Genetic and Environmental Variability in Sorghum [*Sorghum bicolor* (L.) Moench] Germplasm Collected from Rajasthan and Madhya Pradesh

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Sorghum (*Sorghum bicolor* L. Moench) germplasm collections consisting of 80 accessions from Madhya Pradesh and Rajasthan were evaluated during *kharif* 2008 and 2009 (June-October) season for 22 agro-morphological traits using minimal descriptors developed by NBPGR. Analysis of variance showed significant differences among genotypes for 22 traits. Large variation among genotypes was found for the traits *viz.,* days to flowering (49-85 days), leaf length (47-95 cm), leaf width (4.2-8.7 cm), number of leaves per plant (7-15), plant height (165-349 cm), panicle length (8.2-29.4 cm), panicle width (3.5-8.9 cm), 100-seed weight (1.7-3.4 g), days to maturity (101-121 days), stem fresh weight/10 plants) (575-3,225 g) and stem dry weight/10 plants (288-2188 g). Selections can be practiced for traits such as days to flowering, leaf length, leaf orientation, days to maturity and plant height as governed by additive gene action.

Key Words: Cluster analysis, GCV, PCV, Principal components, Sorghum

Introduction

Sorghum [*Sorghum bicolor* (L.) Moench] is fifth most important cereal crop worldwide after wheat, rice, maize and barley (FAO, 2004). It is grown during rainy and post-rainy seasons in semi-arid regions of the country on the marginal lands. It is better adapted to drought-prone regions with poor soils when compared to other cereal crops. In India, the crop is mostly grown in Maharashtra, Karnataka, Andhra Pradesh, Madhya Pradesh, Rajasthan, Uttar Pradesh, Gujarat and Tamil Nadu. In India it occupies 7.8 million ha. In the light of rapidly increasing human population and expansion of agriculture into marginal areas, the importance of sorghum in semi-arid regions of the world will increase in future (House, 1995). In order to meet the food requirement of the increasing population, development of high yielding varieties is essential. Farmers and breeders use local cultivars or landraces for varietal improvement programmes. They are morphologically similar or different as they are adapted to particular environments. For the present study traditional cultivars or primitive cultivars or local landraces or farmer's variety of sorghum were collected from Rajasthan and Madhya Pradesh and evaluated at the Directorate of Sorghum Research, Hyderabad.

Materials and Methods

The sorghum germplasm collections consisting of 80 accessions from Rajasthan and Madhya Pradesh were the base material used for evaluation. The germplasm collection represented all the basic races of sorghum viz., *bicolor* (8), *durra* (40), *durra-bicolor* (6), *durra-caudatum* (24), and *guinea-caudatum* (2) (Table 1). These accessions were evaluated in *kharif* 2008 and 2009 (June-October) season at the New area field farm of Directorate of Sorghum Research, Rajendranagar, Hyderabad located at latitude 17^0 19' 28.5" N and longitude 78^0 24' 13.4" E at an altitude of 524 m msl. The seed material was sown in augmented block design plots with two replications in both the growing seasons. Each genotype was sown in three rows, 5 m long, with a row-to-row spacing of 45 cm, and plant-to-plant spacing within a row, of 15 cm. Recommended cultural practices were followed to raise the crop. The data were recorded in each genotype on 22 agro-morphological traits following minimal descriptor developed by National Bureau of Plant Genatic Resources (Mahajan *et al.,* 2000). Five representative plants in each accession were tagged for recording the qualitative and quantitative traits. The seedling vigour was recorded in 14-days-old seedlings. The midrib colour was recorded in the one month aged seedlings. The data on days to 50% flowering was recorded during the panicle emergence stage. The leaf orientation, leaf length (cm), and leaf width (cm), number of leaves, plant height (cm), were recorded during the physiological maturity stage. The earhead shape, compactness, length (cm) and width (cm) were counted during the maturity stage. The stem fresh weight (g), stem dry weight (g) and 100-seed weight (g) were measured after the harvesting. The glume colour,

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Table 1. List of accessions collected from two states with racial classification

Sl. No.	Genotype	National Indentity Number	State	District	Race
1	E 1	IC 338968	Rajasthan	Udaipur	Durra
2	E 2	IC 338969	Rajasthan	Udaipur	Durra-caudatum
3	E 3	IC 338970	Rajasthan	Udaipur	Durra
4	E 4	IC 338971	Rajasthan	Udaipur	Durra-caudatum
5	E 5	IC 338972	Rajasthan	Udaipur	Durra-caudatum
6	E 7	IC 338973	Rajasthan	Rajsamand	Durra
7	E 9	IC 338974	Rajasthan	Rajsamand	Durra
8	E 11	IC 338976	Rajasthan	Rajsamand	Bicolor
9	E 12	IC 338977	Rajasthan	Rajsamand	Durra-caudatum
10	E 13	IC 338978	Rajasthan	Rajsamand	Bicolor
11	E 14	IC 338979	Rajasthan	Rajsamand	Durra
12	E 15	IC 338980	Rajasthan	Rajsamand	Bicolor
13	EJ 2	IC 338982	Rajasthan	Udaipur	Durra-caudatum
14	EJ 3	IC 338983	Rajasthan	Pali	Durra-caudatum
15	EJ 4	IC 338984	Rajasthan	Pali	Guinea-caudatum
16	EJ 5	IC 338985	Rajasthan	Pali	Durra-caudatum
17	EJ 6	IC 338986	Rajasthan	Pali	Durra-caudatum
18	EJ 7	IC 338987	Rajasthan	Sirohi	Durra
19	EJ 8	IC 338988	Rajasthan	Sirohi	Durra
20	EJ 9	IC 338989	Rajasthan	Sirohi	Durra
21	EJ 10	IC 338990	Rajasthan	Sirohi	Bicolor
22	EJ 11	IC 338991	Rajasthan	Sirohi	Bicolor
23	EJ 12	IC 338992	Rajasthan	Sirohi	Bicolor
24	EJ 13	IC 338993	Rajasthan	Sirohi	Durra
25	EJ 14	IC 338994	Rajasthan	Sirohi	Durra
26	EJ 15	IC 338995	Rajasthan	Sirohi	Durra-caudatum
27	EJ 16	IC 338996	Rajasthan	Sirohi	Durra
28	EJ 17	IC 338997	Rajasthan	Sirohi	Durra
29	EJ 18	IC 338998	Rajasthan	Sirohi	Durra bicolor
30	EJ 19	IC 338999	Rajasthan	Pali	Durra
31	EJ 20	IC 339000	Rajasthan	Pali	Durra-caudatum
32	EJ 21	IC 339001	Rajasthan	Pali	Durra
33	EJ 22	IC 339002	Rajasthan	Pali	Durra
34	EJ 23	IC 339003	Rajasthan	Pali	Durra-caudatum
35	EJ 24	IC 339004	Rajasthan	Pali	Durra
36	EJ 25	IC 339005	Rajasthan	Pali	Durra
37	EJ 26	IC 339006	Rajasthan	Pali	Durra
38	EJ 27	IC 339007	Rajasthan	Pali	Durra
39	EJ 28	IC 339008	Rajasthan	Pali	Durra
40	EJ 29	IC 339009	Rajasthan	Pali	Durra-caudatum
41	EJ 30	IC 339010	Rajasthan	Pali	Durra
42	EJ 31	IC 339011	Rajasthan	Pali	Durra
43	EJ 32	IC 339012	Rajasthan	Pali	Durra
44	EJ 33	IC 339013	Rajasthan	Pali	Durra
45	EJ 34	IC 339014	Rajasthan	Nagaur	Durra
46	EJ 35	IC 339015	Rajasthan	Nagaur	Durra
47	EJ 36	IC 339016	Rajasthan	Nagaur	Durra bicolor
48	EJ 37	IC 339017	Rajasthan	Nagaur	Durra
49	EJ 38	IC 339018	Rajasthan	Nagaur	Durra
50	EJ 39	IC 339019	Rajasthan	Ajmer	Durra
51	EJ 40	IC 339020	Rajasthan	Ajmer	Durra-caudatum
52	EJ 41	IC 339021	Rajasthan	Tonk	Durra-caudatum
53	EJ 42	IC 339022	Rajasthan	Tonk	Durra bicolor
54	EJ 43	IC 339023	Rajasthan	Tonk	Durra-caudatum
55	EJ 44	IC 339024	Rajasthan	Bhilwara	Durra
56	EJ 45	IC 339025	Rajasthan	Bhilwara	Durra bicolor
57	EJ 46	IC 339026	Rajasthan	Bhilwara	Durra
58	EJ 47	IC 339027	Rajasthan	Bhilwara	Durra bicolor
59	EB 1	IC 332460	Madhya Pradesh	Indore	Durra-caudatum
60	EB 2	IC 332461	Madhya Pradesh	Indore	Durra-caudatum
61	EB 3	IC 332462	Madhya Pradesh	Dhar	Durra-caudatum
62	EB 4	IC 332463	Madhya Pradesh	Dhar	Durra-caudatum
63	EB 5	IC 332464	Madhya Pradesh	Dhar	Bicolor

Sl. No.	Genotype	National Identity Number	State	District	Race
64	EB 6	IC 332465	Madhya Pradesh	Dhar	Bicolor
65	EB 7	IC 332466	Madhya Pradesh	Dhar	Durra-caudatum
66	EB 8	IC 332467	Madhya Pradesh	Dhar	Durra-caudatum
67	EB 9	IC 332468	Madhya Pradesh	Dhar	Durra
68	EB 10	IC 332469	Madhya Pradesh	Dhar	Durra
69	EB 11	IC 332470	Madhya Pradesh	Dhar	Guinea-caudatum
70	EB 12	IC 332471	Madhya Pradesh	Dhar	Durra bicolor
71	EB 13	IC 332472	Madhya Pradesh	Jhabua	Durra-caudatum
72	EB 14	IC 332473	Madhya Pradesh	Jhabua	Durra
73	EB 15	IC 332474	Madhya Pradesh	Jhabua	Durra
74	EB 16	IC 332475	Madhya Pradesh	Jhabua	Durra
75	EB 17	IC 332476	Madhya Pradesh	Jhabua	Durra-caudatum
76	EB 18	IC 332477	Madhya Pradesh	Jhabua	Durra
77	EB 19	IC 332478	Madhya Pradesh	Jhabua	Durra
78	EB 20	IC 332479	Madhya Pradesh	Jhabua	Durra
79	EB 21	IC 332480	Madhya Pradesh	Jhabua	Durra-caudatum
80	EB 22	IC 332481	Madhya Pradesh	Dhar	Durra

glume coverage, presence of awns, grain color, grain size and grain lustrous were observed after the harvesting stage. For qualitative and quantitative traits data, average of five plants per genotype, were computed and these were used for statistical analyses.

Analysis of variance (ANOVA) was carried out assuming season effects as random, and cultivar effects as fixed. The homogeneity of error variance was established as per Gomez and Gomez (1984). Coefficient of variation (CV%), phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV) and heritability in broad-sense (h^2) were calculated according to the procedure described by Singh and Chaudhary (1985), and expected genetic advance (GA) as suggested by Johnson *et al.* (1995). The data were subjected to multivariate analyses (Mahalanobis, 1949) and the genotypes were further grouped into different clusters based on Ward's minimum variance method (Hair *et al.,* 1987), and principal component analysis was done according to Rao (1964). All the data analysis was performed using Indostat (2004).

Results and Discussion

Genetic Variability

Analysis of variance showed significant differences among genotypes for all traits studied. Large variation among genotypes was found for the traits, days to flowering (49-85 days), leaf length (47-95 cm), leaf width (4.2-8.7 cm), number of leaves per plant (7-15), plant height (165-349 cm), panicle length (8.2-29.4 cm), panicle width (3.5-8.9 cm), 100 seed weight (1.7-3.4 g), days to maturity (101-121 days), stem fresh weight/10 plants) (575-3225 g) and stem dry weight (288-2188 g) (Table 1). Analysis of variance showed significant differences among the genotypes for 22 traits. Significant GxE interactions for leaf length and leaf width of the plants were observed.

Genetic Diversity

Phenotypic and genotypic co-efficient of variations, heritability and genetic gain were calculated following Burton and De Vane (1953). Significant differences were observed among the genotypes for all the characters indicating presence of adequate genetic variability in the experimental material. The genetic constants for the characters revealed that the magnitude of phenotypic co-efficient of variation (PCV) was higher than the corresponding genotypic co-efficient of variation (GCV) denoting environmental factors influencing their expressions to some degree or other. Narrow difference between PCV and GCV suggested their relative resistance to environmental alteration. In the present study, the PCV and GCV were higher for days to 50% flowering, leaf length, leaf width, number of leaves, plant height, earhead length, earhead width, 100-seed weight, days to maturity, stem fresh weight, stem dry weight, vigour, leaf orientation, midrib colour, earhead shape, earhead compactness, glume colour, glume covering (Table 2). High amount of GCV and PCV suggested greater scope for selection of superior genotypes for these traits. The lower degree or equal GCV and PCV for presence of awns, grain size, grain color and grain lustrous indicated that improvement for such traits might be achieved only

Table 2. Genetic variability, heritability and genetic advance for different traits in sorghum germplasm collected from Rajasthan and Madhya Pradesh

Traits	Mean	C.V.	C.D 5%	Range	Variance (Genotypical)	Variance (Phenotypical)	ECV	GCV	PCV	h^2 percentage (Broad sense)	Genetic advance as % of mean (5%)
Days to 50% flowering (days)	66.90	10.07	9.38	49-85	55.55	100.90	10.07	11.14	15.02	55.00	17.03
Leaf length (cm)	70.99	12.04	11.91	46.6-94.5	127.55	200.65	12.04	15.91	19.95	64.00	26.13
Leaf width (cm)	6.21	15.09	1.30	4.2-8.7	0.54	1.41	15.09	11.81	19.16	38.00	14.98
Number of leaves	10.39	15.16	2.19	7-15	3.89	6.37	15.16	18.97	24.28	61.00	30.52
Plant height (cm)	252.62	10.84	38.16	165-349.1	2258.62	3009.10	10.84	18.81	21.72	75.00	33.58
Earhead length (cm)	16.57	14.95	3.45	8.2-29.4	27.29	33.42	14.95	31.53	34.90	82.00	58.69
Earhead width (cm)	5.55	15.39	1.19	3.5-8.9	1.03	1.76	15.39	18.33	23.93	59.00	28.92
100-Seed weight (g)	2.40	20.66	0.69	1.7-3.4	0.12	0.37	20.66	14.59	25.29	33.00	17.33
Days to maturity (days)	109.16	4.83	7.34	101-121	26.55	54.31	4.83	4.72	6.75	49.00	6.80
Stem fresh weight (g)	1632.66	40.44	919.78	575-3225	338238.10	774205.00	40.44	35.62	53.89	44.00	48.50
Stem dry weight (g)	937.00	52.49	685.10	288-2188	150568.30	392442.50	52.49	41.41	66.86	38.00	52.84
Vigour	2.71	2.06	0.08	2-3	0.21	0.21	2.06	16.74	16.86	99.00	34.22
Leaf orientation	1.10	5.07	0.08	1-2	0.09	0.09	5.07	27.27	27.74	97.00	55.24
Midrib colour	1.28	4.37	0.08	1-2	0.20	0.20	4.37	35.00	35.28	99.00	71.55
Earhead shape	3.77	1.48	0.08	2-7	2.58	2.58	1.48	42.59	42.61	100.00	87.68
Earhead compactness	1.75	3.19	0.08	1-3	0.52	0.52	3.19	41.16	41.28	99.00	84.53
Glume colour	4.65	1.20	0.08	2-10	7.93	7.93	1.20	60.51	60.53	100.00	124.64
Glume covering	2.33	2.40	0.08	1-4	0.85	0.85	2.40	39.52	39.60	100.00	81.27
Awns	0.73	0.00	-	0-1	0.20	0.20	0.00	61.98	61.98	100.00	127.67
Grain size	5.83	0.00	-	3-9	3.01	3.01	0.00	29.77	29.77	100.00	61.33
Grain colour	3.09	0.00	-	1-14	9.90	9.90	0.00	101.93	101.93	100.00	209.97
Grain lustrous	0.16	0.00	-	0-1	0.14	0.14	0.00	228.45	228.45	100.00	470.61

up to some extent. Similar findings were also obtained by Warkad *et al.* (2008). Equal GCV and PCV was observed in sorghum for plant height up to base of flag leaf, stigma length, plant height, panicle length (Reddy, *et al.,* 2009). High GCV and PCV values were found for grain lustrous.

The determination of the heritable portions is not based only on the estimation of the GCV and PCV. The estimation of heritability along with the coefficient of variability would mean the amount of advance expected. Burton (1952) also suggested that GCV and heritability estimate would give better information about the efficiency of the selection. The heritability ranged from 33 (100-seed weight) to 100 (earhead shape, glume colour, glume covering, presence of awns, grain size, grain colour and grain lustrous). The utility of heritability is increased when it is used to estimate genetic advance (Johnson *et al.,* 1995). The genetic advance has an added edge over heritability as a guiding factor to breeders in selection programme. High heritability coupled with high genetic advance and GCV was noticed for grain colour, grain lustrous, presence of awns, earhead shape and earhead compactness.

Table 3. Cluster mean values for different contributing characters

S. No	Variable	PC I	PC I	PC II	PC III	PC IV
1	Days to flowering (days)	66.71	66.71	66.66	68.70	72.75
2	Leaf length (cm)	70.69	70.69	71.88	70.24	77.05
3	Leaf width (cm)	6.18	6.18	6.23	6.30	6.53
4	Number of leaves (No)	10.36	10.36	10.54	9.95	11.75
5	Plant height (cm)	255.00	255.00	254.46	212.95	283.63
6	Earhead length (cm)	14.77	14.77	20.92	20.10	27.13
7	Earhead width (cm)	5.52	5.52	5.90	4.66	5.50
8	100-Seed weight (g)	2.45	2.45	2.28	2.22	2.53
9	Days to maturity (days)	109.32	109.32	109.10	106.65	114.00
10	Stem fresh weight (g)	1635.97	1635.97	1641.18	1440.00	2262.50
11	Stem dry weight (g)	944.58	944.58	943.01	772.50	1225.00
12	Vigour	2.81	2.81	2.46	2.40	2.00
13	Leaf orientation	1.13	1.13	1.13	1.00	1.00
14	Midrib colour	1.20	1.20	1.43	1.80	2.00
15	Earhead shape	3.24	3.24	4.93	5.15	7.00
16	Earhead compactness	1.47	1.47	2.41	2.60	3.00
17	Glume colour	4.34	4.34	4.60	8.40	7.00
18	Glume covering	2.28	2.28	2.60	1.80	4.00
19	Awns	0.87	0.87	0.53	0.00	0.00
20	Grain size	6.41	6.41	4.78	3.80	3.00
21	Grain colour	1.49	1.49	8.16	2.00	14.00
22	Grain lustrous	0.24	0.24	0.07	0.00	0.00

Table 4. Matrix of principal components of 22 variables for 80 sorghum germplasm

S. No	Variable	PC I	PC II	PC III	PC IV
1	Days to flowering (days)	0.00057	0.01386	0.00582	0.02258
2	Leaf length (cm)	0.00268	0.01832	0.00261	0.04537
3	Leaf width (cm)	0.00112	-0.00036	0.00006	-0.0019
4	Number of leaves (No)	0.00099	0.01327	-0.00521	0.01596
5	Plant height (cm)	-0.0014	0.017	-0.01088	0.03573
6	Earhead length (cm)	0.02035	0.00138	0.052	-0.00346
7	Earhead width (cm)	0.00017	0.01594	-0.02072	0.03526
8	100-Seed weight (g)	0.00098	0.01308	-0.00074	0.01583
9	Days to maturity (days)	0.00185	0.01422	0.00039	0.02041
10	Stem fresh weight (g)	0.00167	0.01122	-0.00007	0.01314
11	Stem dry weight (g)	0.00018	-0.00232	0.00354	-0.00118
12	Vigour	-0.02405	-0.01468	-0.03671	0.03878
13	Leaf orientation	-0.0047	-0.02125	-0.03358	0.03687
14	Midrib colour	0.01223	-0.02898	0.05501	-0.03703
15	Earhead shape	0.14817	-0.10351	0.65734	0.35008
16	Earhead compactness	0.00763	0.04441	-0.02309	-0.07413
17	Glume colour	0.06074	-0.88706	-0.33683	0.12449
18	Glume covering	-0.02576	-0.05567	-0.28149	-0.40529
19	Awns	-0.09534	0.2362	-0.16442	0.14118
20	Grain size	-0.16693	0.28583	-0.52977	0.63239
21	Grain colour	0.71544	0.2335	-0.23924	-0.30342
22	Grain lustrous	-0.65088	0.04548	0.03035	-0.41213
	Root	213350.5	40488.19	32098.16	11047.6
	% Var. Exp.	69.21899	13.1359	10.41386	3.58426
	Cum. Var. Exp.	69.21899	82.35486	92.76874	96.353

The 80 sorghum germplasm genotypes tested for two years during the seasons were grouped into four clusters based on D^2 values (Table 5). The distribution pattern indicated that the maximum number of genotypes were included in cluster I with 57 genotypes, followed by cluster II having 17 genotypes and cluster III having five genotypes. The cluster IV has only one genotype i.e. E 11 (IC 338976). The cluster distance ranged from 2218.3 to 4640.8 within the clusters and 5972.5 to 45279.1 between clusters (Table 6). The inter-cluster distance were higher than intra-cluster distance, which indicated wide genetic diversity among the accessions of different groups than those of same cluster. The least intra-cluster distance among the accessions was 2218.3. In cluster I, there was lack of variation among the accessions.

The diversity among the present set of material was also supported by the appreciable amount of variation among cluster means for different characters (Table 4). The cluster which is diverse from other clusters

Table 5. Grouping of genotypes into different clusters

Cluster	Genotype Name
I	EJ 26 (IC 339006), EJ 27 (IC 339007), EJ 24 (IC 339004), E 9 (IC 338974), EJ 6 (IC 338986), EJ 15 (IC 338995), EJ 17 (IC 338997), EJ 22 (IC 339002), EJ 32 (IC 339012), EB 3 (IC 332462), EJ 19 (IC 338999), EB 16 (IC 332475), EB 21 (IC 332480), E 7 (IC 338973), EJ 30 (IC 339010), EJ 36 (339016), EJ 33 (IC 339013), EJ 21 (IC 339001), EJ 29 (IC 339009), EJ 23 (IC 339003), EJ 20 (IC 339000), EJ 5 (IC 338985), EJ 39 (IC 339019), EJ 3 (IC 338983), EJ 14 (IC 338994), EB 14 (IC 332473), EJ 8 (IC 338988), EJ 16 (IC 338996), EB 19 (IC 332478), EJ 38 (IC 339018), EJ 31 (IC 339011), EJ 35 (IC 339015), EB 9 (IC 332468), EJ 47 (339027), EJ 41 (IC 339021), EJ 7 (IC 338987), EB 1 (IC 332460), EB 15 (IC 332474), EJ 42 (IC 339022), E 2 (IC 338969), EJ 37 (IC 339017), EJ 45 (IC 339025), EB 10 (332469), E 5 (IC 338972), E 4 (IC 338971), EB 20 (IC 332479), EB 4 (IC 332463), EJ 40 (IC 339020), EB 22 (IC 332481), EB 5 (IC 332464), EJ 25 (IC 339005), EB 2 (IC 332461), EB 7 (IC 332466), EJ 34 (IC 339014), EJ 2 338982), EB 13 (IC 332472), EJ 12 (IC 332471)
II	EJ 44 (IC 339024), EJ 46 (IC 339026), EB 18 (IC 332477), E 1 (IC 338968), EJ 28 (IC 339008), E 12 (IC 338977), EB 8 (IC 332467), EB 12 (IC 332471), EB 6 (IC 332465), EB 11 (IC 332470), E 14 (IC 338979), EJ 43 (IC 339023), E 13 (IC 338978), EJ 11 (IC 338991), EJ 18 (IC 338998), EJ 10 (IC 338990), EJ 9 (IC 338989)
III	EJ 4 (IC 338984), EB 17 (IC 332476), E 3 (IC 338970), EJ 13 (IC 338993), E 15 (IC 338980)
IV	E 11 (IC 338976)

has different mean values for leaf width, number of leaves, earhead length, earhead width, 100-seed weight, stem fresh weight, stem dry weight, midrib colour, earhead shape, earhead compactness, glume colour, glume covering, awns, grain size, grain colour, and grain lustrous. Cluster IV also was diverse from other clusters due to different cluster mean values for days to flowering, leaf length, leaf orientation, days to maturity, plant height. Exploitation of genetic resources within and among these contrasting pools of diversity may provide a different source of germplasm with combination traits for utilization in the sorghum improvement programme. Landraces adapt to different climatic conditions which may be used for developing improved cultivars for yield. Selection for the traits plant height, grain weight can be practiced and incorporated easily as the traits are governed by additive gene action. The traits glume colour, awns, grain colour, grain lustrus are governed by the non-additive gene effects and can be made use for developing distinct variety.

Table 6. Average intra (bold) and inter cluster distances for 80 genotypes of sorghum *(Tocher method)*

Cluster	I	II	III	IV
I	2218.26	15318.97	5972.54	45279.08
II		4640.78	11191.85	12563.12
III			3259.75	32376.30
IV				0

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