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Genetic Divergence for Grain Quality and Productivity Traits in Rabi Sorghum

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***Abstract* – The grain productivity of *rabi* sorghum in India is very low (750 kg/ha) compared to kharif sorghum. To enhance grain quality, productivity and shoot fly tolerance of *rabi* sorghum, prior information on the nature and magnitude of genetic diversity present in germplasm collection is a pre-requisite. One hundred *rabi* sorghum germplasm lines of diverse origin were used to estimate genetic diversity. Among the 15 quantitative traits studied, the highest contribution towards the divergence was by plant height, Days to flowering, panicle weight, panicle length, number of primaries per panicle, dead heart percentage and grain yield were also contributed towards diversity. The genotypes were grouped into 23 clusters. Clustering pattern obtained in the present study indicates that no relationship was observed between the geographical diversity and genetic diversity.**

***Keywords* – Clusters, D^2 values, Diversity and Sorghum.**

I. INTRODUCTION

Sorghum originating in tropical Africa is a crop with extreme genetic diversity. The grain productivity of *rabi* sorghum in India is lower (750 kg/ha) than *kharif* sorghum (1100 kg/ha) eventhough *rabi* sorghum is highly valued because of its excellent grain and fodder quality. The varieties and hybrids developed did not become popular because of poor grain quality and shoot fly susceptibility. To enhance grain quality productivity and shoot fly tolerance of *rabi* sorghum, prior information on the nature and magnitude of genetic diversity present in germplasm collection is a pre-requisite. An attempt was made in the present investigation to study the nature and magnitude of genetic divergence and also to identify divergent parents from distantly related clusters for hybridization programme.

II. MATERIALS AND METHODS

A total of 100 *rabi* sorghum germplasm including 20 land races, 10 exotic lines, 21 indigenous IS lines, 11 all released (*kharif* and *rabi*) varieties 45 B and R lines and 3 special sorghum types were grown in a randomized block design with 3 replications during *rabi* season of 2004-05 at Regional Agricultural Research Station, Bijapur. Five randomly selected plants from each line were utilized for recording all observations except dead heart percent. Genetic diversity was studied using Mahalanobis D^2 statistic (Rao, 1952) and clustering was done following Tocher's method for 15 quantitative traits. It is an unique tool for discriminating population considering a set of parameters.

III. RESULTS AND DISCUSSION

The genotypes were grouped into 23 clusters (Table 1) indicating the presence of greater diversity among the genotypes under study. The maximum number of genotypes (46) were grouped in cluster I followed by cluster II (21), cluster IV (9), cluster VII (3) and cluster X (3). The rest of the clusters were of solitary types. The formation of solitary clusters may be due to total isolation preventing the gene flow or intensive natural/human selection for diverse adoptive complexes. These genotypes may be very unique and useful in breeding point of view.
Intercluster distances presented in Table 2 reveal maximum divergence between clusters XXII and XXIII (125.27) followed by cluster XXIII and XXI (115.73). The intracluster distance varies from 26.64 (cluster VII) to maximum distance of 30.4 (cluster I). This reveals the presence of divergent genotypes within the clusters.

Among the 15 quantitative traits studied, the highest contribution towards the divergence was by plant height. Similar results were reported by Kukadia *et al.* (1981), Sisodia *et al.* (1983), Dabholkar *et al.* (1983). and Mehendiratta and sindhy (1972). Days to flowering, panicle weight, panicle length, number of primaries per panicle, dead heart percentage and grain yield were also contributed towards diversity. These results are similar to results of Arunachalam and Ram, 1967), Biradar *et al.* (1996).

Cluster XXII exhibited the highest mean for plant height, cluster XI showed highest panicle weight, cluster XX exhibited highest for number of primaries per panicle and seed bulk density. Cluster XX had highest seed reflectance, highest protein content in cluster 14 and cluster XV had recorded the highest grain yield per plant. It could be suggested that genotypes present in respective cluster with high mean performance for particular quantitative traits can be utilized in breeding programme to improve those traits (Table 3).

In the present study based on D^2 values the genotypes were classified as highly divergent medium divergent and low divergent pairs as indicated in table.(Table 4) Among these maximum diversity was observed between the genotypes 401B vs SPV 570 followed by SPV 570 vs POP sorghum shiggov , medium diversity was observed between the Yannigar vs BRJ 67 and Ramkhe vs ICSB 83B, while very low diversity was observed between the genotypes E 36-1 vs SFR-2. Highly divergent pairs can be utilized for future hybridization programme for developing potential hybrids with high panicle weight and grain yield.
Clustering pattern obtained in the present study indicates that no relationship was observed between the geographical diversity and genetic diversity. In order to select genetically diverse genotypes the material should be

screened for the important traits *viz.*, plant height, grain yield, days to flowering, panicle weight, panicle length and dead heart percentage.

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Table 1: Distribution of 100 *rabi* sorghum germplasm lines into different clusters

Cluster No.	No. of genotypes	Genotypes
1	46	Jevargi-L, D-Maldandi, Yannigar, Dodd Mogra, SVD-9662, Yarnal-L, IS-3420, Hattarkihal-L-3, IS-36348, Ramkha, BRJ-357, GRC-17-1, Katizapur-L, B.K. Chandki, H1D, IS-37257, IS-19248, IS-40766, IS-32248, Pop-sorg-Shiggov, M.H.Jola, G.M., Harnidagadi, Kovlagi-L, RS-585, BRJ-362, IS-37232, IS-4882, SSV-74, E-36-1, IS-4657, SPV-1516, 9B, ICSB-37B, IS-22464, IS-37283, BJMS-2B, SFR-2, Ravasab, Sweet Sorg, IS-18579, 116B, IS-4587, IS-23490, M31-2B, RSLG-262
2	21	SPV-570, M-35-1, CSV-216R, SFR-7, IS-13771, RR-9817, M148-138, SPV-489, RRJ-359, RS-29, BRJ-356, BJMS-3B, CSV8R, RS-615, BRJ-67, BRJ-364, BRJ-204, Kouta Aurad, RR-9818, CSV14R, BRJ-62
3	1	Sel-3
4	9	104B, P2B, ICSB83B, 53B, 401B, BJMS-1B, 296B, 117B, Swati
5	1	DSV-5
6	1	IS-4946
7	3	5-4-1, Nilgal-L, N. Maldandi
8	1	Chittapur-L
9	1	JP-1-1-5
10	3	IS-2312, IS-18551, Basavanamoti
11	1	DSV-4
12	1	Dadagi Solapur
13	1	IS-4703
14	1	SVD-9662
15	1	R-354
16	1	SPV-1546
17	1	Semiloose
18	1	Pop-Sorg-Shiggov
19	1	C-43
20	1	IS-33720
21	1	SPV-1588
22	1	BRJ-360
23	1	101B

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Table 2 : Average D² values of intra and inter cluster distances among 100 *rabi* sorghum germplasm lines evaluated during *rabi* 2004-05 at Bijapur

Cluster	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII	XVIII	XIX	XX	XXI	XXII	XXIII
I	**30.49**	44.08	34.87	41.48	47.85	34.70	43.63	37.52	42.65	39.14	52.63	57.37	35.54	45.57	50.49	40.51	44.24	45.22	50.87	51.26	66.69	67.73	67.43
II		**28.82**	37.38	52.55	35.37	43.77	55.32	52.64	39.24	42.69	37.75	40.12	43.17	64.06	38.51	40.42	63.30	53.11	76.52	52.72	42.19	46.48	89.14
III			**0.00**	49.66	50.85	36.43	40.70	53.46	52.67	36.11	56.79	60.52	37.35	55.37	51.46	40.95	60.37	32.49	67.31	54.13	57.84	50.69	81.31
IV				28.13	63.28	35.25	67.64	55.25	53.37	54.15	60.59	62.79	50.01	38.11	57.04	61.46	48.03	55.92	48.36	60.03	78.57	86.05	47.75
V					**0.00**	47.98	48.60	38.74	18.82	42.90	26.81	25.28	37.07	75.20	35.15	25.92	65.37	60.92	80.66	45.15	34.07	45.19	98.58
VI						**0.00**	52.14	46.95	39.40	35.17	56.48	48.25	26.41	52.30	51.68	44.25	58.40	45.22	62.38	38.69	59.45	71.81	63.33
VII							**26.64**	39.73	50.52	45.90	58.76	66.36	38.21	70.05	58.06	33.95	62.05	43.95	67.19	55.50	68.03	57.61	94.11
VIII								**0.00**	32.57	47.18	48.79	54.85	35.46	58.67	48.39	30.35	37.83	57.29	51.07	55.00	69.77	71.28	78.52
IX									**0.00**	40.39	28.27	24.36	34.14	65.77	39.77	33.34	58.76	62.20	70.07	35.39	45.31	61.03	84.90
X										**28.93**	51.90	51.82	41.50	55.39	61.23	44.21	65.30	58.15	72.39	35.8	50.85	61.31	80.24
XI											**0.00**	31.89	52.06	70.58	38.86	45.08	66.72	67.00	77.64	49.10	44.92	52.97	95.57
XII												**0.00**	44.84	81.12	39.30	45.03	76.42	70.05	88.95	43.78	33.20	57.68	98.54
XIII													**0.00**	66.72	38.20	23.56	56.03	35.50	64.80	46.09	56.48	59.69	81.21
XIV														**0.00**	77.05	73.00	44.90	69.87	39.46	67.82	91.70	96.01	39.60
XV															**0.00**	33.58	58.46	47.62	74.37	66.58	54.57	51.32	95.29
XVI																**0.00**	55.60	43.34	71.30	54.76	50.62	45.99	94.97
XVII																	**0.00**	62.61	29.67	79.43	92.68	89.62	61.78
XVIII																		**0.00**	66.06	68.80	74.25	61.21	85.78
XIX																			**0.00**	80.42	106.79	104.46	47.36
XX																				**0.00**	51.54	72.11	84.44
XXI																					**0.00**	39.65	115.73
XXII																						**0.00**	125.27
XXIII																							**0.00**

Diagonal values indicate intracluster distances.

Table 3: Clusters means of 15 quantitative characters

Clusters	DF		DH		PH		PW		PL		NP		TW		BD		TD		SV		SS		SO		SP		SR		GY		Score	Rank
I	69.745	(4)	45.502	(16)	117.638	(16)	39.652	(11)	15.903	(8)	51.928	(12)	2.909	(17)	0.747	2	0.805	(8)	0.052	(7)	3.178	(15)	2.931	(11)	13.545	(9)	15.025	(11)	34.860	(14)	161	12
II	75.238	(7)	40.672	(12)	131.676	(9)	58.748	(6)	15.433	(9)	59.423	(8)	3.416	(9)	0.741	4	0.833	(5)	0.058	(5)	3.196	(12)	2.934	(9)	13.616	(8)	14.858	(15)	43.753	(8)	126	4
III	62.330	(1)	41.970	(13)	136.800	(6)	39.670	(12)	14.800	(11)	50.070	(15)	3.370	(10)	0.740	5	0.820	(7)	0.060	(3)	3.250	(10)	3.230	(4)	14.430	(4)	14.340	(21)	24.920	(17)	139	7
IV	71.704	(5)	52.486	(18)	95.029	(20)	46.562	(9)	21.426	(3)	51.667	(14)	3.003	(16)	0.743	3	0.802	(9)	0.057	(5)	3.012	(20)	2.958	(8)	14.404	(5)	14.934	(13)	29.391	(16)	164	14
V	100.330	(12)	36.150	(08)	135.900	(07)	50.730	(7)	13.000	(13)	67.670	(6)	3.640	(03)	0.740	5	0.840	(4)	0.080	(1)	3.430	(06)	2.800	(15)	13.400	(11)	15.120	(9)	50.810	(4)	118	3
VI	75.000	(6)	56.850	(21)	115.200	(18)	33.100	(14)	17.730	(7)	70.000	(5)	2.500	(20)	0.740	5	0.830	(6)	0.040	(9)	3.060	(19)	3.500	(3)	11.330	(19)	14.300	(22)	29.450	(15)	189	17
VII	94.443	(15)	33.110	(04)	142.933	(03)	24.667	(23)	10.700	(15)	46.333	(18)	3.190	(12)	0.740	5	0.820	(7)	0.057	(6)	3.183	(13)	3.010	(6)	15.557	(2)	14.740	(16)	21.013	(19)	164	14
VIII	105.330	(23)	34.660	(05)	115.800	(17)	27.000	(22)	9.530	(18)	47.600	(17)	3.180	(13)	0.740	5	0.790	(11)	0.060	(3)	3.340	(07)	2.930	(10)	13.370	(12)	15.010	(12)	42.870	(10)	185	16
IX	102.670	(22)	40.590	(11)	120.200	(15)	48.670	(8)	9.930	(17)	70.530	(4)	3.060	(15)	0.740	5	0.740	(15)	0.060	(3)	3.230	(11)	2.630	(17)	11.430	(18)	15.440	(3)	43.300	(9)	173	15
X	100.814	(20)	36.120	(07)	126.311	(12)	33.446	(15)	10.053	(16)	54.821	(11)	3.143	(14)	0.740	5	0.783	(12)	0.059	(4)	3.251	(09)	2.857	(14)	13.452	(10)	15.063	(10)	35.728	(12)	155	9
XI	102.330	(21)	31.610	(02)	126.200	(13)	71.570	(1)	17.930	(6)	61.500	(7)	3.550	(05)	0.740	5	0.900	(1)	0.060	(3)	3.160	(17)	2.900	(12)	13.700	(7)	14.630	(18)	40.670	(11)	129	5
XII	98.000	(18)	50.870	(17)	128.500	(11)	63.670	(2)	9.530	(18)	81.130	(3)	3.570	(4)	0.740	5	0.770	(13)	0.070	(2)	3.170	(16)	2.270	(16)	13.000	(13)	14.400	(20)	50.830	(3)	161	12
XIII	90.330	(13)	58.680	(22)	131.600	(10)	29.800	(19)	13.000	(20)	59.070	(9)	2.810	(18)	0.740	5	0.820	(7)	0.060	(3)	2.960	(21)	3.600	(2)	11.600	(16)	14.470	(19)	35.630	(13)	197	18
XIV	84.670	(2)	28.160	(01)	84.070	(02)	38.870	(13)	19.070	(4)	44.070	(20)	2.760	(19)	0.740	5	0.800	(10)	0.050	(8)	3.180	(14)	3.830	(1)	19.430	(1)	15.220	(8)	21.530	(18)	126	4
XV	95.000	(16)	55.690	(20)	134.200	(08)	59.470	(5)	18.600	(5)	44.930	(19)	2.460	(21)	0.750	1	0.840	(04)	0.050	(8)	2.560	(23)	2.900	(12)	12.530	(14)	15.290	(6)	53.400	(1)	163	13
XVI	95.670	(17)	43.470	(14)	141.500	(04)	33.470	(17)	13.000	(13)	51.870	(13)	3.920	(7)	0.740	5	0.860	(02)	0.070	(2)	3.847	(1)	2.870	(13)	11.530	(17)	15.260	(7)	46.990	(5)	130	6
XVII	87.330	(11)	39.330	(10)	95.170	(19)	31.430	(18)	10.700	(15)	22.770	(22)	3.420	(8)	0.740	5	0.830	(06)	0.070	(2)	3.580	(4)	3.000	(7)	9.830	(20)	15.430	(4)	45.670	(6)	157	10
XVIII	76.000	(88)	62.810	(23)	141.800	(05)	33.500	(16)	26.330	(1)	36.130	(21)	1.730	(23)	0.740	5	0.820	(15)	0.050	(8)	2.780	(22)	2.600	(18)	14.000	(7)	14.930	(14)	21.410	(20)	206	19
XIX	89.670	(12)	43.690	(15)	83.830	(22)	28.730	(20)	12.870	(14)	21.370	(23)	3.280	(11)	0.740	5	0.770	(13)	0.060	(3)	3.670	(3)	3.000	(7)	14.130	(6)	14.680	(17)	19.130	(21)	189	17
XX	92.670	(14)	37.660	(09)	121.300	(14)	44.070	(10)	9.470	(19)	90.370	(1)	3.430	(7)	0.740	5	0.850	(03)	0.060	(3)	3.550	(5)	2.870	(13)	12.300	(15)	15.550	(1)	16.330	(22)	141	8
XXI	82.000	(10)	36.030	(06)	151.700	(02)	62.600	(3)	14.600	(12)	88.400	(2)	3.980	(1)	0.740	5	0.760	(14)	0.070	(2)	3.820	(2)	2.900	(12)	14.670	(3)	15.460	(2)	51.430	(2)	78	1
XXII	80.000	(9)	32.390	(03)	172.100	(01)	60.900	(4)	15.270	(10)	55.330	(10)	3.540	(6)	0.740	5	0.820	(07)	0.050	(8)	3.300	(8)	3.200	(5)	17.370	(2)	15.350	(5)	45.570	(7)	90	2
XXIII	66.000	(3)	53.630	(19)	58.530	(23)	27.600	(2)	25.470	(2)	40.130	(16)	3.210	(2)	0.750	1	0.830	(06)	0.050	(8)	3.110	(18)	2.900	(12)	13.000	(13)	15.010	(12)	16.070	(23)	160	11

Number in parenthesis indicate relative grade/score for each character across 23 clusters

DF - Days to 50% flowering
DH - Dead heart (%)
PH - Plant height at maturity
PW - Panicle weight
PL - Panicle length
NP - Number of primaries per panicle
TW - Test weight
BD - Seed bulk density
TD - Seed true density
SV - Seed volume
SS - Seed size
SO - Seed oil content
SP - Seed protein
SR - Seed reflectance
GY - Grain yield

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Table 4: Practical utility of divergent pairs

S. No.					D^2 values
I. Highly divergent pairs					
1.		**401-B**	Vs	**SPV570**	
	PW	34.63		60.8	**1208.22**
	GY	22.84		39.64	
2.		**SPV570**	Vs	**Pop-sorghum shiggov**	
	PW	60.8		33.5	**1141.81**
	GY	39.64		21.41	
3.		**R354**	Vs	**CS3541**	
	PW	59.47		38.87	**1138.61**
	GY	53.40		21.53	
4.		**SPV570**	Vs	**R354**	
	PW	60.8		59.47	**1117.26**
	GY	39.64		53.40	
5.		**BJMS-1B**	Vs	**R354**	
	PW	45.8		59.47	**1090.19**
	GY	30.53		53.40	
II. Medium divergent pairs					
1.		**Yannigar**	Vs	**BRJ67**	
	PW	25.87		56.4	**585.75**
	GY	16.38		49.3	
2.		**Ramkhe**	Vs	**ICSB 83B**	
	PW	33.73		48.0	**594.52**
	GY	27.53		36.78	
3.		**Ramkhe**	Vs	**M31-2B**	
	PW	33.73		36.77	**597.90**
	GY	27.53		35.65	
4.		**Ramkhe**	Vs	**BJMS-1B**	
	PW	33.73		45.8	**598.48**
	GY	27.53		30.53	
5.		**Harni dagdi**	Vs	**Pop sorghum shiggov**	
	PW	35.00		29.13	**607.46**
	GY	47.07		21.41	
III. Low divergent pairs					
1.		**E36-1**	Vs	**RS585**	
	PW	43.07		42.4	**12.39**
	GY	40.79		38.6	
2.		**E36-1**	Vs	**SFR-2**	
	PW	43.07		43.27	**14.85**
	GY	40.79		38.17	
3.		**E36-1**	Vs	**IS4882**	
	PW	43.07		35.67	**20.78**
	GY	40.79		40.23	
4.		**DSV-4**	Vs	**BRJ357**	
	PW	71.57		27.73	**20.52**
	GY	40.67		33.53	
5.		**ICSB37B**	Vs	**96B**	
	PW	44.2		44.83	**19.70**
	GY	37.26		26.91	

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