International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(3): 2766-2768

Received: 13-03-2019
Accepted: 15-04-2019

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Genetic diversity analysis in *Tagetes erecta* L. genotypes

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Abstract
The present investigation on "Genetic variability studies in marigold genotypes" was conducted at the Department of Floriculture and Medicinal Crops, Horticultural College and Research Institute, Periyakulam during 2013-2014 to assess the existence of genetic variability in divergent genotypes of marigold (*Tagetes* erecta). The genetic divergence study based on D^2 analysis grouped the 31 genotypes of *Tagetes erecta* into seven clusters. The genotypes were raised in Randomized block design with three replications and these genotypes were grouped in seven clusters. The genotypes AM-1, 34, 9, 11, 16, 17, 22, 25, 27, 28 and 31 were collected from NBPGR, TNAU, IIHR and FRS. The maximum intra cluster distance is 269.573 (cluster VI) followed b 266.028, 265.385, 261.521 of the same cluster. The inter cluster distance ranged between 94.461 and 269.573. The ranking of component characters for divergence using D2 analysis revealed that the character duration of flowering contributed maximum divergence followed by flower yield per plant and days to harvest. The pattern of distribution of these genotypes in various clusters showed considerable amount of genetic divergence among these genotypes for all the vegetative and flowering characters studied. Depending upon the mean value, the genotypes can be used us parents in hybridization programme for the higher yield. As these genotypes have better means for yield and yield contributing characters and are placed in different clusters showing great genetic diversity.

Keywords: Genetic diversity, cluster analysis

Introduction
Marigold is a popular annual flower that can be grown on a commercial scale. It has gained popularity on account of its easy cultivation and wide adaptability. Free flowering habit, short duration to produce marketable flowers, wide spectrum of colour, shape, size and good keeping quality make marigold an acceptable commercial crop. Commonly, called as Sendumalli in Tamil. Most commonly grown flowers in India, extensively used on religious and social functions. Gained popularity among gardeners, as it is easily cultivated and has wide acceptability. It has a habit of profuse flowering, short duration, attractive colour, shape, size and good keeping quality attracted attention of traders and producers. Flowers are sold in market as loose flowers and garlands. Marigold in general has an oil recovery of about 0.20-0.35 per cent. African marigold is also known as Rose of Indies. Nugget is the most recent interspecific triploid hybrid of African marigold developed in USA. Dietary carotenoids can be used to treat cancer and photosensitivity diseases. Marigolds are also known to have plenty of health benefits on account of their high content of antioxidants. These antioxidants are known to be effective in combating the damage that may be caused by free radicals which are typically the by-products of environmental factors such as pollution or cigarette smoke or even normal body functions. A variety of chemical constituents have been isolated from *Tagetes* species and their structures elucidated. They belong to the classes as essential oils, thiophenes, flavonoids, carotenoids and phenolic compounds. A preliminary phytochemical screening of the crude successive extracts of the roots of *Tagetes erecta* revealed the presence of sterols, glycosides, gums and mucilages (Mehta, 1995) [2].

Materials and methods
A field experiment was laid out in Randomized Block Design with three replications at Horticultural Crops (2013) at Horticultural College and Research Institute, Periyakulam. Sixty seven genotypes were taken and sown in portrays. The field was ploughed twice thoroughly and levelled properly. Bunds and channels were laid and ridges and furrows were formed.

Sixty seven genotypes were raised in a randomized block design (RBD) with three replications in two seasons. The plants were transplanted on one side of ridges with a spacing of 40 x 30 cm (*Tagetes erecta*) in three replications. Observations on five plants in each row were recorded for twenty characters *viz.*, germination percentage, plant height, internodal length, number of branches, days to flowering, bud appearance, bud diameter, buds per plant, number of flowers per plant, flower diameter, flower stalk length, flower stalk girth, duration of flowering, days to harvest, shelf life, crop duration, individual flower weight, flower yield per plant, carotenoid content and xanthophyll content. Based on degree of divergence (D^2values) between any two genotypes, grouping of genotypes was done by using Tocher's method (Singh *et al.* 1977) [6].

Results and Discussion

Clustering of genotypes

The genotypes were clustered based on diversity analysis. The D^2 values were worked out for 1431 pairs of combinations in *Tagetes erecta*. By the application of clustering technique, the thirty one genotypes were grouped into VII different clusters. The cluster I was largest with twelve genotypes which was followed by cluster II with five genotypes, cluster VII with four genotypes, cluster III with three genotypes and cluster IV with two genotypes. Clustering summarizes the information on relationships between objects by grouping similar units so that the relationship may be easily understood and communicated. As the genotypes have better means for yield and yield contributing characters and are placed in different clusters showing great genetic diversity. The results are in accordance with the findings of Pal *et al.* (2006) [3] in gladiolus.

Inter and intra cluster distances

The cluster VI had maximum intra cluster D^2 value. The inter cluster D^2 values ranged from 94.461 to 269.573 (cluster I and cluster VI). The cluster distance was lowest between the cluster I and IV in *Tagetes erecta*. Selection of genotypes belonging to the clusters with maximum inter cluster distance had also been proposed by Mehta *et al.* (2004); Patil *et al.* (2001) [4]. Hence, these locally adapted diverse genotypes as parents might be exploited more fruitfully for the forthcoming breeding programme and to play a vital role in the crop improvement. These results were supported by the findings of Patil (2011) [4] in anthurium.

Cluster mean for different characters

In *Tagetes erecta*, Cluster II had the highest cluster mean for plant height, days to flowering, individual flower weight and flower yield per plant. Cluster III had highest cluster mean for number of flowers per plant and flower diameter. Cluster V showed highest cluster mean for duration of flowering. Cluster VI recorded highest cluster mean for number of branches. Thus, the clusters II, III, V and VI scored the highest mean values for yield and yield attributing traits. The usefulness of multivariate analysis for study of morphologically complex individual and for measuring the degree of divergence between biological populations can be used in different fields of research. Hence, the genotypes comprised in the cluster might be utilized as the parents for the breeding programme in the near future. As these genotypes have better means for yield and yield contributing characters and are placed in different clusters showing great genetic diversity. The result indicated the possibility of obtaining high vigour and selection of superior genotypes. An increase in species diversity can also affect the genetic diversity. If there are many genotypes, the genetic diversity at that level will be larger than fewer species. On the other hand, genetic diversity within each species can decrease. These results were in concurrence with the findings of Kavitha *et al.* (2010) [1] in gerbera; Ranjan and Rupali (2013) [5] in carnation.

Relative contribution of each characters

In the present investigation an assessment of the contribution of different characters of the genotypes towards divergence indicated that the duration of flowering was the maximum contributor for genetic divergence wherein the bud appearance and individual flower weight exhibited very less contribution towards genetic divergence in *Tagetes erecta*. The contributions of different characters are responsible for total genetic divergence. The character that appears the maximum number of times had greater contribution towards diversity. These results are in line with the results of Rupali and Ranjan (2013) [5].

Table 1: Clustering of genotypes in *Tagetes erecta*

Clusters	Accession number	Genotypes
Cluster I	AM-1, AM-3, AM-4	IC – 392875,IIHR Acc.No.1,Coimbatore local 1
	AM-9, AM-11, AM-16, AM-17,	IC – 392898,IC – 392897,IC – 353761,PKM local (2 KR)
	AM-22, AM-25, AM-27, AM-28, AM-31	IC – 353960,Thovalai orange,Coimbatore local 2,IC – 392973,IC – 392879
Cluster II	AM-5, AM-9, AM-13, AM-24, AM-30	IC – 353956, IC – 392898, IC – 353971, IC – 392894, IC – 392974
Cluster III	AM-20, AM-25, AM-29	IC – 353968, Thovalai orange, PKM local (1.5 KR)
Cluster IV	AM-6, AM-8	IC – 392877,PAU Acc.No.1
Cluster V	AM-10, AM-15	IC – 392899, Nilakottai local
Cluster VI	AM-12, AM-18, AM-23	IC – 537602, IC – 353970, IC – 353958
Cluster VII	AM-2, AM-14, AM-7	Coimbatore orange, PAU Acc.No.2, IC – 353972

Table 2: Intra and inter cluster distance for *Tagetes erecta*

	1	2	3	4	5	6	7
1	94.461	251.394	258.166	184.074	249.171	255.712	187.758
2		215.894	227.058	244.589	222.624	266.028	234.961
3			215.633	224.983	190.258	265.385	237.539
4				115.601	201.758	269.573	192.689
5					129.332	246.903	209.844
6						226.786	261.521
7							230.110

Table 3: The mean values of clusters for quantitative parameters in *Tagetes erecta*

S. No.	Characters	Cluster I	Cluster II	Cluster III	Cluster IV	Cluster V	Cluster VI	Cluster VII
1	Germination percentage	70.552	83.656	78.582	68.800	76.900	72.250	76.050
2	Plant height	88.202	125.218	121.579	81.248	116.855	108.978	101.529
3	Internodal length	1.590	2.116	1.840	1.620	1.435	1.941	2.194
4	Number of branch	30.870	31.090	32.418	30.933	33.285	34.403	32.145
5	Days to flowering	23.992	35.573	34.381	24.877	30.762	34.569	27.082
6	Bud appearance	13.250	8.022	10.744	12.800	14.225	13.851	13.026
7	Bud diameter	1.208	1.389	1.292	1.198	1.167	1.232	1.163
8	Buds per plant	30.805	38.212	41.939	36.360	30.805	40.962	35.097
9	Number of flowers per plant	30.805	38.279	42.064	36.360	30.805	41.073	35.097
10	Flower diameter	3.637	5.901	5.943	3.782	4.313	4.972	3.598
11	Flower stalk length	3.423	5.343	5.264	4.295	4.618	6.351	4.267
12	Flower stalk girth	1.393	2.389	1.737	1.450	1.445	2.181	1.592
13	Duration of flowering	55.057	70.782	74.630	77.147	78.962	47.630	71.728
14	Days to harvesting	56.600	56.725	73.660	69.033	85.617	63.353	62.003
15	Shelf life	3.677	4.653	4.900	3.642	3.902	4.792	3.692
16	Crop duration	134.310	100.026	107.172	130.823	100.488	96.144	100.978
17	Individual flower weight	6.510	9.859	8.055	6.557	8.398	8.407	7.952
18	Flower yield per plant	220.400	342.914	244.393	215.202	235.922	309.073	253.903

Table 4: Per cent contribution of eighteen characters towards diversity in *Tagetes erecta*

S No	Character	No of First Rank	% Contribution
1	Germination percentage	22	14.731
2	Plant height	54	11.613
3	Internode length	14	9.000
4	Number of branches	30	12.000
5	Days to flowering	20	10.000
6	Bud appearance	8	3.720
7	Bud diameter	10	4.000
8	Buds per plant	4	4.860
9	Number of flowers per plant	20	6.000
10	Flower diameter	31	6.667
11	Flower stalk length	33	7.097
12	Flower stalk girth	13	8.645
3	Duration of flowering	78	16.774
14	Days to harvesting	64	13.763
15	Shelf life	65	13.979
16	Crop duration	19	4.086
17	Individual flower weight	18	3.871
18	Flower yield per plant	66	14.194
	Total	569	100

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