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Genetic diversity analysis for yield parameters in yellow pericarp sorghum (*Sorghum bicolor* L.) Moench genotypes

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Abstract
Forty ICRISAT genotypes of grain sorghum yellow pericarp having different geographical origins were evaluated at ARS, Madhira for diversity study using D^2 analysis. The analysis of variance showed highly significant differences among the accessions for all the characters. Principal component analysis showed that PC I, PC II and PC III, contributed 83.41, 9.06 and 3.80 % of total variance. Among the five clusters, Cluster 1 is the largest and had the maximum number (32) of genotypes followed by cluster 2 with 4 genotypes, cluster 3 with 2 genotypes and cluster 4 and cluster 5 with single genotype each. Percent contribution towards genetic divergence showed that plant height contributed the most (57.82%) followed by leaf length (22.82%), grain yield per plant (7.82%).

Keywords: Sorghum, divergence, yield

Introduction
Sorghum is the third most important cereal crop cultivated extensively in India after wheat and rice. Sorghum grown in *rabi* season is characterized by its excellent grain quality, exclusively utilized for human consumption and hence fetches higher market price as compared to *kharif*. Normally sorghum is consumed in the form of *Roti*, but now days it is also consumed as *hurda* (roasted grains separated from sorghum panicles at dough stage) in Maharashtra region. Yield improvement in sorghum is essential to have multiple benefits of the crop. Understanding of genetic diversity of a species is fundamental in any crop improvement programme. For such species, in general the parents with more genetic divergence are expected to yield heterotic hybrids in addition to generating a broad spectrum of variability in segregating generations. The D2 statistic is a useful multivariate statistical tool for effective discrimination among various genotypes on the basis of genetic divergence (Murty and Arunachalam, 1966). Hence, an attempt has been made to study the genetic divergence in available germplasm of sweet grain sorghum for percent threshed grains and fodder yield and its components to provide a basis for selection of parents for hybridization.

Materials and Methods
Forty ICRISAT yellow sorghum genotypes having different geographical origins were evaluated at ARS, Madhira during *rabi* season of 2016-17 in a randomized block design with two replications. Each entry was planted in 4 rows of 4m length keeping 45 and 15 cm spacing between and within rows. Total ten observations were recorded *viz*. plant height, days to 50% flowering, days to maturity, number of leaves per plant, leaf length, leaf width, ear length, straw weight, 100 seed weight and grain yield per plant.
Divergence was estimated by the multivariate analysis using Mahalanobis's (1936) [2] and D^2 statistic as described by Rao (1952) [4]. On the basis of D^2 values obtained, the variables were grouped into different clusters by employing Tocher's method (Rao, 1952) [4]. The percent contribution of each character to the total divergence was calculated by ranking each character on the basis of transformed uncorrelated values. Finally, the percent contribution for each character was calculated by taking total number of ranks of all the characters to hundred. The data were analyzed statistically using the software WINDOSTAT, developed by INDOSTAT services Ltd. Hyderabad, India.

Results and Discussion

The analysis of variance showed highly significant differences among the accessions for all the characters studied indicating the presence of considerable variability in the experimental material.

Principal component analysis

Total three principle components, accounting 96.29% of total variance were obtained from principle component analysis. These three PCs i.e. PC I, PC II and PC III, contributed 83.41, 9.06 and 3.80 % of total variance (Fig 1). The results obtained from PCA were further corroborated by cluster analysis using UPGMC (Unweighted Paired Group Method using Centroids). Forty ICRISAT sorghum lines were grouped into five distinct clusters (Fig. 1).Cluster 1 is the largest and had the maximum number (32) of genotypes followed by cluster 2 with 4 genotypes, cluster 3 with 2 genotypes and cluster 4 and cluster 5 with single genotype each (Fig 2). The D^2 analysis carried out thus helped to identify the diverse accessions from the available germplasm for the use in crop improvement programmes.

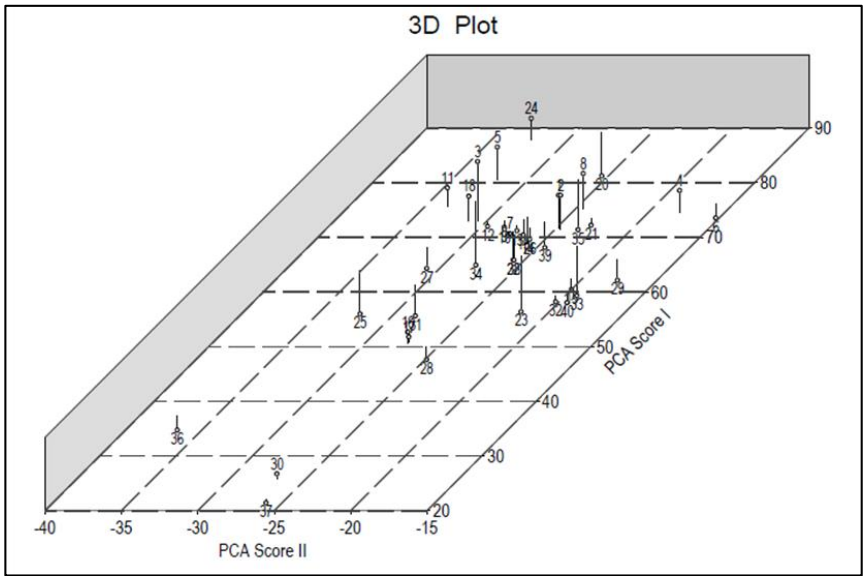

Fig 1: Principal component analysis diagram for 40 yellow sorghum ICRISAT genotypes

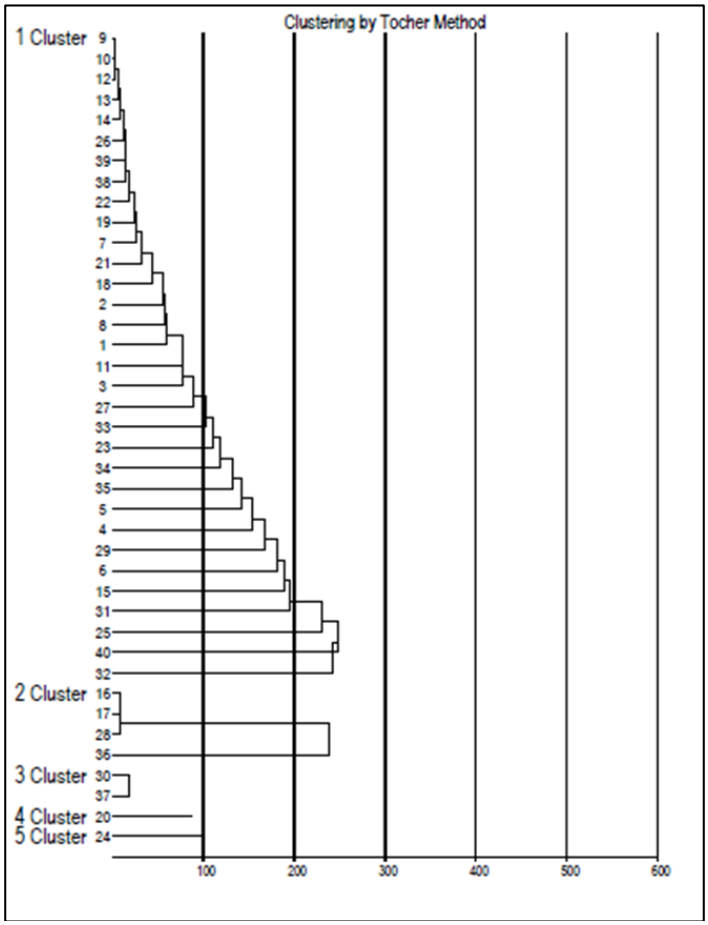

Fig 2: Dendrogram showing clustering of 40 ICRISAT yellow sorghum genotypes

Cluster distances and cluster means

Intra and inter cluster distances for five different clusters are presented in Table 2. Highest intra cluster distance of 12.82 was recorded for cluster 2 followed by cluster 1 (11.79) and cluster 3 (4.36). The inter cluster distances ranged from 65.50 (between cluster 3 and 4), followed by 64.43 (between cluster 3 and 5), 47.72 (between cluster 1 and 3), 43.01 (between cluster 2 and 4), 42.03 (between cluster 2 and 5) and 10.58 (between cluster 4 and 5). The maximum amount of heterosis is expected from the crosses with parents belonging to the most divergent clusters ie., between cluster 3 and 4. Similar results were reported by Singh *et al.* (2001) [7], Umakanth *et al* (2003) [8] and More *et al.*, (2018) [3]. The progenies derived from such crosses are expected to show wide variability, providing greater scope for isolating transgressive segregants in the advanced generations which can be used for selecting desirable genotypes for yield improvement in sorghum. The cluster means for various traits included in the present study are shown in Table 3.

Table 1: Principal component analysis in ICRISAT yellow sorghum lines for ten morphological characters

		1 Vector	2 Vector	3 Vector
	Eigene value (Root)	7697.73100	836.74380	351.55040
	% Var. Exp.	83.41383	9.06709	3.80946
	Cum. Var. Exp.	83.41383	92.48094	96.29039
1	Plant height	0.95449	0.21863	0.06503
2	Days to 50% flowering	0.09129	-0.00615	0.12773
3	Days to maturity	-0.00717	0.00837	0.06183
4	No. of leaves per plant	-0.02692	-0.02459	0.02436
5	Leaf length	0.16423	-0.89276	-0.03747
6	Leaf width	0.11380	0.00127	0.06754
7	Ear length	0.05927	-0.20135	0.34826
8	Straw weight	-0.08981	-0.06088	0.63052
9	100 seed weight	0.14452	-0.15155	-0.65843
10	Grain yield per plant	0.08636	-0.29538	0.12926

Table 2: Intra and inter cluster distances for ten characters in 40 ICRISAT yellow pericarp sorghum genotypes

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
Cluster 1	11.79	26.48	47.72	20.53	20.80
Cluster 2	26.48	12.82	24.82	43.01	42.03
Cluster 3	47.72	24.82	4.36	65.50	64.43
Cluster 4	20.53	43.01	65.50	0.00	10.58
Cluster 5	20.80	42.03	64.43	10.58	0.00

Table 3: Cluster means for ten characters in 40 ICRISAT yellow pericarp sorghum genotypes

	Plant height	Days to 50% flowering	Days to maturity	No. of leaves per plant	Leaf length	Leaf width	Ear length	Straw weight	100 seed weight	Grain yield per plant
Cluster 1	360.95	74.08	104.91	12.13	68.49	7.29	20.74	525.18	3.27	52.00
Cluster 2	220.15	74.45	104.50	9.15	66.65	6.97	17.80	300.00	2.73	46.19
Cluster 3	89.90	70.00	101.50	6.50	52.70	6.00	17.62	50.85	2.44	39.43
Cluster 4	464.60	81.00	106.00	15.00	77.43	9.20	26.80	1000.00	4.08	48.82
Cluster 5	451.20	71.00	89.00	14.60	89.57	6.40	20.60	1.30	2.39	43.54

Percent contribution towards genetic divergence

The relative contribution of different traits towards genetic divergence is shown in Table 4. Plant height contributed the most (57.82%) followed by leaf length (22.82%), grain yield per plant (7.82%), straw weight (4.23%), ear length (3.46%) and days to 50% flowering (2.82%).The genotypes grouped into different clusters are shown in Table 5. Similar results were reported by Yadav *et al* (2004) [9], Elangovan and Babu (2015) [1], Jain and Patel (2016) [5] and Nishant *et al* (2018) [6]. This information can also be used to assess the genetic divergence among the genotypes for framing an effective breeding programme for selection of parents for yield gain in sorghum genotypes under study.

Table 4: Percent contribution of ten traits towards genetic divergence in 40 ICRISAT sorghum genotypes

Source	Times ranked 1st	Contribution %
Plant height	451	57.82
Days to 50% flowering	22	2.82
Days to maturity	4	0.51
No. of leaves per plant	0	0.00
Leaf length	178	22.82
Leaf width	1	0.13
Ear length	27	3.46
Straw weight	33	4.23
100 seed weight	3	0.38
Grain yield per plant	61	7.82

Table 5: Clustering pattern of 40 sorghum yellow pericarp genotypes

Cluster	No. of accessions	Genotypes
I	32	IS-23479, IS-935, IS-535, IS-19125, IS-22426, IS-21736, IS-23014, IS-21735, IS-21728, IS-18333, IS-19290, IS-25039, IS-84, IS – 23422, IS-24685, IS-10932, IS-19003, IS – 19105, IS-19126, IS-3979, IS-19278, IS-22375, IS-24867, IS-2394, N-32518, IS-10973, IS-3691, IS-16200, IS-22998, IS-19261, IS-22978, IS-24805
II	4	IS-22963, IS-22944, IS-23047, IS-12038
III	2	IS-16210, IS-10799
IV	1	IS-2951
V	1	IS-1053

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