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Aparna Srinivasan
Department of Floriculture and Landscaping, TNAU, Coimbatore, Tamil Nadu, India

M Kannan
Adhiparasakthi Horticultural College, G.B. Nagar, Kalavai, Tamil Nadu, India

R Ravikesavan
Department of Millets CPBG, TNAU, Coimbatore, Tamil Nadu, India

P Jeyakumar
Department of Crop Physiology, TNAU, Coimbatore, Tamil Nadu, India

S Subramaniam
Department of Floriculture and Landscaping, TNAU, Coimbatore, Tamil Nadu, India

Correspondence
Aparna Srinivasan
Department of Floriculture and Landscaping, TNAU, Coimbatore, Tamil Nadu, India

Estimation of genetic variability, heritability and genetic advance for high yield and tolerance to drought stress in marigold (*Tagetes* spp.) genotypes

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

Abstract
Thirty-two genotypes of marigold were collected and estimated for their genetic variability, heritability and genetic advance as per cent of mean under two treatments – 100% FC (control) and 50% FC (drought stress treatment) in a 32 x 2 factorial experiment under quadruplicate by completely randomized design. Based on the estimates of genetic variability, heritability and genetic advance as per cent of mean, results revealed that yield can be increased substantially through simple selection procedure based on characters such as plant height, number of flower per plant, number of branches per plant, shoot fresh and dry weight, root fresh and dry weight, root length, single flower weight, chlorophyll SPAD value at vegetative and flowering stages, stomatal conductance at vegetative and flowering stages and photosynthetic rate at vegetative and flowering stages due to the presence of additive type of gene action. Thus, these characters should be considered for selection and for development of drought tolerant and high yielding genotypes in a breeding programme of marigold.

Keywords: Marigold, genetic variability, heritability, genetic advance

Introduction
Drought is a complex environmental stress factor, which can occur at different periods in the growth and development of the crop cycle with different intensities. Drought stress dramatically, limits crop growth and development and can trigger a significant decrease in crop yield and quality. Drought involves a decrease in environmental water potential that accelerates water flow out of plant cells driven by the potential gradient and cellular dehydration arises as a result of osmotic stress.

Flowers are the source of joy and happiness, grace and elegance, beauty and energy, soothing and healing, enriched with medicinal and nutraceutical properties. Loose flowers constitute jasmine, rose, marigold, tuberose, chrysanthemum, celosia, China aster, lotus *etc*. In India, about 255 thousand hectares area is under cultivation of flowers and loose flower production was estimated to be 1754 thousand metric tonnes during 2013-14 (NHB, 2015). Demand for loose flowers is increasing day by day due to its presence in religious and social functions. Among the loose flowers, marigold flowers apart from garland making, occupies a unique position in poultry industry as its extract is used commercially as an additive to poultry feed to improve bird (fat and skin) and egg yolk pigmentation (Bailey and Chen, 1981; Tyczkowski and Hamilton, 1987) [29]. It has been shown that the lutein esters of marigold extract are efficiently absorbed into the human blood stream (Bowen *et al*., 2002) [5].

Climate change has dramatically increased the frequency and extension of drought episodes in the last decades in many areas of the world (Giannakopoulos *et al*., 2009). The rapid global warming, besides an increase in mean temperatures worldwide, is causing more frequent, longer and more intense extreme weather phenomena, such as droughts, 'heat waves,' or floods. Mitigation of global warming is a formidable challenge at present, and there is an urgent need of selecting more stress tolerant genotypes of cultivated plants (Gholinezhad, Darvishzadeh & Bernousi, 2014) [8]. Considering that in the near future, water will be scarcer considered more expensive resource and that irrigation will be restrictively used, selection and diversification of stress tolerant cultivars should be a priority for contemporary ornamental horticulture (Niu, Rodriguez & Wang, 2006) [18]. So far not much research work has been emphasized in bringing up drought tolerance of marigold hybrid in and around India. Conventional breeding has been based on empirical selection for yield (Atlin and Lafitte,

2002) [1]. However, this approach is far from being optimal, since yield is a quantitative trait and characterized by a low heritability and a high genotype x environment interaction (Babu *et al*., 2003) [2]. It is strongly believed that understanding of a physiological and molecular basis may help target the key traits that limit yield. Such an approach may complement conventional breeding programs and hasten yield improvement (Cattivelli *et al*., 2008) [7].

Genetic improvement of any crop mainly depends upon the amount of genetic variability present in the population and the germplasm serves as a valuable source of base population and provide scope for wide variability which is essential for initiating the crop improvement program (Burton, 1952) [6]. However, the success of breeding depends on the extent and the magnitude of variability existing in the germplasm. At the same time, improvement is possible on the basis of heritable variation. For a successful crop improvement programme, information on the nature and magnitude of genetic variability, degree of transmission of the traits is of immense importance.

Hence, both heritability and genetic advance as per cent of mean were determined to get a clear picture of the scope of improvement in various characters through selection. The success of any crop improvement programme depends on the presence of genetic variability and the extent to which the desirable trait is heritable. This variation offers an opportunity for indirect selection for yield in marigold. Therefore, the objective of this present research work has been undertaken in order to estimate the genetic variability, heritability and genetic advance between characters of various marigold genotypes.

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. Thirty-two marigold germplasm were collected for the study from various institutes and their sources are presented in Table 1. Seeds were sown in nursery and twenty-four days old seedlings were transplanted to pots containing growing medium of sand, red earth and vermicompost (1:2:1, v/v) in a 32 x 2 factorial experiment under quadruplicate by completely randomized design. Soil samples were collected randomly and soil moisture content at field capacity was measured with a pressure plate apparatus. After ten days of transplanting, drought stress was induced by varying the field capacity of the soil at 100% and 50%. Well-watered plants were used as control and were watered every other day to 100% field capacity. Plants undergoing drought stress treatment were subjected to five days stress by withholding irrigation, then plants were re-watered to 50% field capacity. Observations were recorded at 100% FC and 50% FC on traits such as 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), chlorophyll SPAD value at vegetative and flowering stages, chlorophyll stability index (%), membrane stability index (%), transpiration rate at vegetative and flowering stages (mmol H_2O m^{-2} s^{-1}), stomatal conductance at vegetative and flowering stages (mol H_2O m^{-2} s^{-1}), photosynthetic rate at vegetative and flowering stages (µmol CO_2 m^{-2} s^{-1}), proline at vegetative and flowering stages (mg g^{-1}), soluble protein at vegetative and flowering stages (mg g^{-1}) and flower yield per plant (g). The genotypic and phenotypic coefficient of variation was estimated according to the methods of Burton (1952) [6]. Heritability in broad sense was calculated as per the method given by Lush (1949) [14] and Robinson *et al.* (1949) [23] and the expected genetic advance as per cent of mean was worked out as suggested by Johnson *et al.* (1955) [10].

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	

Result and Discussion

In any crop breeding programme, the mean performance and variability are the primary and important factors for selection. Based on the mean performance of a genotype, undesirable plant may be eliminated and also variability may be used for selection procedure.

Genetic variability in the base population plays an important role in any crop-breeding programme. For an effective breeding programme it is essential to have a large amount of variation in the material at the hand of the breeder. The extent of diversity in a crop determines the limits of selection for improvement. The characters of economic importance are generally quantitative in nature and exhibit a considerable degree of interaction with environment. Thus, it becomes necessary to compute variability present in the breeding material and its partitioning into genotypic and phenotypic coefficient variation.

In the present investigation, the genetic parameters such as mean, genetic variability consisting of genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability and genetic advance as per cent of mean for control (100 *per cent* field capacity) and drought stress treatment (50 *per cent* field capacity) are given in Table 2 and 3 respectively. It was observed that at 100% FC, the magnitude of PCV was higher than GCV with respect to characters such as plant height, days to first flowering, number of branches/plant, root fresh weight, root length, single flower weight, chlorophyll stability index, membrane stability index, transpiration rate at vegetative and flowering stages, stomatal conductance at vegetative stage whereas, at 50% FC, the same was observed in traits such as plant height, days to first flowering, number of flowers/plant, number of branches/plant, shoot fresh and dry weight, root fresh and dry weight, root: shoot ratio, root length, single flower weight, chlorophyll SPAD value at vegetative and flowering stages, chlorophyll stability index, membrane stability index, transpiration rate at vegetative and flowering stages, stomatal conductance at vegetative and flowering stages, photosynthetic rate at vegetative and flowering stages and yield. The higher magnitude of PCV over GCV indicated that there is greater genotype x environment interactions on the above mentioned traits. The result is in agreement with the findings of Sreekala *et al.,* (2002) [28], Mathew *et al.* (2005), Singh and Misra (2008) [27], Pratap *et al.* (2009) [21] and Singh and Singh, (2010) [25].

Table 2: Genetic parameters for 20 characters of marigold genotypes at 100% FC

S. No.	Characters	Mean	GCV (%)	PCV (%)	h^2 (%)	GA (%) of mean
	Plant height (cm)	64.44	20.45	20.46	99.91	52.45
2	Days to first flowering	32.31	9.31	10.01	99.74	33.70
3	Number of flowers per plant	25.97	20.26	10.00	99.92	81.86
4	Number of branches/plant	2.90	5.41	10.12	97.03	64.36
5	Shoot fresh weight (g)	36.86	17.16	10.02	99.53	58.09
6	Shoot dry weight (g)	28.04	19.37	10.00	99.91	75.30
7	Root fresh weight (g)	12.21	9.58	10.01	99.81	56.43
8	Root dry weight (g)	7.32	12.38	10.00	99.94	94.25
9	Root: shoot ratio	0.34	32.54	10.10	98.15	36.35
10	Root length (cm)	11.39	6.19	10.02	99.64	37.73
11	Single flower weight (g)	4.02	4.29	10.00	99.83	44.03
12	Chlorophyll SPAD value at vegetative stage	35.90	15.33	10.12	97.71	52.08
	Chlorophyll SPAD value at flowering stage	37.12	14.38	10.12	97.56	48.01
13	Chlorophyll stability index (%)	82.68	5.60	10.18	96.55	12.46
14	Membrane stability index (%)	77.43	6.49	10.10	98.09	15.04
15	Transpiration rate at vegetative stage (mmol H_2O m^{-2} s^{-1})	6.54	5.07	10.03	99.83	40.87
	Transpiration rate at flowering stage (mmol H_2O m^{-2} s^{-1})	7.24	4.63	10.06	99.22	35.34
16	Stomatal conductance at vegetative stage (mol H_2O m^{-2} s^{-1})	0.99	7.45	10.44	90.99	146.42
	Stomatal conductance at flowering stage (mol H_2O m^{-2} s^{-1})	0.73	27.47	10.02	99.74	66.13
17	Photosynthetic rate at vegetative stage (µmol CO_2 m^{-2} s^{-1})	11.36	11.66	10.01	99.88	71.24
	Photosynthetic rate at flowering stage (µmol CO_2 m^{-2} s^{-1})	10.03	11.71	10.00	99.86	76.16
18	Proline at vegetative stage (mg g^{-1})	1.22	21.76	10.01	99.72	40.56
	Proline at flowering stage (mg g^{-1})	1.43	23.62	10.01	99.79	40.68
19	Soluble protein at vegetative stage (mg g^{-1})	31.56	27.03	10.07	98.66	98.45
	Soluble protein at flowering stage (mg g^{-1})	40.92	24.40	10.00	99.94	78.54
20	Flower yield/plant (g)	90.41	65.94	10.44	99.97	142.85

High PCV (>20) and high GCV (>20) was found for plant height alone at 100% FC whereas, at 50% FC, characters such as plant height, number of flowers/plant, number of branches/plant, shoot fresh and dry weight, root fresh and dry weight, root: shoot ratio, root length, single flower weight, chlorophyll SPAD value at vegetative and flowering stages, stomatal conductance at vegetative and flowering stages, photosynthetic rate at vegetative and flowering stages and yield exhibited high PCV and GCV**.** The result is in accordance with the findings of Kavitha and Anburani (2010) [12] for number of flowers per plant; Pal *et al.,* (2010) for plant height; Karuppaiah and Senthil (2011) [11] for number of branches per plant, flower head weight and flower yield per plant; Raghuvanshi and Sharma (2011) [22] for flower yield per plant and fresh weight of flower; Bharathi *et al.* (2014) [4] for days to first flowering, plant height, number of flowers per plant, single flower weight and flower yield per plant, Kumar *et al.* (2014) [13] for number of primary branches per plant, number of flowers per plant and flower yield per plant; Vishnupriya *et al.* (2015) [30] for number of primary branches, single flower weight and total flower weight; Sahu (2016) [24] for number of secondary branches per plant, fresh flower weight per plant and yield per hectare; and Nilima *et al.* (2017) [17] for number of flowers per plant, weight of flower, yield of flowers per ha.

Moderate PCV (10-20) and GCV (10-20) were recorded for number of flowers per plant, shoot fresh and dry weight, root dry weight, root: shoot ratio, Chlorophyll SPAD value at vegetative and flowering stages, stomatal conductance at flowering stage, Photosynthetic rate at vegetative and flowering stages, proline at vegetative and flowering stages, soluble protein at vegetative and flowering stages and yield at 100% FC. However, at 50% FC traits like days to first flowering, chlorophyll stability index, membrane stability index and transpiration rate at vegetative and flowering stages. This indicated that selection would be difficult for these characters, as the genotypic effect would be modified by the environmental effect. These results are in agreement with the findings of Raghuvanshi and Sharma (2011) [22].

The knowledge of heritability of a character is important as it indicates the extent to which improvement is possible through selection (Robinson *et al.*, 1949) [23]. It is a measure of the genetic relationship between parent and progeny and has widely been used to assess the degree to which a character may be transmitted from parent to offspring. It also indicates the relative importance of heredity and environment in the expression of these characters. In the present study, high heritability was observed for all traits studied at both 100% FC and 50% FC which implies that there is scope for improvement of these characters through direct selection. High heritability alone does not guarantee large gain from selection unless sufficient genetic gain attributable to additive gene action is present. Genetic advance in a trait is the product of heritability and selection differential and has an added advantage over heritability as a guiding factor in a selection programme where characters to be improved are desired.

At 100% FC, high heritability (>60) coupled with high genetic advance as per cent of mean (>20) was observed for all the characters except for chlorophyll stability index and membrane stability index, whereas, at 50% FC, all the traits studied revealed high heritability coupled with high genetic advance suggesting that these characters are governed by the additive type of action and such characters are useful for phenotypic selection. The result of the present study are in agreement with the findings of Singh and Kumar (2008) [26], Pal *et al.* (2010), Bharathi *et al.* (2014) [4], Sahu (2016) [24] for plant height and days to first flowering; Mathew *et al.* (2005) [15]; Singh and Misra (2008) [25]; Kavitha and Anburani (2010) [12]; Rahjuvanshi and Sharma (2011) and Sahi (2016) for number of flowers per plant; Patnaik *et al.*(2002) [20] and Bharathi *et al.* (2014) [4] for flower yield per plant. However, high heritability (>60) and moderate genetic advance (10-20) was recorded for only two characters *viz.*, chlorophyll stability index and membrane stability index at 100% FC which points to a major role of non-additive gene action in the transmission of these characters from parents to offspring.

Table 3: Genetic parameters for 20 characters of marigold genotypes at 50% FC

S. No.	Characters	Mean	GCV (%)	PCV (%)	h^2 (%)	GA (%) of mean
1	Plant height (cm)	54.93	28.92	29.01	99.37	59.39
2	Days to first flowering	27.04	18.45	18.57	98.69	37.76
3	Number of flowers per plant	20.90	51.69	51.74	99.80	106.37
4	Number of branches/plant	2.47	34.09	34.12	99.78	70.14
5	Shoot fresh weight (g)	24.71	38.87	39.18	98.40	79.43
6	Shoot dry weight (g)	17.13	59.62	59.71	99.69	122.62
7	Root fresh weight (g)	12.51	33.56	33.62	99.62	69.00
8	Root dry weight (g)	8.15	51.52	51.56	99.87	106.07
9	Root: shoot ratio	0.53	23.80	24.60	93.59	47.43
10	Root length (cm)	12.24	26.32	26.42	99.26	54.02
11	Single flower weight (g)	3.19	20.99	21.10	98.93	43.01
12	Chlorophyll SPAD value at vegetative stage	28.13	29.59	30.29	95.43	59.55
	Chlorophyll SPAD value at flowering stage	26.23	40.13	40.17	99.83	82.60
13	Chlorophyll stability index (%)	70.86	12.84	13.01	97.35	26.10
14	Membrane stability index (%)	61.12	11.44	11.65	96.28	23.11
15	Transpiration rate at vegetative stage (mmol H_2O m^{-2} s^{-1})	7.40	18.51	18.98	95.09	37.18
	Transpiration rate at flowering stage (mmol H_2O m^{-2} s^{-1})	8.28	18.52	18.94	95.66	37.32
16	Stomatal conductance at vegetative stage (mol H_2O m^{-2} s^{-1})	0.60	46.46	46.94	97.98	94.74
	Stomatal conductance at flowering stage (mol H_2O m^{-2} s^{-1})	0.58	37.60	38.24	96.70	76.17
17	Photosynthetic rate at vegetative stage (µmol CO_2 m^{-2} s^{-1})	10.30	40.32	40.41	99.53	82.86
	Photosynthetic rate at flowering stage (µmol CO_2 m^{-2} s^{-1})	8.95	43.84	44.00	99.31	90.01
18	Proline at vegetative stage (mg g^{-1})	2.15	21.73	10.02	99.72	40.56
	Proline at flowering stage (mg g^{-1})	2.79	23.59	10.01	99.79	40.68
19	Soluble protein at vegetative stage (mg g^{-1})	21.64	27.03	10.07	98.66	98.45
	Soluble protein at flowering stage (mg g^{-1})	28.80	24.40	10.00	99.94	78.54
20	Flower yield/plant (g)	54.27	71.73	71.77	99.88	147.67

Conclusion

In the present study, at 100% FC, high estimates of PCV and GCV was observed only for plant height whereas at 50% FC, high PCV and GCV was observed for characters plant height, number of flower per plant, number of branches per plant, shoot fresh and dry weight, root fresh and dry weight, root length, single flower weight, chlorophyll SPAD value at vegetative and flowering stages, stomatal conductance at vegetative and flowering stages and photosynthetic rate at vegetative and flowering stages. It was also observed that higher magnitude of heritability and genetic advance was recorded for all the characters studied except for chlorophyll stability index and membrane stability index at 100% FC while at 50% FC, all traits showed high heritability coupled with high genetic advance. These results suggested that yield can be increased substantially through simple selection procedure based on characters such as plant height, number of flower per plant, number of branches per plant, shoot fresh and dry weight, root fresh and dry weight, root length, single flower weight, chlorophyll SPAD value at vegetative and

flowering stages, stomatal conductance at vegetative and flowering stages and photosynthetic rate at vegetative and flowering stages due to the presence of additive type of gene action. In other words, these characters should be taken into consideration for phenotypic selection and for development of drought tolerant and high yielding marigold genotypes.

References

1. Atlin GN, Lafitte HR. Developing and testing rice varieties for water-saving systems in the tropics. Water-wise Rice production. 2002; (1):275.
2. Babu RC, Nguyen BD, Chamarerk V, Shanmugasundaram P, Chezhian P, Jeyaprakash P *et al.* Genetic analysis of drought resistance in rice by molecular markers. Crop Sci. 2003; 43(4):1457-69.
3. Bailey D, Chen JN. Chromatographic analyses of xanthophylls in egg yolks from laying hens fed turf Bermuda grass (*Cynodon dactylon*) meal. J Food Sci. 1989; 54:584-586.
4. Bharathi TU, Jawaharlal M, Kannan M, Manivannan N, Raveendran M. Correlation and path analysis in African marigold (*Tagetes erecta* L.). The Bio scan. 2014; 9:1673-1676.
5. Bowen PE, Herbst-Espinosa SM, Hussain EA, *et al*. Esterification does not impair lutein bioavailability in humans. J Nutr. 2002; 132:3668-3673
6. Burton GW. Quantitative inheritance in grasses. Proceedings on International Grassland Congress. 1952, 277-283.
7. Cattivelli L, Rizza F, Badeck FW, Mazzucotelli E, Mastrangelo AM. Francia E *et al*. Drought tolerance improvement in crop plants: An integrated view from breeding to genomics. Field Crop Res. 2008; 115:1-14.
8. Gholinezhad E, Darvishzadeh R, Bernousi. Evaluation of drought tolerance indices for selection of confectionery sunflower (*Helianthus anuus* L.) landraces under various environmental conditions. Notulae Botanicae Horti Agrobotanici Cluj-Napoca. 2014; 42(1):187-201.
9. Giannakopoulos C, Sager PL, Bindi M, Moriondo M, Kostopoulou E, Goodess CM. Climatic changes and associated impacts in the Mediterranean resulting from a 2°C global warming. Global and Planetary Change, 2014.
10. Johnson HW, Robinson HF, Comstock RE. Estimates of genetic and environmental variability in soybean. Agron. J. 1955; 47:314-318.
11. Karuppaiah PK, Senthil P. Variability, heritability and genetic advance for yield, yield attributes and xanthophyll content in African marigold (*Tagetes erecta* L.). Crop Res. 2011; 41:117-119.
12. 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.
13. Kumar A, Pratap B, Beer K. Studies on genetic variability and character association in French marigold (*Tagetes patula* L.). Bio sci, 2014, 1007.
14. Lush JL. Heritability of quantitative characters in farm animals. Hereditas. 1949; 35:356-375.
15. Mathew R, Beniwal BS, Bhatia SK, Deswal DP. Variability and correlation studies in African marigold (*Tagetes erecta* L.). Res. Crops. 2005; 6:322-327.
16. Anonymous. National Horticulture Board Database, 2015; 302.
17. Nilima G, Badge S, Patil S, Gourao G. Genetic variability studies for various quantitative traits in marigold. Int. J Pure App. Bio sci. 2017; 5:751-757.
18. Niu G, Rodriguez DS, Wang YT. Impact of drought and temperature on growth and leaf gas exchange of six bedding plant species under greenhouse conditions. HortSci. 2006; 41:1408-1411.
19. Pal K, Kumar K, Jitendra K. Study on genetic variability, heritability and genetic advance in african marigold (*Tagetes erecta* L.) under Meerut region. Prog. Agri. 2015; 210(10):144-149.
20. Patnaik N, Mohanty CR. Genetic variability, heritability and genetic advance in African marigold (*Tagetes erecta* L.). Orissa J Hort. 2002; 30:90-94.
21. Pratap B, Singh AK, Kumar A, Chandra R. Estimation of genetic variability, heritability and genetic advance in marigold (*Tagetes* sp.). Curr. Adv. Agric. Sci. 2009; 1(2):89-90.
22. 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.
23. Robinson HF, Comstock RE and Harvey PH. Estimates of heritability and the degree of dominance in corn. Agron. J. 1949; 41:353-359.
24. Sahu JK. Variability, Heritability and Genetic Advance Studies in African marigold (*Tagetes erecta* L.) Genotypes. Indira Gandhi Krishi Vishwavidhyalaya, Raipur, 2016.
25. Singh, Misra KKD. Genetic variability in quantitative characters of marigold. Indian J Hort. 2008, 187-192.
26. Singh AK, Singh D. Genetic variability, heritability and genetic advance in marigold. Indian J Hort. 2010; 67:132-136.
27. Singh D, Kumar S. Studies on genetic variability, heritability, genetic advance and correlation in marigold. J Orna. Hort. 2008; 11(1):27-31.
28. Sreekala C, Raghava SPS, Mishra RL, Volefi SR. Assessment of variability for carotenoids and yield components in African marigold. J Ornamental Hort. 2002; 5(2):5-7.
29. Tyczkowski JK, Hamilton PB. Metabolism of lutein diester during aflatoxicosis in young chickens. Poult Sci. 1987; 66(12):2011-2016.
30. Vishnupriya K, Jawaharlal M, Kannan M. Correlation Studies in African marigold (*Tagetes erecta* L.). Trends in Bio sci. 2015; 8(8):2023-2025.