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RESEARCH ARTICLE

Diversity of Sorghum [*Sorghum bicolor* (L.) Moench] germplasm from Gujarat, India

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Abstract

Landraces are the varieties nurtured and cultivated by the farmers through traditional method of selection over the decades. The "landrace" is a primitive cultivar grown by farmers and their successors since ancient times. Directorate of Sorghum Research (DSR), Hyderabad and Sorghum Research Station, Sardarkrushinagar Dantiwada Agricultural University (SDAU), Deesa, Gujarat has explored different areas of Gujarat state and collected 147 sorghum accessions. The important landraces are *Chachadia, Char, Deshi, Deshi Malwan, Gundri, Jawari, Kamal Parva, Maklani, Malwan, Poru, Rajka Jowar, Solapuri, Sundi jowar, Sundia, Utavali and Wagad*. Forty-six accessions were collected from Kutch district, followed by Banaskanta (30), Patan (13), Surat, Surendrapur, Ahmednagar (each 7), Bhavanagar, Junagadh, Mahesana (each 6), Jamnagar, Sabarkantha (each 4), Bharuch, Dang (each 3) Vadodara, Porbandar (each 2) and Marilia comprisiong only one accession. These accessions were classified into basic races viz., *bicolor* (18), *durra* (67), *bicolor-guinea* (1), *caudatum* (1), *durra-bicolor* (19), *durra-caudatum* (2) and *guinea-caudatum* (1). Variability among the collections is very high. Farmers mainly use their traditional deshi sorghum. Most of the accessions are tall (88) in plant height, semi compact ear head (79), bold seeded (126) and white coloured seed (61) to pearly white (40). Out of these E 182 (IC 568399), E 183 (IC 568400), E 184 (IC 568401), E 160 (IC 568377), E 161 (IC 568378), E 162 (IC 568379), E 163 (IC 568380), ERN 26 (IC 568541), ERN 27 (IC 568542) and ERN 28 (IC 568543) accessions are identified as salinity tolerant. EJN 4 (IC 585174) is very early flowering and matures at 75 days with tolerant to disease and drought. ERN 1 (IC 568516) is dual type and E 173 (IC 568390) and E 158 (IC 568375) are sweet sorghum type. Majority of the accessions are used as fodder.

INTRODUCTION

Exploration and collection of germplasm are primarily aimed to augment the diversity in plant genetic resources which are the basic raw materials to meet the current and future requirements of crop improvement programmes. The continued availability of plant genetic resources with breeders is necessary not only for sustaining crop productivity but also for stabilizing production in the country. These resources of known or potential use to man constitute a broad spectrum of diverse gene pools representing assemblage of landraces, primitive cultivars, varieties of traditional agriculture as well as wild and weedy relatives of crop plants (IPGRI 1993). A wider genetic base, thus, helps the breeders in the development of improved crop varieties designed to combine high yield potential with

superior quality, resistance to diseases and pests, and also better adaptation to abiotic stress environments. The traditional varieties or landrace population are often highly variable in appearance, but each is identifiable, having particular properties or characteristics, such as early or late maturing, adaptability to a particular soil type, etc. They specially exhibited their higher potential in local marginal area where they appear equal or some time superior to modern varieties in term of yield (Weltzien and Fishbeck, 1990). Many of the landraces and primitive cultivars have already vanished and some are on the verge of it due to their abandonment by farmers in lieu of high yielding varieties. The remaining ones are genetically deteriorating gradually due to hybridization, selection or genetic drift. It is, therefore the immediate requirement to assess, collect and maintain them in suitable environments and conserve in National Genebank.

Sorghum is of African origin (Kimber, 2003) and Africa has largest diversity of cultivated and wild sorghum (Doggett 1988; deWet, 1977). In the Indian Subcontinent there is evidence for early cereal cultivation discovered at an archaeological site in Western parts of Rojdi (Saurashtra) which dating back to about 4500 before present (Damania, 2002) and India is considered to be secondary center of origin of sorghum (Vavilov, 1992). Agriculture of the state is characterized as dry farming. In most part of the state, hoeing with blade harrows practiced as substitute to ploughing. Annual ploughing is not necessary because only one crop is grown in each year. The subsistence of the crops dominated by the state is bajra and jowar (Patel, 1977). The saline wetlands of the western portion of the northern region covering the estuaries of Rupen, Saraswathi and Banas rivers in particular, favour excellent growth of many species of wild grasses for pastoral communities (Bhan, 1994). Based on the archeological evidences pearl millet, sorghum and finger millet are most important. Finger millet forms the most important plant right from the beginning of the settlement (Weber and Vishnu Mitree, 1989). The millets used to continue in use in the post-urban phase at Orio Timbo (Rissaman, 1985; Reddy, 1991).

Gujarat has geographical area of 1,96,024 sq km and accounts for 6.19 percent of the total area of the country. It is located in the Gujarat plain and hill agro climatic zone and based on evapo-transpiration it comes in the semi arid climate. State comprises of 26 districts and divided in eight agro climatic zones based on agro climatic conditions that support cultivation of a wide range of crops. The state produces a large variety of crops and its cropping pattern reflects the spatial variations in climate and topography. Sorghum is the important crop of the Gujarat mainly grown as a fodder and dual purpose over an area about 1,55,200 hectares with the production of 1,78,600 million tones and 1,151 kg/ha productivity (Anonymous, 2010). Its Stover is an important feed in the livestock sector for draft and dairy animals particularly in the dry seasons when other feed resources are in short supply. It is grown as a rainy-season (kharif season) in the area of North, middle and south Gujarat and winter season (rabi season) in the Bharuch, Porbandar, Surat, Vadodara, Junagarh and Naramda districts of Gujarat. The major constraints restricting yield improvement are drought on medium- to shallow soils, shoot fly and stem borer and leaf diseases. The present exploration was undertaken to collect germplasm in different areas of Gujarat, so that it could be used in breeding programs for resistance to both biotic and abiotic stresses and maintain them in suitable environments for preserve them.

Gujarat is the home of the largest number of traditional crops. The state is an important region in the country with its different kinds of ecosystem and had been a Centre of activities for many historical events from the days of national movement. State comprising 31 districts, with having greatest diversity in plants and as well as in fauna. With its largest variety of communities, farmers have played a significant role in preserving and conserving traditional plant varieties. Agriculture sector provides the major source of income to the population of the state and the major crops in this state are Paddy, Wheat, Sorghum, Pearl millet, Maize, Cotton, Groundnut, Tobacco, Sugarcane, Pulses viz., Black gram, Green gram, Cowpea, Pomegranate, Grapes etc,. In most of the areas of the state, sorghum is cultivated as a sole crop but is sometimes grown mixed with bajra, blackgram, cotton and redgram and cultivated in rotation with black gram, green gram, red gram and groundnut to maintain the soil fertility. A primary centre of genetic diversity of any cultivated species harbors many valuable genes such as resistance to diseases, insect pests, physiological stress and quality characteristics. It could provide genetic material that may prove valuable in any plant breeding programme. And right behind this boon for our future food security lies the years of selection, breeding and conservation initiatives of the farmers for generations in an ambience of supporting ecosystems.

Sorghum is classified into five basic races viz., *bicolor, guinea, caudatum, kafir and durra*, these basic races are further classified into ten intermediate races *durra-caudatum*, *durra-guinea, durra-kafir, durra-bicolor, caudatum-guinea*, *caudatum-kafir, caudatum-bicolor*, *guinea-kafir*, *guinea-bicolor*, and *kafir-bicolor* (Harlan, 1972). Many areas traditional farmers have developed complex farming systems adapted to the local conditions helping them to sustainable manage harsh environments and to meet their subsistence needs without depending on external inputs or technologies of modern agriculture. Using knowledge gained through experience, and locally available resources, indigenous farmers have developed integral and diversified production polyculture systems adapted to the different ecological systems.

Materials and Methods

Directorate of Sorghum Research (DSR) has organized the exploration to collect the sorghum landraces from Gujarat during 2007 – 2010. There were 17 districts explored for the sorghum germplasm collection and 147 accessions were collected from these districts viz., Ahmedabad, Banaskantha, Bharuch, Bhavnagar, Dang, Jamnagar, Junagadh, Kutch, Mahesana, Merelia, Patan, Porbandar, Sabarkantha, Surat, Surendrapur and Vadodara. The germplasm collection programmes were planned to cover the unexplored area and areas explored in the past. A total of four trips were made originating from South Gujarat, Middle Gujarat, Sourastra region and North Gujarat. The attempt was made to collect an accession every 20 to 30 miles. Latitude and longitude coordinates the collection points were noted at each collection site using a handheld GPS (Garmin – Oregon 550) device. Farmers, informants, and shepherds were interviewed to collect information on history, cultivation practices, and other details. Ear head / panicle samples were collected by selective sampling method either from the standing crop or from heaps in fields after harvest and seed material from Mandi. The explorations were jointly undertaken by Directorate of Sorghum Research and Sorghum Research Station, Sardar Krushinagar Dantiwada Agricultural University, Deesa (Banaskantha) Gujarat. The prime objective of the present mission was to collect forage type, biotic and abiotic resistance local landraces.

Results and discussion

A total of 147 sorghum accessions were collected from 17 districts from the state. Major collection of 46 accessions was from Kutch district, followed by Banaskanta (30), Patan (13), Surat, Surendrapur, Ahmednagar (each 7), Bhavanagar, Junagadh, Mahesana (each 6), Jamnagar, Sabarkantha (each 4), Bharuch, Dang (each 3), Vadodara, Porbandar (each 2) and Marilia comprisiong only one accession. The germplasm collection represented with all basic races of sorghum viz., *bicolor* (18), *durra* (67), *bicolor-guinea* (1), *caudatum* (1), *durra-bicolor* (19), *durra-caudatum* (2) and *guinea-caudatum* (1) (Table1&2). Variability among the collections is very high. Farmers mainly use their traditional deshi sorghum. Most of the accessions are tall (88) in plant height, semi compact ear head (79), bold seeded (126) and white coloured seed (61) to pearly white (40). The variability in ear head is presented in Fig. 2, 4, 5, 6, 7 and 8. The variability in seed colour is presented in Fig. 1, 5 and 8. Most of the popular landraces in these collections have specific useful traits and traditional utilities that need to be explored and utilized in the breeding programs to evolve trait specific genotypes. The landrace Utavali viz., EJN 14 (IC 585184), EJN 15 (IC 585185) is cultivated extensively in the Kankraj taluka / Banaskanta district. Farmer harvested this landrace along with ear head at the time of maturity to feed the cattle. The landrace Gundari viz., ERN 28 (IC 585198), ERN 29 (IC 585199) is mainly cultivated in Kutchh district. Malwan viz., ERN 14 (IC 568529), ERN 16 (IC 568531) is the the famous dual purpose landrace of the Gujarat originated from Malwan villege / Surendernagar District. Gundari and Solapuri land races are typical salinity tolerant lines (Fig 3). Solapuri (ERN 26 – IC 568541) landrace has been imported from Solapur region of Maharastra, which is a selection from M 35-1 (Fig 5). Landraces often have survived and adapted to different biotic and abiotic stresses in cultivation and thus offer a good source of genes with potential resistance, making them important for modern plant breeding (Newton et al, 2010). Based on the altitudinal variations sorghum cultivation varied from 14 m to 431 m (above mean sea level). It seems, cultivation practices done near to the sea shore and it proved that the genotypes are tolerant for salinity.

Genetic diversity created in the farmers' fields over millennia, complemented by the diversity present in wild relatives of crops, provides the raw material for improving crop productivity through plant breeding (Upadhaya et al., 2008). Collection and conservation of sorghum germplasm has been accelerated in the past four decades to prevent the extinction of landraces and wild relatives of cultivated sorghum. Since then, germplasm collection and conservation have become integral components of crop improvement programs at both national and international levels (Rosenow and Dahlberg 2000). Under the present collection, the accessions E 182 (IC 568399), E 183 (IC 568400), E 184 (IC 568401), E 160 (IC 568377), E 161 (IC 568378), E 162 (IC 568379), E 163 (IC 568380), ERN 26 (IC 568541), ERN 27 (IC 568542) and ERN 28 (IC 568543) (Fig 4 and 5) are salinity tolerant. The accession EJN 4 (IC 0585174) is very early and matures at 75 days and tolerant to disease and drought. Accession ERN 1 (IC 568516) was dual type and accessions E 173 (IC 568390) and E 158 (IC 568375) are sweet sorghum type. The sorghum local landraces are cultivated by the farmers over the decades. Majority of the accessions collected was fodder types. Further characterization of these collections will be helpful in exploiting them in breeding for drought or salinity tolerance.

Table 1. Geographical distribution of sorghum landraces collected from Gujarat

SN	Acc. Name	IC Number	Local Name	District	Taluk	Village	Latitude	Longitude	Altitude	Associated crop
1	E 145	IC 568362		Surat	Songadh	Fort songadh	21.0864	73.3066	139	Mixed with Redgram
2	E 146	IC 568363	Deshi	Surat	Songadh	Balamrai	21.0809	73.3446	154	Sole
3	E 147	IC 568364	Deshi	Surat	Songadh	Balamrai	21.0809	73.3446	154	Mixed with redgram
4	E 148	IC 568365	Deshi	Surat	Songadh	Borpada	21.0191	73.3740	166	Mixed with Redgram & Blackgram
5	E 149	IC 568366	Deshi	Surat	Songadh	Borpada	21.0191	73.3740	166	Mixed with Redgram
6	E 150	IC 568367	Deshi	Surat	Songadh	Borpada	21.0191	73.3740	166	Mixed with Redgram
7	E 151	IC 568368	Deshi	Surat	Songadh	Borpada	21.0191	73.3740	166	Mixed with Redgram
8	E 152	IC 568369		Dang	Ahaw	Baridipada	20.5938	73.3708	160	Mixed with Blackgram
9	E 153	IC 568370	Poru	Dang	Ahaw	Jamlapada	20.5074	73.4069	418	Sole
10	E 154	IC 568371	Poru	Dang	Ahaw	Jamun vihar	20.4939	73.4136	471	Sole
11	E 155	IC 568372		Bharuch	Amod	Samni	21.5204	72.5523	21	Sole
12	E 156	IC 568373		Bharuch	Amod	Amod	21.5857	72.5245	16	Sole
13	E 157	IC 568374		Bharuch	Jambosur	Jambosur	22.0365	72.4912	24	Sole
14	E 158	IC 568375	Sundia	Vadodara	Padra	Chitral	22.1026	72.5711	30	Sole
15	E 159	IC 568376	Rajka Jowar	Vadodara	Padra	Vadugapalayam	22.1264	72.5898	41	Sole
16	E 160	IC 568377		Ahmedabad	Bholuka	Bhagwadha	22.3780	72.1340	20	Sole
17	E 161	IC 568378	Sundi jowar	Ahmedabad	Bholuka	Dingda	22.3464	72.1189	14	Sole
18	E 162	IC 568379		Ahmedabad	Bardobath	Lothal	22.1485	72.1457	14	Sole
19	E 163	IC 568380	Char	Ahmedabad	Dandhuga	Raiga	22.2473	72.0095	22	Sole
20	E 164	IC 568381		Ahmedabad	Dandhuga	Dandhya	22.2223	72.5883	24	Sole
21	E 165	IC 568382		Ahmedabad	Barvala	Barvala	22.1045	71.5355	34	Sole
22	E 166	IC 568383		Bhavnagar	Vallabhipur	Malpara	22.0585	71.5357	31	Sole
23	E 167	IC 568384		Bhavnagar	Vallabhipur	Vallabhipur	21.5192	71.5316	20	Sole
24	E 168	IC 568385		Bhavnagar	Songandh	Sonoserra	24.4412	71.4518	58	Sole
25	E 169	IC 568386		Bhavnagar	Gadhada	Jalia	21.4812	71.3621	74	Mixed with Cotton
26	E 170	IC 568387		Bhavnagar	Gadhada	Mandva	21.4827	71.3364	88	Sole
27	E 171	IC 568388		Bhavnagar	Gadhada	Mandva	21.4827	71.3364	88	Sole

28	E 172	IC 568389		Marelia	Babra	Chammadi	21.4989	71.1548	186	Sole
29	E 173	IC 568390	Wagad	Junagadh	Khesad	Khesad	21.1708	70.1513	67	Sole
30	E 174	IC 568391		Junagadh	Khesad	Khesad	21.1683	70.1529	52	Sole
31	E 175	IC 568392		Junagadh	Veraval	Ghadu	21.0250	70.1733	22	Sole
32	E 176	IC 568393		Junagadh	Veraval	Chandala	20.5764	70.2009	25	Mixed with Blackgram
33	E 177	IC 568394		Junagadh	Veraval	Balpara	20.5547	70.2387	15	Sole
34	E 178	IC 568395	Hundri	Junagadh	Mangroad	Diwara	21.1283	70.0142	15	Sole
35	E 179	IC 568396	Hundri	Porbandar	Porbandar	Benaneal	21.2049	69.5344	23	Sole
36	E 180	IC 568397	Hundri	Porbandar	Porbandar	Rathia	21.2483	69.4945	21	Sole
37	E 181	IC 568398	Hundri	Jamnagar	Kalyanpur	Lambu	21.5605	69.1746	28	Sole
38	E 182	IC 568399		Jamnagar	Kalyanpur	Rojit	22.0065	69.1319	24	Sole
39	E 183	IC 568400		Jamnagar	Kalyanpur	Rojit	22.0513	69.0734	24	Sole
40	E 184	IC 568401	Hundri	Jamnagar	Kalyanpur	Babrasa	22.0492	69.1119	18	Sole
41	ERN 1	IC 568516	Malwan	Banaskantha	Palanpur	Kumbharan	24.0960	72.1736	175	Sole
42	ERN 2	IC 568517	Deshi	Banaskantha	Palanpur	Kumbharan	24.0960	72.1736	175	Sole
43	ERN 3	IC 568518	Malwan	Banaskantha	Palanpur	Kumbharan	24.0960	72.1736	175	Sole
44	ERN 4	IC 568519	Deshi Malwan	Banaskantha	Palanpur	Kumbharan	24.0960	72.1736	175	Sole
45	ERN 5	IC 568520	Deshi	Banaskantha	Palanpur	Kumbharan	24.0960	72.1736	175	Sole
46	ERN 6	IC 568521	Deshi	Banaskantha	Palanpur	Kumbharan	24.0960	72.1736	175	Sole
47	ERN 7	IC 568522		Banaskantha	Palanpur	Kumbharan	24.0960	72.1736	175	Sole
48	ERN 8	IC 568523	Deshi	Banaskantha	Palanpur	Kumbharan	24.0960	72.1736	175	Sole
49	ERN 9	IC 568524	Deshi	Banaskantha	Palanpur	Badarpura	24.1194	72.2063	189	Sole
50	ERN 10	IC 568525	Deshi	Banaskantha	Palanpur	Chandirar	24.1292	72.1965	178	Sole
51	ERN 11	IC 568526	Malwan	Banaskantha	Palanpur	Chandirar	24.1292	72.1965	178	Sole
52	ERN 12	IC 568527	Deshi	Banaskantha	Palanpur	Gangansana	23.5647	72.2117	141	Sole
53	ERN 13	IC 568528	Kamal Parva	Banaskantha	Palanpur	Gangansana	23.5705	72.2100	138	Sole
54	ERN 14	IC 568529	Malwan	Banaskantha	Palanpur	Goglasan	23.5673	72.2091	141	Sole
55	ERN 15	IC 568530	Deshi	Banaskantha	Palanpur	Goglasan	23.5673	72.2091	141	Sole
56	ERN 16	IC 568531	Malwan	Banaskantha	Palanpur	Goglasan	23.5673	72.2091	141	Sole
57	ERN 17	IC 568532	Deshi	Mahesana	Mahesana	Panjote	23.3693	72.2126	103	Sole
58	ERN 18	IC 568533	Deshi	Patan	Patan	Dinoj	23.4018	72.1616	85	Sole

59	ERN 19	IC 568534	Deshi	Patan	Patan	Dinoj	23.4018	76.1616	85	Sole
60	ERN 20	IC 568535	Deshi	Patan	Patan	Dinoj	23.4018	76.1616	85	Sole
61	ERN 21	IC 568536	Deshi	Patan	Patan	Dinoj	23.4018	76.1616	85	Sole
62	ERN 22	IC 568537		Patan	Patan	Ganesh pura	23.3579	72.1165	65	Sole
63	ERN 23	IC 568538	Chachadia	Surendrapur	Patidi	Naviani	23.2861	71.5791	47	Sole
64	ERN 24	IC 568539	Deshi	Surendrapur	Patidi	Naviani	23.2861	71.5791	47	Sole
65	ERN 25	IC 568540	Deshi	Surendrapur	Patidi	Naviani	23.2861	71.5791	47	Sole
66	ERN 26	IC 568541	Solapuri	Surendrapur	Patidi	Savada	23.1387	71.4515	47	Sole
67	ERN 27	IC 568542	Deshi	Surendrapur	Patidi	Savada	23.1387	71.4515	47	Sole
68	ERN 28	IC 568543	Kuntri Kundri	Surendrapur	Patidi	Savada	23.1387	71.4515	47	Sole
69	ERN 29	IC 568544	Kundri	Surendrapur	Patidi	Savada	23.1387	71.4515	47	Sole
70	ERN 30	IC 568545	Deshi	Patan	Siddapur	Sujanpur	23.5752	72.2208	160	Sole
71	ERN 31	IC 568546	Deshi		Kheralu	Kheralu	23.5341	72.3544	184	Sole
72	ERN 32	IC 568547	Deshi	Ahmedabad	Manasa	Manasa	23.2559	72.3911	119	Sole
73	EJN 1	IC 585171	Jawari	Banaskantha	Danta	Punjpur	24.1826	72.7322	269	Sole
74	EJN 2	IC 585172	Jawari	Banaskantha	Danta	Punjpur	24.1826	72.7322	269	Sole
75	EJN 3	IC 585173	Deshi	Banaskantha	Vadali	Bhalusana	23.9790	72.8840	182	Sole
76	EJN 4	IC 585174	Deshi	Banaskantha	Vadali	Hatharwa	23.9461	72.9954	222	Sole
77	EJN 5	IC 585175	Deshi	Banaskantha	Vadali	Hatharwa	23.9465	72.9884	214	Sole
78	EJN 6	IC 585176	Deshi	Banaskantha	Bhiloda	Malesa	23.8082	73.1816	222	Sole
79	EJN 7	IC 585177	Deshi	Sabarkantha	Bhiloda	Betali	23.7271	73.3026	218	Sole
80	EJN 8	IC 585178	Deshi	Sabarkantha	Bhiloda	Tintoi	23.6278	73.2991	181	Sole
81	EJN 9	IC 585179	Deshi	Sabarkantha	Bhiloda	Tintoi	23.6278	73.2991	181	Sole
82	EJN 10	IC 585180	Deshi	Sabarkantha	Himmatnagar	Raighat	23.6002	73.1867	175	Sole
83	EJN 11	IC 585181	Utavali	Banaskantha	Kankraj	Shihori	24.0390	71.9308	140	Sole
84	EJN 12	IC 585182	Deshi	Banaskantha	Kankraj	Thara	23.9686	71.8249	78	Sole
85	EJN 13	IC 585183	Deshi	Banaskantha	Kankraj	Thara	23.9686	71.8249	78	Sole
86	EJN 14	IC 585184	Utavali	Banaskantha	Kankraj	Thara	23.9530	71.8200	72	Sole
87	EJN 15	IC 585185	Utavali	Banaskantha	Kankraj	Sadvjivas	23.9530	71.8200	72	Sole
88	EJN 16	IC 585186	Deshi	Banaskantha	Rathanpore	Oon	23.8981	71.7749	63	Sole
89	EJN 17	IC 585187	Deshi	Banaskantha	Santalpur	Sindhada	23.8064	71.3206	37	Sole

90	EJN 18	IC 585188	Deshi	Banaskantha	Santalpur	Sindhada	23.8064	71.3206	37	Sole
91	EJN 19	IC 585189	Jowari	Kutch	Rapar	Mekhel	23.5098	70.9643	40	Sole
92	EJN 20	IC 585190	Deshi	Kutch	Bhachau	Adhoi	23.3195	70.5359	64	Sole
93	EJN 21	IC 585191	Deshi	Kutch	Bhachau	Adhoi	23.3195	70.5359	64	Sole
94	EJN 22	IC 585192	Deshi	Kutch	Bhachau	Adhoi	23.3195	70.5359	64	Sole
95	EJN 23	IC 585193	Deshi	Kutch	Bhachau	Gokul	23.1979	70.2308	19	Sole
96	EJN 24	IC 585194	Gundri	Kutch	Anjar	Anjar	23.1044	70.0192	66	Sole
97	EJN 25	IC 585195	Deshi	Kutch	Anjar	Anjar	23.0167	69.8753	65	Sole
98	EJN 26	IC 585196	Maklani	Kutch	Mundera	Gunjala	22.9217	69.7873	48	Sole
99	EJN 27	IC 585197	Gundri	Kutch	Bhuj	Nama Bhandra	23.0662	69.7350	135	Sole
100	EJN 28	IC 585198	Gundri	Kutch	Anjar	Varsamedi	23.1319	70.0761	50	Sole
101	EJN 29	IC 585199	Deshi	Kutch	Anjar	Varsamedi	23.1319	70.0761	50	Sole
102	EJN 30	IC 585200	Deshi	Kutch	Bhachau	Nani Chira	23.1987	70.2321	21	Sole
103	EJN 31	IC 585201	Deshi	Kutch	Bhachau	Punisar	23.3600	70.3473	21	Sole
104	EJN 32	IC 585202	Deshi	Kutch	Bhachau	Medhpar	23.3799	70.3499	30	Sole
105	EJN 33	IC 585203	Deshi	Kutch	Raper	Raper	23.5769	70.6237	69	Sole
106	EJN 34	IC 585204	Deshi	Kutch	Raper	Pragpur	23.5458	70.7413	105	Sole
107	EJN 35	IC 585205	Gundri	Kutch	Raper	Bhutakia	23.5426	70.8037	107	Sole
108	EJN 36	IC 597630	Dhenchania	Kutch	Satalpur	Bhabra				Sole
109	EJN 37		Gundri	Kutch	Satalpur	Bhabra				Sole
110	EJN 38	IC 597631	Solapuri	Kutch	Satalpur	Bar				Sole
111	EJN 39	IC 597632		Kutch	Satalpur	Bar				Sole
112	EJN 40	IC 597633		Kutch	Satalpur	Bar				Sole
113	EJN 41	IC 597634	Solapuri	Kutch	Raper	Bilasuar	23.2880	70.5578	51	Sole
114	EJN 42	IC 597635	Solapuri	Kutch	Raper	Bilasuar	23.2880	70.5578	51	Sole
115	EJN 43	IC 597636		Kutch	Samakyali	Dorichari	23.2385	70.4621	70	Sole
116	EJN 44	IC 597637		Kutch	Samakyali	Chithod	23.2364	70.4333	93	Sole
117	EJN 45	IC 597638		Kutch	Lakadia	Lakadia	23.1938	70.3256	84	Sole
118	EJN 46	IC 597639	Gundri	Kutch	Lakadia	Lakadia	23.1938	70.3256	84	Sole
119	EJN 47	IC 597640	Gundri	Kutch	Anjur	Nagavaladin	23.5845	69.5884	41	Sole
120	EJN 48	IC 597641		Kutch	Dhalabina	Bidhada	22.5316	69.3096	47	Sole
121	EJN 49	IC 597642		Kutch	Dhalabina	Sri Ramnagar	22.5394	69.2660	51	Sole

122	EJN 50	IC 597643	Jowari	Kutch	Mandvi	Mandvi	22.5232	69.2380	44	Sole
123	EJN 51	IC 597644		Kutch	Mandvi	Sambrai	23.0167	69.0514	60	Sole
124	EJN 52	IC 597645		Kutch	Mandvi	Kutaya	23.0199	69.2488	46	Sole
125	EJN 53	IC 597646		Kutch	Mandvi	Domra	23.0274	69.0384	42	Sole
126	EJN 54	IC 597647		Kutch	Naliya	Barvadia	23.0507	69.0042	41	Sole
127	EJN 55	IC 597648		Kutch	Naliya	Barvadia	23.0585	68.5945	41	Sole
128	EJN 56	IC 597649		Kutch	Naliya	Vavadia	23.0640	68.5852	47	Sole
129	EJN 57	IC 597650		Kutch	Naliya	Varvadia	23.0640	68.5852	47	Sole
130	EJN 58	IC 597651		Kutch	Naliya	Vagot	23.2239	68.4193	39	Sole
131	EJN 59	IC 597652		Kutch	Nakhatrana	Vgradi	23.2816	69.0817	38	Sole
132	EJN 60	IC 597653		Kutch	Bhuj	Fotadi	23.1172	69.3024	39	Sole
133	EJN 61	IC 597654		Kutch	Bhuj	Sukhbra	23.1300	69.3772	129	Sole
134	EJN 62	IC 597655		Kutch	Bhuj	Bhujadi	23.1407	69.4410	123	Sole
135	EJN 63	IC 597656		Kutch	Bhuj	Bhujadi	23.1407	69.4410	123	Sole
136	EJN 64	IC 597657		Kutch	Anjar	Indraprastha	23.1346	70.0847	54	Mixed with castor
137	EJN 65	IC 597658		Mahesana	Unjha	Unnava	23.4610	72.2163	120	Sole
138	EJN 66	IC 597659		Mahesana	Unjha	Unnava	23.4610	72.2163	120	Sole
139	EJN 67	IC 597660		Mahesana	Unjha	Unnava	23.4610	72.2163	120	Sole
140	EJN 68	IC 597661		Mahesana	Unjha	Unnava	23.4610	72.2163	120	Sole
141	EJN 69	IC 597662		Mahesana	Unjha	Unnava	23.4610	72.2163	120	Sole
142	EJN 70	IC 597663	Solapuri	Patan	Sami	Moti Chandu	23.3609	71.4594	118	Sole
143	EJN 71	IC 597664	Dinelenia	Patan	Sami	Moti Chandu	23.3609	71.4594	118	Sole
144	EJN 72	IC 597665	Gundri	Patan	Sami	Jesoda	23.3487	71.4766	118	Sole
145	EJN 73	IC 597666	Danchania	Patan	Sami	Jesoda	23.3487	71.4766	118	Sole
146	EJN 74	IC 597667	Chachadia	Patan	Sami	Jesoda	23.3487	71.4766	118	Sole
147	EJN 75	IC 597668	Chachadia	Patan	Sami	Madri	23.4163	71.5186	80	Sole

Table 2. Geographical distribution and morphological observation of sorghum landraces in Gujarat

Sl.No.	Acc. Name	IC Number	Soil colour	Soil texture	Plant Height	Ear head compactness	Seed structure	Seed colour	Glume colour	Other information
1	E 145	IC 568362	Black	Sandy	Tall	Semi compact	Bold	Pearly white	Straw	
2	E 146	IC 568363	Black	Sandy	Tall	Semi loose	Medium	Red	Red	Fodder
3	E 147	IC 568364	Red	Sandy	Tall	Semi compact	Bold	Pearly white	Straw	
4	E 148	IC 568365	Red	Sandy	Tall	Semi compact	Bold	Pearly white	Red	
5	E 149	IC 568366	Black	Sandy	Tall	Semi compact	Bold	White	Purple	
6	E 150	IC 568367	Black	Sandy	Tall	Semi compact	Bold	Lihgt yellow	Red	
7	E 151	IC 568368	Black	Sandy	Tall	Semi compact	Bold	White	Light red	
8	E 152	IC 568369	Black	Sandy	Very tall	Loose	Bold	White	Red	
9	E 153	IC 568370	Red	Sandy	Very tall	Very loose	Bold	Pearly white	Purple	
10	E 154	IC 568371	Black	Sandy	Very tall	Very loose	Bold	White	Purple	
11	E 155	IC 568372	Red	Sandy	Tall	Loose	Small	Light red	Black	Weedy type
12	E 156	IC 568373	Black	Sandy	Medium	Semi compact	Bold	Pearly white	Purple	Fodder
13	E 157	IC 568374	Brown	Sandy	Medium	Semi compact	Bold	Pearly white	Purple	Fodder
14	E 158	IC 568375	Brown	Sandy	Dwarf	Semi compact	Bold	Pearly white	Straw	Sweet stalk juice
15	E 159	IC 568376	Brown	Sandy	Very tall	Semi loose	Medium	Red	Red	Fodder
16	E 160	IC 568377	Black	Sandy	Tall	Semi compact	Bold	Pearly white	Red	Saline tolerant
17	E 161	IC 568378	Black	Sandy	Tall	Semi compact	Bold	Pearly white	Straw	Saline tolerant
18	E 162	IC 568379	Black	Sandy	Tall	Semi compact	Bold	Pearly white	Straw	Saline tolerant
19	E 163	IC 568380	Brown	Sandy	Tall	Semi compact	Bold	Pearly white	Straw	Saline tolerant
20	E 164	IC 568381	Black	Sandy	Very tall	Compact	Bold	Pearly white	Straw	
21	E 165	IC 568382	Black	Sandy	Tall	Compact	Bold	Pearly white	Straw	Fodder
22	E 166	IC 568383	Brown	Sandy	Very tall	Compact	Bold	Pearly white	Straw	Fodder
23	E 167	IC 568384	Brown	Sandy	Very tall	Compact	Bold	Pearly white	Straw	Fodder
24	E 168	IC 568385	Black	Sandy	Very tall	Semi compact	Bold	Pearly white	Purple	Fodder
25	E 169	IC 568386	Black	Sandy	Tall	Semi compact	Bold	Pearly white	Straw	
26	E 170	IC 568387	Black	Sandy	Very tall	Semi loose	Bold	Red	Purple	Fodder
27	E 171	IC 568388	Black	Sandy	Tall	Semi loose	Bold	Pearly white	Yellow	Fodder
28	E 172	IC 568389	Brown	Sandy	Tall	Compact	Bold	Red	Red	Fodder

29	E 173	IC 568390	Brown	Sandy	Tall	Semi compact	Bold	White	Red	Sweet stalk juice
30	E 174	IC 568391	Black	Sandy	Very tall	Loose	Medium	Light red	Purple	
31	E 175	IC 568392	Black	Sandy	Very tall	Loose	Medium	Light red	Purple	
32	E 176	IC 568393	Black	Sandy	Tall	Semi compact	Bold	White	Straw	Fodder
33	E 177	IC 568394	Black	Sandy	Very tall	Semi compact	Bold	White	Straw	Fodder
34	E 178	IC 568395			Tall	Semi compact	Medium	White	Straw	Fodder
35	E 179	IC 568396	Brown	Sandy	Tall	Compact	Bold	White	Straw	Fodder
36	E 180	IC 568397	Brown	Sandy	Tall	Semi compact	Bold	Pearly white	Straw	Fodder
37	E 181	IC 568398	Brown	Sandy	Tall	Semi compact	Bold	Pearly white	Straw	Fodder
38	E 182	IC 568399	Brown	Sandy Loam	Tall	Compact	Bold	Pearly white	Straw	Saline tolerant
39	E 183	IC 568400	Brown	Sandy Loam	Tall	Compact	Bold	Pearly white	Straw	Saline tolerant
40	E 184	IC 568401	Brown		Tall	Semi compact	Bold	Pearly white	Straw	Saline tolerant
41	ERN 1	IC 568516	Black	Sandy	Very tall	Compact	Medium	White		Malwan, Dual Purpose, Goose neck.
42	ERN 2	IC 568517	Red		Tall	Semi compact	Bold	Pearly white	Purple	Awns
43	ERN 3	IC 568518	Red	Sandy	Tall	Semi compact		Pearly white	Straw	Goose neck, Awns.
44	ERN 4	IC 568519	Red	Sandy	Tall		Bold	White	Red	Awns, 75% Covering, Lustrus.
45	ERN 5	IC 568520	Red	Sandy	Very tall	Compact		Pearly white	Straw	Awns
46	ERN 6	IC 568521	Red	Sandy	Very tall	Semi compact	Bold	Pearly white	Purple	Awns, 75 % Covering
47	ERN 7	IC 568522	Red	Sandy	Very tall	Semi compact	Bold	Pearly white		Awns
48	ERN 8	IC 568523	Red	Sandy	Very tall	Semi compact	Bold	Pearly white	Purple	Awns, 100% Covering
49	ERN 9	IC 568524			Tall	Compact	Bold	White	Straw	Awns, 25 % Covering
50	ERN 10	IC 568525	Black	Sandy	Medium	Semi compact	Bold	Pearly white	Straw	100 % Covering
51	ERN 11	IC 568526	Black	Sandy	Medium	Semi compact	Bold	Pearly white	Straw	50% Covering
52	ERN 12	IC 568527	Black	Sandy	Tall	Semi compact	Bold	Pearly white	Purple	Awns, 75 % Covering
53	ERN 13	IC 568528	Black	Sandy	Small			White	Red	50% Covering

54	ERN 14	IC 568529			Tall	Compact	Bold	Pearly white	Straw	Awns, 50% Covering
55	ERN 15	IC 568530	Red	Sandy	Tall	Compact	Bold	Pearly white	Straw	Awns
56	ERN 16	IC 568531	Red	Sandy	Tall	Compact	Bold	Pearly white	Straw	Awns, 50% Covering
57	ERN 17	IC 568532	Red		Medium	Compact	Bold	Chalky white	Straw	25 % Covering
58	ERN 18	IC 568533	Red	Sandy	Tall	Semi loose	Bold	Pearly white	Straw	Awns, 75 % Covering
59	ERN 19	IC 568534	Red	Sandy	Tall	Semi compact	Medium	White	Straw	Awns,100 % Covering
60	ERN 20	IC 568535	Red	Sandy	Very tall	Loose	Bold	Brown	Purple	Awns, 100% Covering
61	ERN 21	IC 568536	Red	Sandy	Tall	Semi compact	Bold	white	Purple	Awns, 75 % Covering
62	ERN 22	IC 568537	Brown	Sandy	Tall	Semi compact	Bold	Pearly white	Straw	Awns
63	ERN 23	IC 568538	Black	Sandy	Tall	Semi compact		White	Purple	50% Covering
64	ERN 24	IC 568539	Black	Sandy	Tall	Semi compact	Bold	White	Red	
65	ERN 25	IC 568540	Black	Sandy	Tall	Semi compact		Yellow	Red	50% Covering
66	ERN 26	IC 568541			Tall			Pearly white		M 35 - 1 type, Saline tolerent.
67	ERN 27	IC 568542			Tall		Small	White	Red	Fodder, Saline tolerant
68	ERN 28	IC 568543			Tall	Semi compact	Medium	Pearly white		Saline tolerant, Gundri Nuclous seed.
69	ERN 29	IC 568544			Tall	Semi compact	Bold	white		
70	ERN 30	IC 568545	Red	Sandy	Tall	Semi compact	Bold	Pearly white	Straw	Awns
71	ERN 31	IC 568546	Red	Sandy	Very tall	Semi compact	Bold	White	Straw	Awns
72	ERN 32	IC 568547			Medium			White		Fodder
73	EJN 1	IC 585171	Red	Sandy	Very tall	Compact	Bold	Yellow white	Greyed purple	Fodder
74	EJN 2	IC 585172	Red	Sandy	Very tall	Semi compact	Bold	Yellow white	Yellow green	Fodder
75	EJN 3	IC 585173	Black	Sandy	Medium	Semi compact	Bold	Yellow white	Yellow green	Fodder, Lustrous

76	EJN 4	IC 585174	Black	Sandy	Medium	Semi compact	Small	White	Yellow green	Very early, disease tolerant, sweet seed, 7 stem tillers, matures at 75 days, grow in low moisture
77	EJN 5	IC 585175	Black	Sandy	Tall	Semi compact	Bold	Yellow white	Yellow green	Fodder
78	EJN 6	IC 585176	Red	Sandy	Tall	Semi compact	Bold	Yellow white	Yellow green	Fodder
79	EJN 7	IC 585177	Black	Sandy	Medium	Semi compact	Bold	White	Greyed orange	Fodder
80	EJN 8	IC 585178	Red	Sandy	Tall	Semi loose	Bold	Light red	Black	Fodder
81	EJN 9	IC 585179	Red	Sandy	Tall	Semi loose	Bold	White	Purple	Fodder
82	EJN 10	IC 585180	Brown	Sandy	Tall	Semi loose	Medium	Light red	Red	Fodder
83	EJN 11	IC 585181	Black	Sandy	Medium	Semi compact	Bold	Yellow white	Yellow green	Fodder
84	EJN 12	IC 585182	Brown	Sandy			Bold	Yellow white		Fodder
85	EJN 13	IC 585183					Bold	Yellow white		Fodder
86	EJN 14	IC 585184	Brown	Sandy	Tall	Semi compact	Bold	White	Greyed orange	Fodder
87	EJN 15	IC 585185	Brown	Sandy	Very tall	Semi compact	Bold	White	Greyed orange	Fodder
88	EJN 16	IC 585186	Brown	Sandy	Tall	Semi compact	Bold	Yellow white	Yellow green	Fodder
89	EJN 17	IC 585187	Brown	Sandy	Tall	Semi compact	Bold	Yellow white	Greyed orange	Fodder
90	EJN 18	IC 585188	Brown	Sandy	Very tall	Semi compact	Medium	Yellow white	Greyed orange	Fodder
91	EJN 19	IC 585189	Brown	Sandy	Tall	Semi compact	Bold	Yellow white	Yellow green	Fodder
92	EJN 20	IC 585190	Brown	Sandy	Tall	Compact	Bold	White	Yellow green	Fodder
93	EJN 21	IC 585191	Brown	Sandy	Tall	Semi loose	Bold	White	Greyed orange	Fodder
94	EJN 22	IC 585192	Brown	Sandy	Tall	Semi compact	Medium	White	Greyed orange	Fodder
95	EJN 23	IC 585193	Brown	Sandy	Medium	Semi compact	Bold	White	Greyed orange	Fodder
96	EJN 24	IC 585194	Brown	Sandy	Medium	Semi compact	Bold	White	Greyed orange	Fodder

97	EJN 25	IC 585195	Brown	Sandy			Bold	White		Fodder
98	EJN 26	IC 585196	Brown	Sandy	Medium	Compact	Bold	White	Greyed orange	Fodder
99	EJN 27	IC 585197	Brown	Sandy	Tall	Compact	Bold	White	Yellow green	Fodder
100	EJN 28	IC 585198	Red	Sandy	Tall	Compact	Bold	White	Yellow green	Fodder
101	EJN 29	IC 585199	Red	Sandy	Tall	Semi compact	Bold	Yellow white	Greyed orange	Fodder
102	EJN 30	IC 585200	Brown	Sandy	Tall	Semi compact	Bold	White	Greyed orange	Fodder
103	EJN 31	IC 585201	Black	Sandy	Tall	Semi compact	Bold	Yellow white	Greyed orange	Fodder
104	EJN 32	IC 585202	Black	Sandy	Tall	Compact	Bold	Yellow white	Yellow green	Fodde
105	EJN 33	IC 585203	Red	Sandy	Very tall	Semi compact	Bold	Yellow white	Yellow green	Fodder
106	EJN 34	IC 585204	Brown	Sandy	Tall	Semi compact	Bold	Yellow white	Yellow green	Fodder
107	EJN 35	IC 585205	Brown	Sandy	Tall	Compact	Bold	White	Greyed orange	Fodder
108	EJN 36	IC 597630			Medium	Semi compact	Bold	Yellow white		Fodder
109	EJN 37				Medium	Compact	Bold	Yellow white		Fodder
110	EJN 38	IC 597631	Black	Sandy	Medium	Semi compact	Bold	White	Greyed orange	Fodder
111	EJN 39	IC 597632	Black	Sandy	Medium	Semi compact	Bold	Yellow white	Grayed purple	Fodder
112	EJN 40	IC 597633	Black	Sandy	Tall	Semi compact	Bold	White	Greyed red	Fodder
113	EJN 41	IC 597634	Black	Sandy	Tall	Semi compact	Bold	Yellow white	Grayed yellow	Fodder
114	EJN 42	IC 597635	Black	Sandy	Tall	Semi compact	Bold	Yellow white	Grayed yellow	Fodder
115	EJN 43	IC 597636	Black	Sandy	Tall	Semi compact	Bold	White		Fodder
116	EJN 44	IC 597637	Brown	Sandy	Tall	Semi loose	Bold	Yellow	Black	Fodder
117	EJN 45	IC 597638	Brown	Sandy	Tall	Semi compact	Bold	Yellow white		Fodder
118	EJN 46	IC 597639	Brown	Sandy	Tall	Compact	Bold	Grayed yellow	Brown	Fodder
119	EJN 47	IC 597640	Black	Sandy	Tall	Semi compact	Bold	Grayed yellow	Black	Fodder
120	EJN 48	IC 597641	Brown	Sandy	Tall	Compact	Bold	Grayed yellow		Fodder

121	EJN 49	IC 597642	Brown	Sandy	Tall	Loose	Bold	Grayed orange		Fodder
122	EJN 50	IC 597643	Red	Sandy	Tall	Compact	Bold	White		Fodder
123	EJN 51	IC 597644	Black	Sandy	Tall	Compact	Bold	Yellow white		Fodder
124	EJN 52	IC 597645	Black	Sandy	Medium	Compact	Bold	White		Fodder
125	EJN 53	IC 597646	Black	Sandy	Very tall	Semi loose	Bold	Grayed orange		Fodder
126	EJN 54	IC 597647	Brown	Sandy	Medium	Compact	Bold	White		Fodder
127	EJN 55	IC 597648	Black	Sandy	Very tall	Semi loose	Bold	White		Fodder
128	EJN 56	IC 597649	Black	Sandy	Medium	Compact	Bold	White		Fodder
129	EJN 57	IC 597650	Black	Sandy	Medium	Compact	Bold	White		Fodder
130	EJN 58	IC 597651	Brown	Sandy	Medium	Semi compact	Bold	White		Fodder
131	EJN 59	IC 597652	Brown	Sandy loam	Dwarf	Semi compact	Bold	White		Fodder
132	EJN 60	IC 597653	Brown	Sandy loam	Dwarf	Compact	Bold	White		Fodder
133	EJN 61	IC 597654	Brown	Sandy loam	Medium	Compact	Bold	White		Fodder
134	EJN 62	IC 597655	Brown	Sandy loam	Tall	Compact	Bold	White		Fodder
135	EJN 63	IC 597656	Brown	Sandy loam	Tall	Semi compact	Bold	White		Fodder
136	EJN 64	IC 597657	Brown	Sandy loam	Very tall	Semi loose	Bold	Grayed orange		Fodder
137	EJN 65	IC 597658			Tall	Semi loose	Bold	White		Fodder
138	EJN 66	IC 597659			Tall		Bold	White		Fodder
139	EJN 67	IC 597660			Tall		Bold	White		Fodder
140	EJN 68	IC 597661			Tall		Bold	White		Fodder
141	EJN 69	IC 597662			Tall		Bold	White		Fodder
142	EJN 70	IC 597663			Tall	Semi compact	Bold	White		Fodder
143	EJN 71	IC 597664	Brown	Sandy loam	Tall	Semi compact	Bold	Greyed yellow		Fodder
144	EJN 72	IC 597665			Tall	Semi compact	Bold	White		Fodder
145	EJN 73	IC 597666			Tall	Semi compact	Bold	Yellow		Fodder
146	EJN 74	IC 597667			Medium	Semi compact	Medium	White		Fodder
147	EJN 75	IC 597668	Brown	Sandy	Medium	Semi compact	Bold	White		Fodder

Fig 1: Variability in seed colour

Fig 2: Variability in ear head size and shape

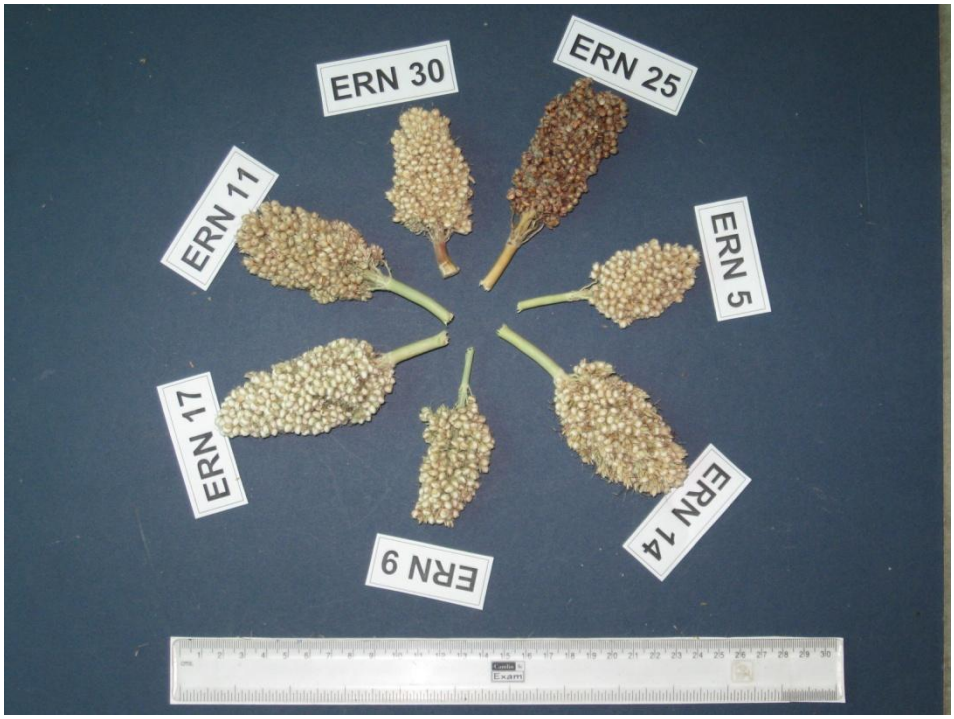

Fig 3: Variability in malwan landrace

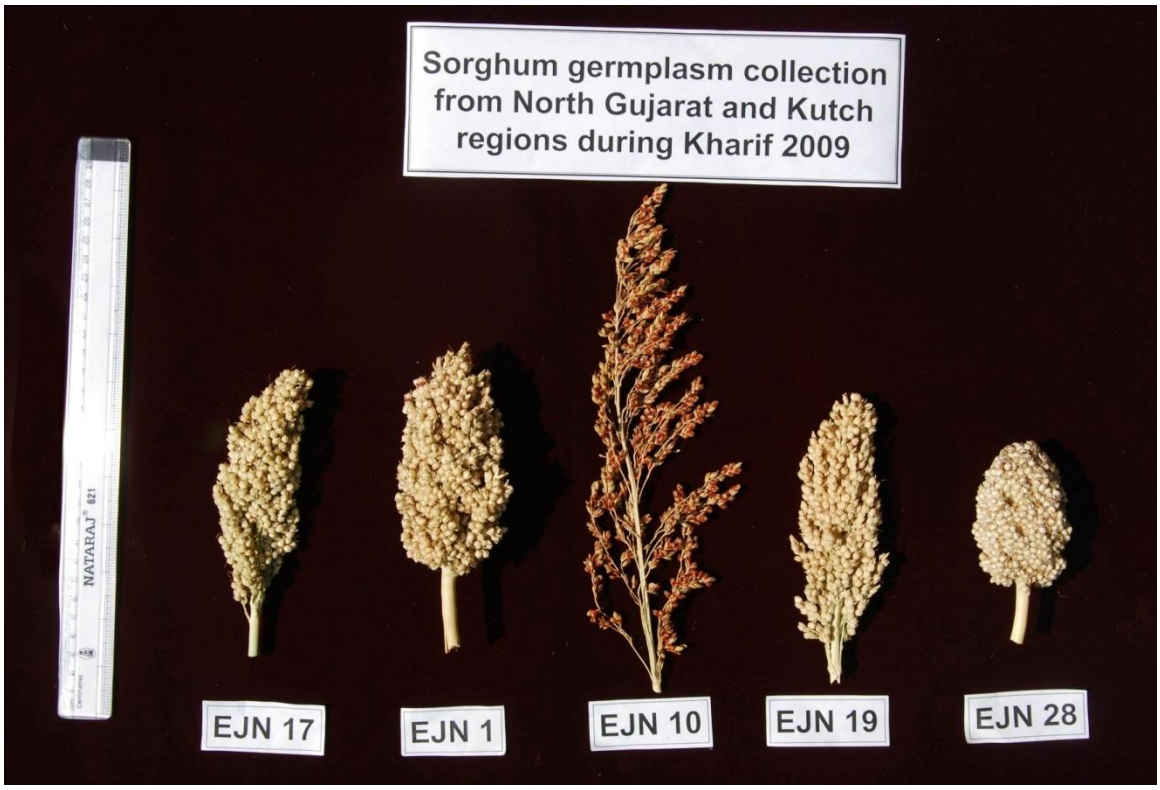

Fig 4: Variability in ear head size and shape

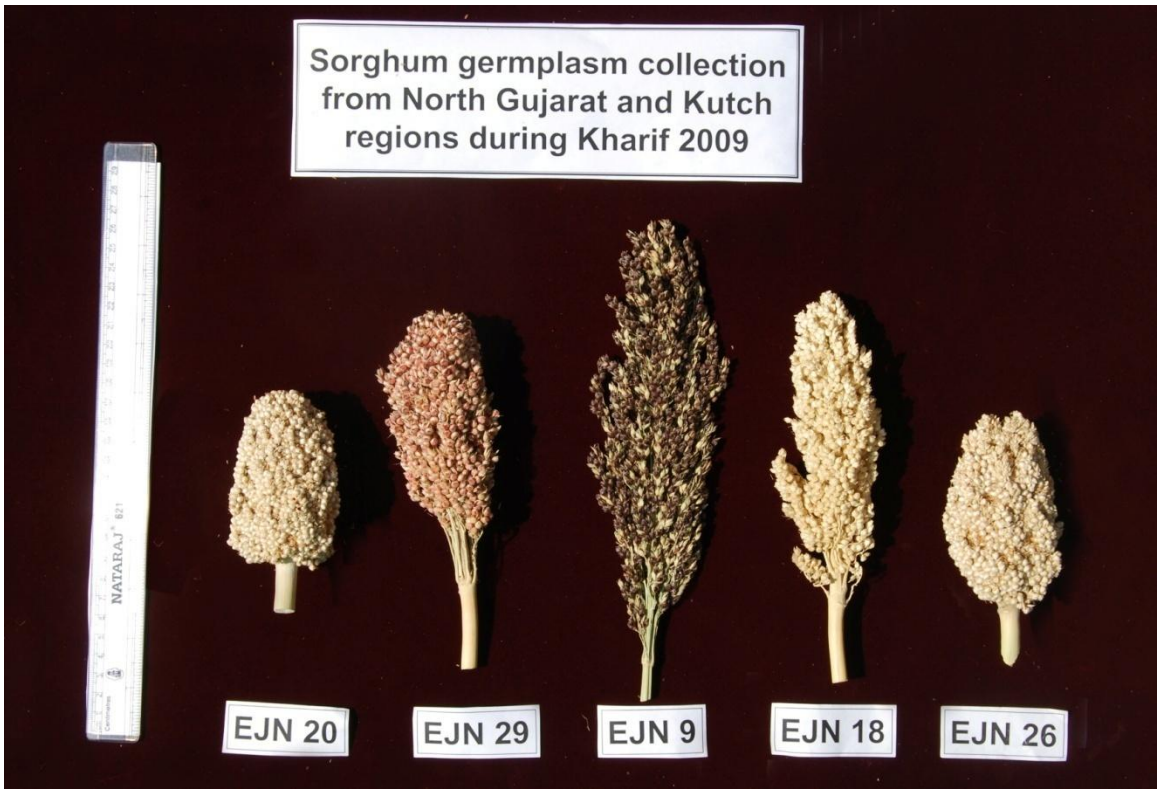

Fig 5: Variability in ear head size and seed colour

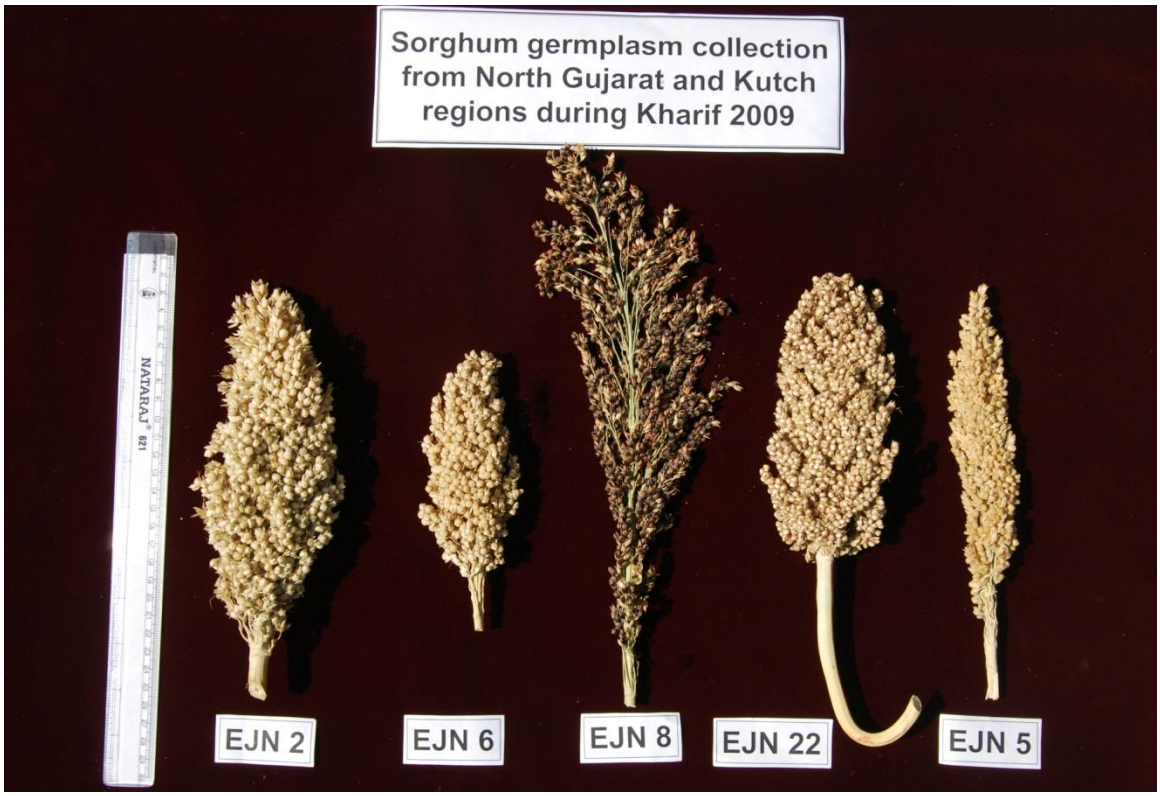

Fig 6: Variability in ear head compactness

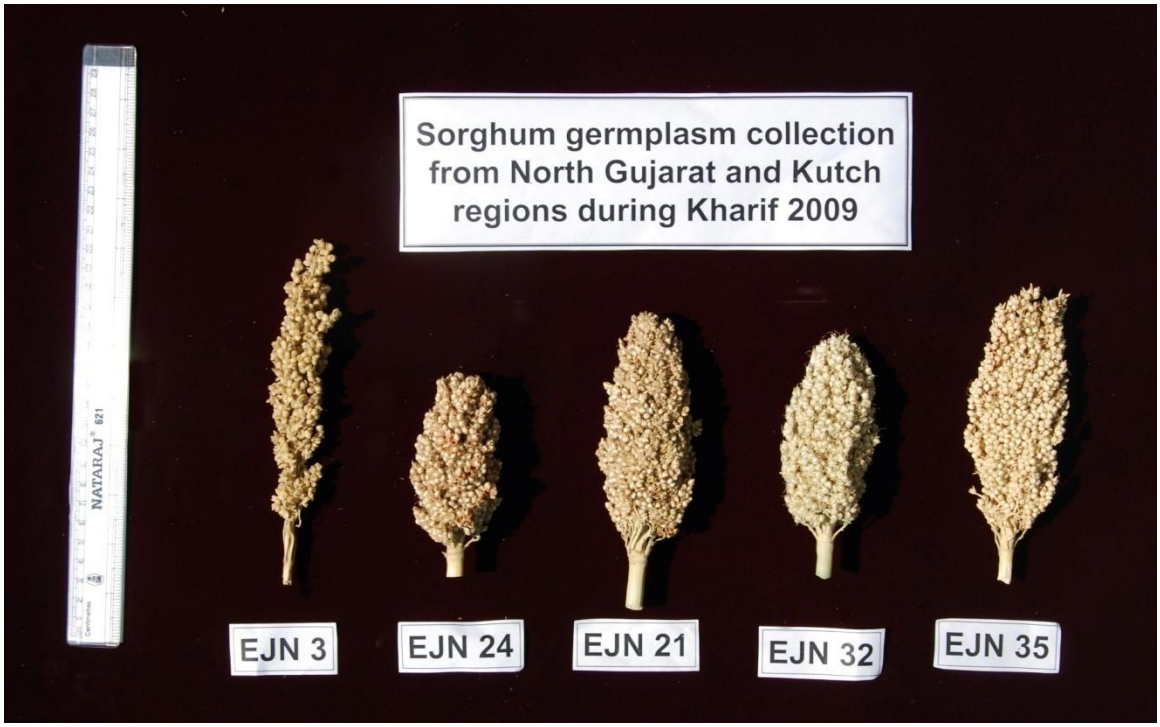

Fig 7: Variability in ear head size

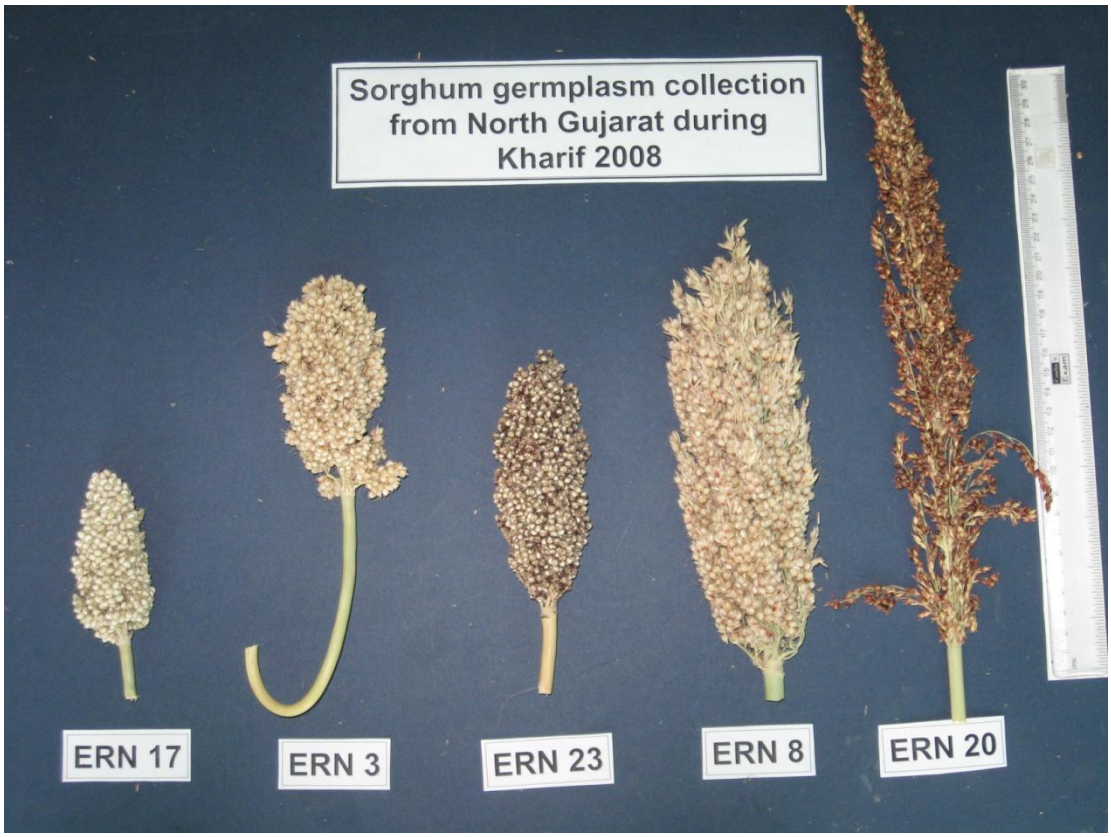

Fig 8: Variability in ear head compactness and seed colour

Conservation

Traditional farmers' strategies emphasis crops diversification as a way of managing risks resulting from climatic vulnerability and market fluctuations. Additionally, they make use of resources available outside their fields. Collection and characterization of sorghum germplasm is an important activity for identifying potential germplasm for utilization in the varietal improvement programme and avoid duplication. Conservation of these local landraces using in situ / on–farm can be successfully achieved by providing special incentives to farmers / local people for growing difficult or uneconomical material on private land or domestic gardens. The village communities may get the benefits through watershed management, wild life habitats and environmental stabilization. Complementary conservation strategies include the protection of saline, disease resistant, high yielding plant populations and traditional crop varieties where they have evolved (in situ) with the collection and preservation of inter and intra-specific, racial diversity in genebanks and agricultural farms. Scientists, individuals need to come forward in coordination to rescue the landrace diversity from un-surveyed and surveyed areas for exploration, collection and conservation of this natural wealth.

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