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Characterization of Sorghum germplasm for various qualitative traits

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Abstract: Present study was performed to characterize 750 germplasm lines with 4 checks namely CSV17, CSV20, CSV27 and CSV21F for various qualitative traits of Sorghum. These 754 genotypes were sown in augmented RBD with 30 replications during *Kharif* 2014 at Instructional Farm, Rajasthan College of Agriculture, Udaipur. Majority of the accessions showed poor early plant vigour (40.2 %), dark green leaf (88.6 %), non- tan leaf sheath pigmentation (60 %), drooping leaves (100 %), white midrib colour (51.6 %), senescence (60 %), loose panicle density (31.5 %), elliptical panicle shape (66.5 %), straw glume colour (48.2 %), 3/4 glume coverage (42.9 %), absence of awns (59.5 %), creamy straw seed (39.9 %), oval grain shape (48.8 %), medium seed size (43.7 %), non-lustrous seed (62.0 %), intermediate endosperm texture (50.3 %) and bicolor race (49.6 %). Very good early plant vigour, tan type leaf sheath pigmentation, drooping leaf orientation, straw glume colour, ½ glume covering, oval grain shape, intermediate endosperm texture appeared in all the 4 check. The results of this study indicated that considerable genetic diversity exists among the sorghum accessions.

Keywords: Accessions, Augmented RBD, Frequency of genotypes, Qualitative traits, Sorghum

INTRODUCTION

Sorghum (*Sorghum bicolor* L. Moench) is one of the important food crops in the world. Sorghum belongs to family Poaceae and tribe Andropogoneae (Harlan and de Wet, 1972). Sorghum is a globally cultivated cereal, unique due to its tolerance to drought, water logging, saline - alkaline, infertile soil and high temperatures (Taylor, 2004). According to the inflorescence (panicle), which varies from very open or loose to very compact, cultivated sorghum have been classified into 5 races *viz.,* Bicolor, Guinea, Caudatum, Durra and Kafir and ten intermediate races corresponding to the pair wise combination of major races. They are identified according to the morphological traits, especially panicle, grain and glume traits (Harlan and de Wet, 1972).

The crop is a C4 photosynthetic plant which increases efficiency of carbon dioxide fixation in plants. Such plants are well adapted to regions of lower latitude that have higher temperatures and are prone to drought (Edwards *et al.,* 2004). Plant genetic resources play an important role in generating new crop varieties with the high yield potential and resistance to biotic and abiotic stresses (Sajid *et al.,* 2008). Sorghum landraces has a wide genetic diversity rich in traits useful in crop improvement (Rosenow and Dalhberg, 2000; Mutegi *et al.,* 2010).

Characterization and evaluation of germplasm are the pre-requisites for the utilization of the available diversity in the crop improvement programme. Hence, the accessions were characterized to assess the variability and identify the promising accessions for different traits. Plant genetic resources play an important role in generating new crop varieties with the high yield potential and resistance to biotic and abiotic stresses (Sajid *et al.,* 2008). Characterization of germplasm is important for the sustainable conservation and increased use of crop genetic resources (Sergio and Gianni, 2005). It involves distinctly identifying characteristics which are heritable leading to classification that will facilitate enhanced utilization of germplasm (Upadhyaya, 2008). The objective of characterizing sorghum germplasm was to describe accessions, establish their characteristics, identify duplicates, identify accessions with desired agronomic traits of Sorghum.

MATERIALS AND METHODS

The experiment was conducted at the Instructional Farm, Department of Plant Breeding and Genetics, Rajasthan College of Agriculture, MPUAT, Udaipur, during kharif season of 2014, in augmented randomized block design with 30 blocks. The experimental

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material consisted of 750 germplasm lines of sorghum along with four checks *viz,* CSV17, CSV20, CSV27 and CSV21F. These checks provided by National Bureau of Plant Genetic Resources (NBPGR) through ICAR- Indian Institute of Millet Research (IIMR). Each of genotype was grown in two meter long single row plot with row to row and plant to plant distance of 45 cm and 10 cm, respectively. Out of the 750 germplasm lines, 59 entries did not germinate and 49 germinated but had poor vigour and could not complete critical growth stages. All the recommended agronomic cultural practices and plant protection measures were followed. Observations were recorded on five competitive plants in each genotype on the basis of visual observation for 17 qualitative characters *viz*., early plant vigour, leaf colour, leaf sheath pigmentation, leaf orientation, leaf midrib colour, stay green, panicle compactness, panicle shape, glume colour, glume covering, presence of awn, grain colour, grain shape, grain size, endosperm texture, grain lusture and race. The data were analyzed using Statistical Package for Social Science (SPSS) version 16.0.

RESULTS AND DISCUSSION

In Sorghum, early vigour is associated with good stand establishment and increased biomass accumulation early in the season which ultimately leads to increased grain yield. Early plant vigour was observed very good in all the four check *viz.,* CSV17, CSV20, CSV27 and CSV21F. At this stage 691 germplasm lines were scored and out of them 228 were very good, 185 good and 278 lines poor in early plant vigour constituting 33.0, 26.8 and 40.2 per cent of the lines evaluated, respectively. Observations recorded on various qualitative traits are given below in Table 1.

Variation was observed for leaf colour in the evaluated sorghum germplasm. Leaf colour was dark green in CSV17 and CSV20, light green in CSV27 and CSV21F checks. At this stage 642 germplasm lines were evaluated. Out of these 569 were dark green, 70 light green and 3 pale green being 88.6, 10.9 and 0.5 per cent, respectively of all lines studied. Elangovan *et al.* (2007) also reported maximum frequency of dark green leaves of sorghum plant. It is proven by various studies the tan character is associated with foliar disease resistance.

Leaf sheath pigmentation was found tan type in all the four checks. Out of 642 germplasm lines 386 were non -tan and 256 were tan being 60.1 and 39.9 per cent germplasm had tan characters and can be used as source for resistance against foliar disease.

Erect leaf architecture reduces shading to the lower leaves, allows better light distribution to the lower canopy, and thus enables higher plant density (Fellner *et al*., 2006 in maize; Tian *et al.,* 2011 in maize; Narayanan *et al*., 2013 in sorghum). The architecture of sorghum hybrids ranges from flat to droopy. The architecture of sorghum has remained largely unchanged during the last 50 year (Assefa and Staggenborg, 2011). New germplasm with advantageous architecture characters are needed to improve sorghum canopy for increasing biomass and grain production. Whereas, in the present study leaf orientation was drooping type in all the four checks and all the 642 germplasm accessions that reached upto this stage.

The check, CSV20 showed white and CSV17, CSV27 and CSV 21F showed green midrib colour. Leaf midrib color among the sorghum germplasm displayed ample variation. Among the 642 germplasm lines 331 had white, 233 green, 61 dark green and 17 yellow midrib colour being 51.6, 36.3, 9.5 and 2.6 per cent, respectively. Similar order of frequency for leaf midrib color was also observed by Durrishahwar *et al.,* (2012) in sorghum germplasm.

Stay green or non-senescence is an important trait associated with drought tolerance (Rosenow, 1977). It is indicated by maintenance of green stems and upper leaves when water is limiting during grain filling. Sorghum genotypes with the stay-green trait continue to fill their grains normally even under limited water or moisture stress conditions (Duncan *et al*., 1981; Rosenow and Clark 1981, Borrell *et al.,* 2000). Delaying the onset of leaf senescence and reducing its rate (*i.e.* two components of the stay green trait) offer an effective strategy for increasing grain production, fodder quality and grain crop residues particularly under water limited conditions. In present investigation stay green trait was present in CSV20 and absent in CSV17, CSV27 and CSV21F. 386 germplasm lines were having senescence and 256 were not having senescence. This indicated that 60.1 per cent were not having stay green character while, 39.9 per cent had stay green character. Stay green can be used in future breeding programme.

Panicle compactness and shape are important characters in determining grain yield and are useful for varietal identification. It was found semi-compact in CSV17 and loose in CSV20, CSV27 and CSV21F. Out of 642 germplasm accessions 202 were loose, 176 were very loose, 119 were broom corn, 75 were semi-compact and 70 were compact being 31.5, 27.4, 18.5, 11.7 and 10.9 per cent frequency, respectively. According to Singh *et al*, (1997) in sorghum and pearl millet, open panicles was preferred in high rainfall and humid areas to avoid mould and ergot diseases. Panicle shape was observed cylindrical in CSV17, elliptical in CSV20 and CSV27 and ovate in CSV21F. Whereas, out of 642 germplasm lines 427 were elliptical, 117 ovate, 52 broom corn, 25 round and 21 cylindrical being 66.5, 18.2, 8.1, 3.9 and 3.3 per cent, respectively.

Glume colour was found straw in all the four checks. The germplasm also showed wide range of glume colors. Out of 627 germplasm accessions, 302 were having straw, 78 black, 71 red, 40 light red, 34 reddish

Table 1. Frequency of genotypes in different categories of characters.

SN	Character	Type	Genotypes					
			Germplasm	%	CSV 17	CSV 20	CSV 27	CSV 21F
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1	Early plant vigour	Poor	278	40.2				
		Good	185	26.8				
		Very good	228	33.0	1	1	1	1
		Total	691					
2	Leaf colour	Pale green	3	0.5				
		Light green	70	10.9			1	1
		Dark green	569	88.6	1	1		
		Total	642					
3	Leaf sheath pigmentation	Non-tan	386	60.1				
		Tan	256	39.9	1	1	1	1
		Total	642					
4	Leaf orientation	Drooping	642	100	1	1	1	1
		Total	642					
5	Leaf midrib colour	White	331	51.6		1		
		Green	233	36.3	1		1	1
		Yellow	17	2.6				
		Dark green	61	9.5				
		Total	642					
6	Stay green	Non-Senescence	256	39.9		1		
		Senescence	386	60.1	1		1	1
		Total	642					
7	Panicle compactness	Compact	70	10.9				
		Semi-compact	75	11.7	1			
		Loose	202	31.5		1	1	1
		Very loose	176	27.4				
		Broom corn	119	18.5				
		Total	642					
8	Panicle shape	Round	25	3.9				
		Ovate	117	18.2				1
		Elliptical	427	66.5		1	1	
		Cylindrical	21	3.3	1			
		Broom corn	52	8.1				
		Total	642					
9	Glume colour	White	11	1.8				
		Straw	302	48.2	1	1	1	1
		Light brown	3	.5				
		Brown	8	1.3				
		Reddish brown	34	5.4				
		Light red	40	6.4				
		Red	71	11.3				
		Dark red	30	4.8				
		Purple	6	1.0				
		Black	78	12.4				
		Straw & brown	33	5.3				
		Straw & purple	11	1.8				
		Total	627					
10	Glume covering	¼	100	15.9				
		½	258	41.1	1	1	1	1

Contd.

Table 1. *Contd.*

		¾	269	42.9				
		Total	627					
11	Presence of awn	Absent	382	59.5	1	1	1	
		Present	260	40.5				1
		Total	642					
12	Grain colour	White	124	22.1			1	1
		Chalky white	11	2.0				
		Creamy straw	224	39.9	1	1		
		Light yellow	13	2.3				
		Yellow	4	.7				
		Light brown	28	5.0				
		Brown	66	11.8				
		Reddish brown	8	1.4				
		Light red	17	3.0				
		Red	1	.2				
		White & red mixed	65	11.6				
		Total	561					
13	Grain shape	Compactly flat	3	.5				
		Round	102	18.2				
		Sub lenticular round but flat from other side	19	3.4				
		Oval	274	48.8	1	1	1	1
		Elliptical	163	29.1				
		Total	561					
14	Grain size	Small	109	19.4	1			
		Medium	245	43.7			1	1
		Bold	207	36.9		1		
		Total	561					
15	Endosperm texture	Compactly corneous	24	4.3				
		Mostly corneous	46	8.2				
		Intermediate	282	50.3	1	1	1	1
		Completely starchy floury	209	37.3				
		Total	561					
16	Grain lusture	Non Lustrous	348	62.0	1	1	1	
		Lustrous	213	38.0				1
		Total	561					
17	Race	Durra	75	12.0				
		Bicolor	311	49.6				1
		Caudatum	29	4.6				
		Guinea	16	2.6				
		Kafir	196	31.3	1	1	1	
		Total	627					

brown, 33 straw brown, 30 dark red, 11 white, 11 straw purple, 8 brown, 6 purple and 3 light brown colour being 48.2, 12.4, 11.3, 6.4, 5.4, 5.3, 4.8, 1.8, 1.8, 1.3, 1.0 and 0.5 per cent, germplasm. Elangovan *et al.,* (2007) also observed different coloured glumes in sorghum germplasm. Darker glumes contributed to grain mould resistance. The variability of glume colour available in the present study may be utilized in screening for grain mold resistance in sorghum, (Audilakshmi *et al.,* 1999). Coverage of seed by glume is directly related with threshability. Threshability becomes poor with increasing coverage. Generally in grain sorghum coverage is less and in fodder types it is maximum. In present investigation glume covering was ½ in all the four checks. Whereas, out of 627 germplasm accessions 269 were covered ¾ of the seed

258 were covered ½ seed and 100 were covered ¼ seed being 42.9, 41.1 and 15.9 per cent, respectively.Absence of awns in sorghum is associated with the ability to reduce evapo-transpiration in dry lowland areas (Ayana and Bekele, 1998 a). Sorghum genotypes with awns are less eaten by birds but are low grain yielders. The findings of this study also indicated that majority of sorghum germplasm having brown grains, which related with high tannin content, are less preferred by birds (Doggett, 1988 b). In present investigation awn was present in CSV21F and absent in CSV17, CSV20 and CSV27 checks. Whereas, out of 642 germplasm accessions 382 were non-awned and 260 were awned being 59.5 and 40.5 per cent, respectively. Grain colour was creamy straw in CSV17 and CSV20 and white in CSV27 and CSV21F checks. Whereas, out of 561 germplasm lines 224 were with creamy straw, 124 white, 66 brown, 65 white and red mixed, 28 light brown, 17 light red, 13 light yellow, 11 chalky white, 8 reddish brown, 4 yellow and 1 red being 39.9, 22.1, 11.8, 11.6, 5.0, 3.0, 2.3, 2.0, 1.4, 0.7 and 0.2 per cent, respectively. Kernel colour determination is important because the information obtained helps in anticipating end product colour quality. White or light sorghums are more preferred for porridge making. Red coloured sorghums are generally preferred for brewing traditional beer (Hikeezi, 2010).Variation was observed for grain shape in the evaluated germplasm. In all the four checks, grain shape was oval. Whereas, out of 561 germplasm lines, grain shape in 274 lines was oval, in 163 elliptical, in 102 round, in 19 sub-lenticular round but flat from other side and in 3 compactly flat being 48.8, 29.1, 18.2, 3.4 and 0.5 per cent, respectively. Grain size was found small in CSV17, medium in CSV27 and CSV21F and bold in CSV20 checks. Whereas, out of 561 germplasm accessions 245 were medium, 207 bold and 109 small being 43.7, 36.9 and 19.4 per cent, respectively. Endosperm texture was observed intermediate in all the four checks. Whereas, 282 germplasm accessions exhibited intermediate, 209 completely starchy floury, 46 mostly corneous and 24 compactly corneous endosperm texture being 50.3, 37.3, 8.2 and 4.3 per cent, respectively of germplasm lines studied. Grain mould resistance is either due to harder grains or higher levels of phenols in seed. Sorghum kernels with more corneous endosperm were more resistant to grain mold than those with floury endosperm (Ibrahim *et al.,* 1985; Jambunathan *et al.,* 1992; Mukuru 1992). Jambunathan *et al.* (1992) and Mukuru (1992) concluded that grain mold resistance in sorghum cultivars with white pericarp is mostly due to kernel hardness and darker glumes also contributed to grain mould resistance. The variability of glume color in this study may be utilized in screening for mould resistance. (Teshome *et al.,* 1997; Kudadjie 2006) and Audilakshmi *et al.* (1999).

Non-lustrous grains were observed in CSV17, CSV20 and CSV27 and lustrous in CSV21F. Out of 561 germplasm lines, 348 were having non-lustrous and 213 lustrous grains being 62.0 and 38.0 per cent, respectively.

Three checks belonged to kafir race *viz*., CSV17, CSV20 and CSV27 while CSV21F belonged to bicolor. Out of 627 germplasm, 311 lines were bicolor type, 196 were kafir, 75 were durra, 29 were caudatum and 16 were guinea being 49.6, 31.3, 12.0, 4.6 and 2.6 per cent, respectively. (Table1). Five basic and ten intermediate races are possible based on grain shape, glumes and panicles (Harlan & de Wet 1972; Harlan 1992).

Members of the race durra have moderate levels of drought resistance and very large panicles as in Yemen (Appa Rao *et al*., 1993), and in Namibia (Appa Rao *et al*., 1992). The race Kafir which is indigenous to Southern Africa (Harlan 1992, Appa Rao *et al.,* 1992) did not reach India along with other races. Sub-race roxburghii of race guinea with small corneous endosperm are extensively grown in the tribal inhabited areas of Andhra Pradesh, Bihar, Madhya Pradesh, and Orissa probably because of their grain mold resistance and strong preference for such grain where the whole grain is cooked like rice (Prasada Rao *et al.,* 1989).

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