -0.028 | -0.055 | -0.005 | 0.030 | -0.130 |
| 3 | -0.077 | -0.004 | 0.353 | 0.316 | 0.583 | -0.504 | 0.066 | -0.116 | 0.058 | 0.039 | 0.034 | 0.618** |
| 4 | -0.069 | -0.006 | 0.203 | 0.547 | 0.950 | -0.812 | 0.082 | -0.143 | 0.049 | 0.077 | 0.153 | 0.896** |
| 5 | -0.195 | 0.006 | 0.078 | 0.196 | 2.649 | -2.292 | 0.135 | -0.236 | -0.057 | 0.054 | 0.101 | 0.390* |
| 6 | -0.194 | 0.005 | 0.077 | 0.193 | 2.639 | -2.300 | 0.132 | -0.231 | -0.060 | 0.053 | 0.091 | 0.365* |
| 7 | -0.168 | 0.002 | 0.139 | 0.266 | 2.124 | -1.807 | 0.169 | -0.295 | 0.058 | 0.083 | 0.113 | 0.531** |
| 8 | -0.168 | 0.002 | 0.139 | 0.265 | 2.123 | -1.807 | 0.169 | -0.295 | 0.059 | 0.083 | 0.113 | 0.530** |
| 9 | 0.049 | -0.007 | 0.111 | 0.144 | -0.809 | 0.745 | 0.053 | -0.094 | 0.185 | 0.047 | 0.017 | 0.263 |
| 10 | -0.090 | -0.001 | 0.115 | 0.354 | 1.209 | -1.022 | 0.118 | -0.206 | 0.073 | 0.119 | 0.172 | 0.674** |
| 11 | -0.081 | 0.003 | 0.043 | 0.306 | 0.981 | -0.764 | 0.070 | -0.122 | 0.012 | 0.075 | 0.274 | 0.726** |
| 21 | -0.060 | -0.002 | 0.087 | 0.285 | 0.792 | -0.701 | 0.071 | -0.124 | 0.039 | 0.070 | 0.074 | 0.458** |

* Significant at 1% level and ** significance at 5% level Residual effect =0.18

**Table 5:** Direct (diagonal) and indirect effects (off diagonal) of different characters on flower yield at 50% FC

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 22 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | -0.461 | 0.035 | 0.299 | 0.104 | 0.841 | -0.628 | 0.076 | -0.045 | 0.012 | 0.049 | 0.152 | 0.492** |
| 2 | -0.151 | 0.108 | -0.072 | -0.001 | 0.064 | 0.081 | 0.002 | -0.001 | 0.005 | -0.028 | -0.015 | -0.053 |
| 3 | -0.221 | -0.012 | 0.625 | 0.166 | 0.430 | -0.391 | 0.065 | -0.039 | -0.010 | 0.103 | 0.186 | 0.935** |
| 4 | -0.255 | -0.001 | 0.549 | 0.189 | 0.411 | -0.344 | 0.060 | -0.036 | -0.008 | 0.085 | 0.182 | 0.827** |
| 5 | -0.411 | 0.007 | 0.285 | 0.082 | 0.943 | -0.780 | 0.081 | -0.048 | 0.015 | 0.060 | 0.157 | 0.472** |
| 6 | -0.350 | -0.011 | 0.296 | 0.079 | 0.890 | -0.827 | 0.086 | -0.051 | 0.008 | 0.079 | 0.205 | 0.500** |
| 7 | -0.349 | 0.002 | 0.407 | 0.113 | 0.759 | -0.707 | 0.100 | -0.060 | -0.008 | 0.097 | 0.243 | 0.683** |
| 8 | -0.348 | 0.002 | 0.407 | 0.113 | 0.758 | -0.707 | 0.100 | -0.060 | -0.008 | 0.097 | 0.243 | 0.682** |
| 9 | 0.143 | -0.015 | 0.165 | 0.037 | -0.357 | 0.176 | 0.022 | -0.013 | -0.039 | 0.040 | 0.085 | 0.247 |
| 10 | -0.153 | -0.020 | 0.441 | 0.109 | 0.389 | -0.443 | 0.066 | -0.040 | -0.011 | 0.147 | 0.280 | 0.821** |
| 11 | -0.183 | -0.004 | 0.304 | 0.090 | 0.388 | -0.442 | 0.064 | -0.038 | -0.009 | 0.107 | 0.383 | 0.679 |
| 21 | -0.091 | -0.017 | 0.320 | 0.067 | 0.309 | -0.356 | 0.047 | -0.028 | -0.009 | 0.092 | 0.177 | 0.604** |

* Significant at 1% level and ** significance at 5% level  Residual effect = 0.13

| | | | | | |
|---|---|---|---|---|---|
| 1 | Plant height (cm) | 2 | Days to first flowering | 3 | Number of flowers/plant |
| 4 | Number of branches/plant | 5 | Shoot fresh weight (g) | 6 | Shoot dry weight (g) |
| 7 | Root fresh weight (g) | 8 | Root dry weight (g) | 9 | Root length (cm) |
| 10 | Root: Shoot ratio | 11 | Single flower weight (g) | 12 | Flower yield (g) |

Shoot fresh weight exerted a high positive indirect effect through days to first flowering, number of flowers per plant, number of branches per plant, root fresh weight, root-shoot ratio and single flower weight while the rest of the traits showed a negative indirect influence on flower yield. However, single flower yield influenced the yield indirectly and positively through days to first flowering, number of flowers per plant, number of branches per plant, shoot fresh weight, root fresh weight, root length, root-shoot ratio and single flower weight.

Under drought stress treatment (50% FC), characters that exhibited the highest positive and highly significant direct effect on flower yield per plant are number of flowers per plant followed by number of branches per plant and root shoot ratio which suggested that under drought stress condition, the influence of number of flowers per plant, number of branches per plant and root-shoot ratio on yield is of high consideration. In addition, the number of flowers per plant exerted the highest positive direct effect on yield through number of branches per plant, shoot fresh weight, root fresh weight, root-shoot ratio and single flower weight while negative indirect effect was exerted through plant height, days to first flowering, shoot dry weight, root dry weight and root length. Similarly at 50% FC, shoot fresh weight also showed highest positive indirect effect through days to first flowering, number of flowers per plant, number of branches per plant, root fresh weight, root length, root-shoot ratio and single flower weight.The residual effect for 100% FC and 50% FC were 0.18 and 0.13 respectively suggesting that the number of characters considered for path coefficient analysis were appropriate. These findings are in consonance with earlier reports of Velmurugan (2002), Karuppaiah *et al*. (2004) [10], Singh and Singh (2005) [19], Kavitha and Anburani (2010) [11], Bharathi *et al*. (2014) [4], Singh *et al*. (2014) [21], Choudhary *et al*. (2015), Vishnupriya *et al*. (2015) [23], Sahu (2016) and Patel *et al*. (2018) [15].

## Conclusion

Based on correlation and path coefficient analyses of 12 characters for 32 marigold genotypes, results revealed that selection should be primarily, based on the component characters which exhibited significant positive correlation with yield and also had either direct or indirect effect on yield which will assist in developing high yield and drought tolerant genotypes in marigold. Results strongly confirmed the reliability of the characters like number of branches per plant, number of flowers per plant, shoot fresh weight, root fresh weight, root-shoot ratio and single flower weight as they have a high direct effect on yield per plant and also possess strong positive and significant association with yield. This suggested that below ground characters i.e. root fresh weight and root-shoot ratio have a direct relevance in improving the flower yield of marigold under water-deficit conditions along with the improvement of several reproductive traits (number of branches per plant, number of flowers per plant, shoot fresh weight and single flower weight). Therefore, it is rewarding to emphasize the above traits in selecting a superior type for flower yield per plant under drought stress conditions in marigold.

## References


1. Ali MA, Nawab NN, Abbas A, Sajjad M. Evaluation of selection criteria in Cicer arietinum L. using correlation coefficients and path analysis. Austr. J Crop Sci. 2009; 3:65-70.
2. Al-Jibouri HA, Miller PA, Robinson HF. Genotypic environmental variances and covariances in an upland cotton cross of interspecific origin**.** Agron. J 1958; 50:633-636.
3. Anuja S, Jahnavi K. Variability, heritability and genetic advance studies in French marigold (*Tagetes patula*) L. Asian J of Hort. 2012; **7**:362-364.
4. Bharathi TU, Jawaharlal M, Kannan M, Manivannan N and Raveendran M. Correlation and path analysis in African marigold (*Tagetes erecta* L.). The Bios can. 2014; 9:1673-1676.
5. Choudhary M, Beniwal BS, Kumari A. Character association and path coefficient analysis studies in marigold. Eco. Env. & Cons. 2015; 21(1):165-171.
6. Dewey DR, Lu KH. A correlation and path coefficient analysis of components of crested wheat grass seed production. Agron. J. 1959, 51:515-518.
7. Doku RV. Variability in local and exotic varieties of cowpea (*Vigna unguiculata* L.). J Agric. Sci. 1970; 3:145-149.
8. Hojnik M, Skerget M, Knez Z. Extraction of lutein from Marigold flower petals-Experimental kinetics and modelling. LWT-Food Sci. Technol, 2008, 41(10).
9. Karuppaiah P, Kumar PS. Correlation and path analysis in African marigold (*Tagetes e*recta L.). Electron J Plant Breed. 2010; 1(2):217-20.
10. Karuppaiah PK, Sudhakaran P, Kumar S, Kathiravan J.

Correlation and path analysis for yield, yield attributes and xanthophylls content in African marigold. South Indian Hort. 2004; 54:3.4-310.
11. Kavitha R, Anburani A. Screening of genotypes through correlation and path co-efficient analysis in African marigold (*Tagetes erecta* L.). Asian J Hort. 2010; 5:458-460.
12. Mathad G, Hegde BS, Mulge R. Correlation and path coefficient analysis in African marigold (*Tagetes erecta* L.). The Karnataka J Hort. 2005; 1:22-29.
13. Namita. Studies on interspecific hybridization in marigold. IARI, Division of Horticulture, New Delhi, 2008.
14. Panwar SS, Kanwar P Namita, Janakiram T, Bharadwaj C. Character association and path coefficient analysis in African marigold (*Tagetes erecta* L.). Vegetos-An Internat. J Plant Res. 2014; 27:26-32.
15. Patel MA, Chawla SL, Chauhan DA, Patil S, Chhatrola HN. Character association and path analysis studies in marigold (*Tagetes* spp.) under the South Gujarat region. J Pharmacognosy Phyto chem. 2018; 7:3576-3580.
16. Raghuvanshi A, Sharma BP. Varietal evaluation of French marigold (*Tagetes patula* Ninn.) under mid-hill zone of Himachal Pradesh. Prog. Agri. 2011; 11:123-126.
17. Sahu JK. Variability, Heritability and Genetic Advance Studies In African Marigold (*Tagetes erecta* L.) Genotypes. Indira Gandhi Krishi Vishwavidhyalaya, Raipur, 2016.
18. Singh AK, Singh OP. Correlation and path coefficient analysis in African marigold (*Tagetes erecta* L.). Adv. Plant Sci. 2009; 22(1):239-41.
19. Singh D, Singh A. Correlation and path coefficient analysis in marigold (*Tagetes* spp.). Progressive Hort. 2005; 37:385.
20. Singh KP, Saha T. Character association and path analysis studies in French marigold. Ann. Hort. 2009; 2:39-42.
21. Singh KP, Raju DVSN, Janakiram T. Determination of genetic variation for vegetative and floral traits in African marigold (*Tagetes erecta*). Indian J Agric. Sci, 2014, 84.
22. Velmurugan K. Breeding for High Flower Yiield and Xanthophyll Content in African marigold (*Tagetes Erecta* L.). Tamil Nadu Agricultural University, Coimbatore, 2002.
23. Vishnupriya K, Jawaharlal M and Kannan M. Correlation Studies in African marigold (*Tagetes erecta* L.). Trends in Bio sci. 2015; 8(8):2023-2025.