

## QUALITATIVE CHARACTERIZATION OF SORGHUM GENOTYPES FOR MORPHOLOGICAL TRAITS

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### SUMMARY

The present investigation was conducted on 49 different sorghum genotypes grown in randomized block design during *kharif* 2018 to evaluate, categorize and classify them on the basis of various DUS parameters. A total of 11 different qualitative traits were characterized as per the guidelines for the conduct of test for Distinctiveness, Uniformity and Stability on sorghum by PPV & FRA, GOI. The observations were taken on five randomly selected plants of each genotype for the following characters viz., anthocyanin coloration of coleoptiles and leaf sheath, midrib colour of leaf and flag leaf, colour of dry anther and glume, panicle shape and density, awn-ness, grain luster and colour. Results revealed that out of 49 genotypes, 11 genotypes were grouped under yellow green and remaining 38 under greyed purple on the basis of anthocyanin colouration of coleoptile. On leaf sheath anthocyanin coloration basis, 15 genotypes were greyed purple and 34 were yellow green. Thirty two genotypes had greyed yellow and 17 genotypes had white leaf mid rib colour. Mid rib coloration of flag leaf in 21 genotypes was white and in 38 genotypes it was found to be yellow green. Presence of awn was observed in 14 genotypes. On the basis of anther colour of dry anther, 17, 1, 8 and 23 genotypes were categorized into four groups viz., yellow orange, orange, orange red and greyed orange, respectively. Whereas, glume colour in genotypes were classified into five categories viz., green white (10), yellow white (13), greyed yellow (7), greyed orange (13) and greyed purple (6). Five different categories of panicle density viz., very loose (3), loose (11), semi loose (16), semi compact (18) and compact (1) were observed at maturity in these sorghum genotypes. On the basis of panicle shape eighteen genotypes had symmetrical, eight had panicle broader in lower part, ten had reverse pyramidal and thirteen had panicle broader in upper part. Twenty seven genotypes had lustrous grain and 22 genotypes had non lustrous grain. Grain colour varied among genotypes viz. white (12), yellow white (26), yellow orange (6), and greyed orange (5). The outcome of these traits tells us about the genetic architecture of the genotypes and their interaction within a specified environment for further improvement.

**Key Words :** Sorghum, characterization, fodder, morphological traits

Sorghum (*Sorghum bicolor* [L.] Moench) is indigenous to Africa, where it was domesticated in Ethiopia about 5,000 years ago (Wani *et al.*, 2012). Sorghum ranks as fifth most staple crop all over the world in term of world grain production (FAO, 2015) and is the economy of people living in warmer temperatures and tropical regions such as South Asia and Africa (Oria *et al.*, 2000). Genetic variability of the economic characters decides the course of genetic improvement of a crop. So, assessment of variability present in agronomic traits becomes necessary to use this variation in crop improvement programmes (Jaipal and Shekhawat, 2016). Morphological measurements and phenotypic characterization can be relied upon for measurement of genetic variability. Genotypes characterization is documentation of distinctly

identifiable traits which are highly heritable while evaluation means the agronomic description of the genotypes, for the characters, that are generally important for breeding and research purposes. Both are required for understanding the genetic relationship among the genotypes that can be used in breeding programmes for improvement of crop (Kumari *et al.*, 2018).

### MATERIALS AND METHODS

The field experiment for present investigation was concluded at Forage Research Area, Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar (Haryana, India) during *kharif* 2018-19. The experiment was conducted in

randomized block design with three replications and two row plot of three meter having row to row & plant to plant distance of 30 cm & 10 cm, respectively.

The climate of Hisar is characterized by semi-arid and subtropical hot and dry winds during summer months. Warm humid in monsoon and cold dry weather in winter are the general features of this region. The mean minimum and maximum temperature exhibit wide variations. A maximum temperature zooming 44 to 48°C during summer and temperature dipping as low as to freezing point accompanied with chill frost in winter is of common occurrence.

The experimental material consists of 49 sorghum genotypes. The genotypes were collected from the Forage Section, Genetics and Plant Breeding Department; CCS HAU, Hisar. The genotypes used for the present investigation is listed in Table 1. A total of 11 characters were studied for the characterization and grouping of the genotypes on the basis of observations recorded as per the guidelines for the conduct of test for distinctiveness, uniformity and stability on sorghum by PPV & FRA, GOI at different stages of plant development. The descriptors and the time and way of taking data are presented in Table 2. The observations were recorded on five randomly selected plants of each genotype for the 11 qualitative traits.

## RESULTS AND DISCUSSION

The DUS descriptors are useful to determine distinctiveness, uniformity and stability of a variety

TABLE 1  
List of sorghum genotypes included in the study

S. No.	Genotype	S. No.	Genotype	S. No.	Genotype
1.	Dairy green	18.	IS 144849	35.	PGN 66
2.	G-800	19.	IS 285831	36.	PGN 9
3.	GFS 5	20.	IS 285913	37.	S713
4.	GP-236	21.	IS 2919	38.	SH1591
5.	GP-237	22.	IS 3244	39.	SOPPON
6.	GP-297	23.	IS 3299	40.	SOR 5449
7.	GP-298	24.	IS 3947	41.	SOR 5504
8.	GP-311	25.	IS 40398	42.	SOR 5510
9.	GP-318	26.	IS 40717	43.	SOR 5578
10.	HC 171	27.	IS 40921	44.	SOR 6408
11.	HC 260	28.	IS 5127	45.	SOR 6453
12.	HC136	29.	IS 585159	46.	SOR 668
13.	HC 308	30.	IS 585176	47.	SPV 2191
14.	HJ 513	31.	IS 585186	48.	SSG 233
15.	HJ 541	32.	IS 608	49.	SUENT
16.	IS 1004	33.	IS 651		
17.	IS 1328	34.	PGN 56		

which form basis of varietal protection. DUS testing is an important aspect before plant varieties registration under PPV & FRA that entails the legal protection of plant varieties, agriculture diversification and overall improvement of agriculture. In present investigation data was collected as per DUS guidelines for sorghum and presented in different tables.

### Anthocyanin coloration of coleoptiles

Anthocyanin coloration of coleoptiles was observed at seedling stage of five randomly selected plants for their characterization and grouping. On this basis, genotypes were broadly categorized as grayed purple and yellow green. Out of 49 examined genotypes; 38 found to be grayed purple while remaining 11 genotypes were yellow green (Plate 1; Table 3). The similar traits were studied in sorghum under different investigation by Nagaraja *et al.*, (2000), Selvaraju and Sivasubramaniam (2000) and Raghuvanshi *et al.*, (2014).

### Leaf Sheath Anthocyanin Coloration

At 5<sup>th</sup> leaf stage, most of the genotypes exhibited yellow green coloration rather than of grayed purple just opposite of seedling anthocyanin coloration of coleoptiles. The total of 34 genotypes was reported to be purple green while 14 genotypes exhibited grayed purple coloration (Plate 2; Table 4). The trait showed agreement with many other studies like by Elangovan *et al.*, (2007), Reddy *et al.*, (2008).

### Leaf Midrib Colour

As per DUS guidelines, leaf midrib colour was also recorded at 5<sup>th</sup> leaf stage of sorghum plant growth. The genotypes were grouped into two categories *i.e.* grayed yellow and white. Thirty two genotypes were classified as grayed yellow and remaining 17 genotypes as white (Plate 3; Table 5). These results are in accordance with those of Sangwan *et al.*, (2005), Raghuvanshi *et al.*, (2014).

### Flag leaf yellow coloration of midrib

Flag leaf midrib coloration was investigated in all 49 genotypes which showed two groups of plants *viz.*, absence and presence of yellow coloration or can be grouped as white and yellow green midrib coloration. Twenty one genotypes were found to be white or absence of yellow coloration and 28

TABLE 2  
Descriptors used to characterize the present genotypes

S. No.	Characteristics	Status	Stage of observation
1.	Anthocyanin coloration of coleoptiles	Yellow green	Seedling 7-8 days after sowing
2.	Leaf sheath anthocyanin Coloration	Grayed purple	5th leaf
3.	Leaf mid rib colour	Yellow green	5th fully developed leaf
4.	Flag leaf yellow coloration of Midrib	Grayed purple	
5.	Anther colour of dry anther	White	Panicle emergence
6.	Glume colour	Grayed yellow	End of flowering
7.	Panicle density at maturity (ear head compactness)	Yellow green	
8.	Panicle shape	White	Physiological maturity of grain
9.	Awn-ness	Grayed orange	
10.	Grain luster	Orange	
11.	Grain colour	Orange red	
		Yellow orange	
		Grayed yellow	
		Green white	
		Yellow white	
		Grayed purple	
		Grayed orange	
		Compact	Physiological maturity
		Semi compact	
		Semi loose	
		Loose	
		Very loose	
		Panicle broader in lower part	Physiological maturity
		Panicle broader in upper part	
		Symmetrical	
		Pyramidal	
		Present	Flowering
		Absent	
		Lustrous	After threshing
		Non-lustrous	
		White	After threshing
		Yellow white	
		Yellow orange	
		Grayed orange	

TABLE 3  
Classification of sorghum genotypes on the basis of seedling anthocyanin coloration of coleoptiles

Grayed purple (38)	GFS 5, SOR 5504, SOR 668, SOR 6408, IS 585159, IS 585176, IS 585186, SOR 6453, IS 144849, IS 285831, IS 285913, GP-236, GP-237, IS 3244, IS 3299, SSG 233, SOPPON, GP-298, PGN 56, GP-318, SPV 2191, PGN 9, SOR 5449, SOR 5510, SOR 5578, IS 40398, IS 40717, IS 40921, IS 3947, IS 5127, IS 1328, IS 2919, IS 651, IS 608, IS 1004, HC136, HC308, S713
Yellow green (11)	G-800, GP-297, GP-311, SUENT, PGN 66, Dairy green, HC 171, HC 260, HJ 513, HJ 541, SH1591

TABLE 4  
Sorghum genotypes are classified on the basis of leaf sheath anthocyanin coloration

Grayed purple (15)	GFS 5, SOR 668, SOR 6408, IS 585159, IS 585176, SOR 6453, IS 3244, IS 3299, GP-318, IS 3947, IS 5127, IS 1328, IS 1004, HC 260, S713
Yellow green (34)	SOR 5504, IS 585186, IS 144849, IS 285831, IS 285913, GP-236, GP-237, G-800, SSG 233, SOPPON, GP-297, GP-298, GP-311, PGN 56, SUENT, SPV 2191, PGN 66, PGN 9, Dairy green, SOR 5449, SOR 5510, SOR 5578, IS 40398, IS 40717, IS 40921, IS 2919, IS 651, IS 608, HC 171, HC136, HC308, HJ 513, HJ 541

genotypes showed presence of yellow coloration *i.e.* yellow green (Plate 4; Table 6). These results can be supported by studies of Reddy *et al.*, (2008), Reddy *et al.*, (2009), Kannababu *et al.*, (2013).

At late flowering stage, the anther colour was found to be useful DUS parameter for grouping and characterizing the sorghum genotypes. In present investigation, genotypes were grouped into four

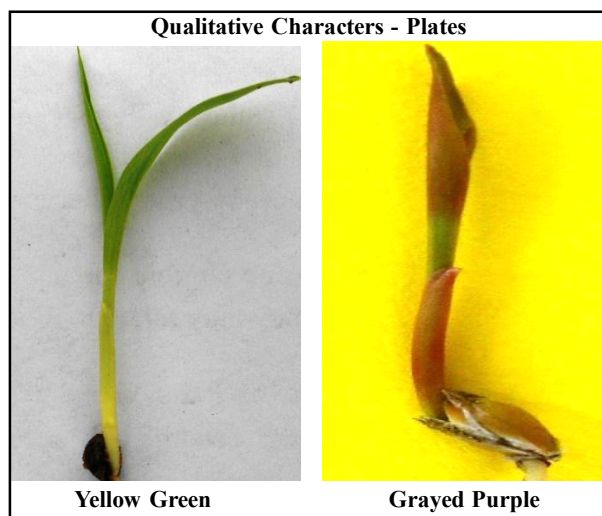


PLATE 1: Seedling anthocyanin coloration of coleoptiles.



PLATE 2: Leaf sheath anthocyanin coloration.

categories *i.e.* grayed orange (23 genotypes), orange (1 genotypes), orange red (8 genotypes), yellow orange (17 genotypes) (Plate 5; Table 7). These results are in accordance with Reddy *et al.*, (2009) and Joshi *et al.*, (2009).

### Glume Colour

Glume colour showed considerable variability in the studied genotypes which form the basis of grouping and characterization. Genotypes



PLATE 3: Leaf midrib colour.



PLATE 4: Flag leaf yellow coloration of mid rib.

were grouped into five major classes; 10 genotypes were observed to be green white, 13 were yellow white, seven were grayed yellow, 13 were grayed orange and six were grayed purple (Plate 6; Table 8). This trait was also studied and found diverse by Umakanth *et al.*, (2002), Missihoun *et al.*, (2015).

### Panicle Density at Maturity

Panicle density characteristics is one of most important morphological marker to characterize different types of sorghum genotypes. The three genotypes were very loose, 15 genotypes semi-loose, 11 genotypes loose, 19 genotypes semi compact and remaining one genotype had compact panicle density at maturity (Plate 7; Table 9). Several other studies

TABLE 5  
On leaf mid rib colour of 5th fully developed leaf basis sorghum genotypes are classified as

Grayed yellow (32)	GFS 5, SOR 5504, SOR 668, SOR 6408, IS 585176, IS 144849, GP-236, GP-237, G-800, SSG 233, SOPPON, GP-297, GP-311, PGN 56, SUENT, GP-318, SPV 2191, PGN 66, PGN 9, Dairy green, SOR 5449, SOR 5510, SOR 5578, IS 40717, IS 40921, IS 3947, IS 608, HC 171, HC308, HC136, HJ 541, S713, SH1591
White (17)	IS 585159, IS 585186, SOR 6453, IS 285831, IS 285913, IS 3244, IS 3299, GP-298, IS 40398, IS 5127, IS 1328, IS 2919, IS 651, IS 1004, HC 260, HJ 513



TABLE 6  
Classification of sorghum genotypes based on flag leaf yellow coloration of mid rib

Absent (21)	SOR 5504, SOR 6408, IS 585186, SOR 6453, IS 144849, IS 285831, GP-237, G-800, IS 3244, IS 3299, SOPPON, GP-298, PGN 66, Dairy green, SOR 5449, SOR 5510, IS 40398, IS 40921, IS 2919, IS 608
Present (28)	GFS 5, SOR 668, IS 585159, IS 585176, IS 285913, GP-236, SSG 233, GP-297, GP-311, PGN 56, SUENT, GP-318, SPV 2191, PGN 9, SOR 5578, IS 40717, IS 3947, IS 5127, IS 1328, IS 651, IS 1004, HC 171

revealed similar pattern of classification like of Pahuja *et al.*, (2002), Sangwan *et al.*, (2005), Reddy *et al.*, (2009) and Missihoun *et al.*, (2015).

### Panicle Shape

On the basis of panicle shape, sorghum genotypes were classified in four categories – panicle broader in lower part (8 genotypes), panicle broader

in upper part (13 genotypes), pyramidal (10 genotypes), symmetrical (18 genotypes) given in Plate 8; Table 10. This trait was also studied and found diverse by Umakanth *et al.*, (2002), Missihoun *et al.*, (2015).

### Awn Presence or Absence

The palea in a sorghum flower may be awned

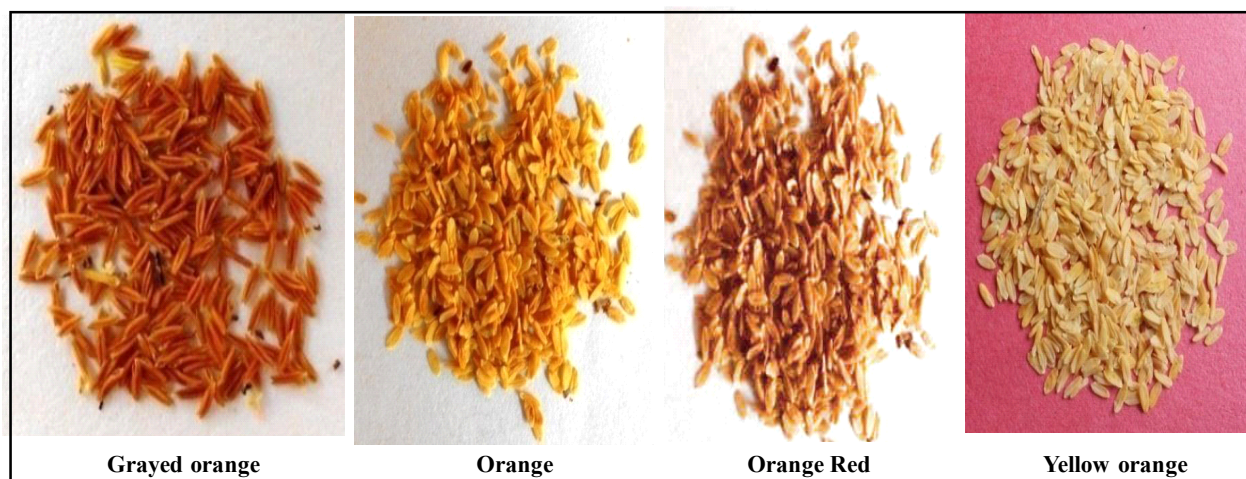


PLATE 5: Anther colour of Dry anther.

TABLE 7  
Classification of sorghum genotypes based on dry anther colour

Grayed orange (23)	IS 585186, IS 285831, GP-237, IS 3299, SOPPON, GP-297, GP-311, GP-318, SPV 2191, PGN 9, Dairy green, SOR 5449, SOR 5510, SOR 5578, IS 40398, IS 5127, IS 608, IS 1004, HC 171, HC 260, HC136, HC308, S713
Orange (1)	SOR 6453
Orange red (8)	SOR 5504, SOR 668, IS 285913, GP-236, PGN 66, IS 40717, IS 40921, IS 3947
Yellow orange (17)	GFS 5, SOR 6408, IS 585159, IS 585176, IS 144849, G-800, IS 3244, SSG 233, GP-298, PGN 56, SUENT, IS 1328, IS 2919, IS 651, HJ 513, HJ 541, SH1591



PLATE 6: Glume colour.

TABLE 8  
On the basis of glume color sorghum genotypes are classified as

Green white (10)	IS 585176, G-800, GP-297, PGN 9, IS 1328, IS 1004, S713, SH1591, HC308, HJ 541
Yellow white (13)	SOR 5504, SOR 668, SOR 6408, IS 585186, SOR 6453, IS 144849, IS 3244, GP-311, PGN 56, IS 40398, IS 3947, HC 260, HJ 513
Greyed yellow (7)	IS 585159, GP-236, SOPPON, GP-318, SOR 5449, IS 40717, IS 651
Greyed orange (13)	IS 285831, IS 285913, SUENT, PGN 66, SOR 5510, IS 2919, GFS 5, GP-237, IS 3299, SSG 233, GP-298, HC136, HC 171
Greyed purple (6)	SPV 2191, Dairy green, SOR 5578, IS 40921, IS 5127, IS 608

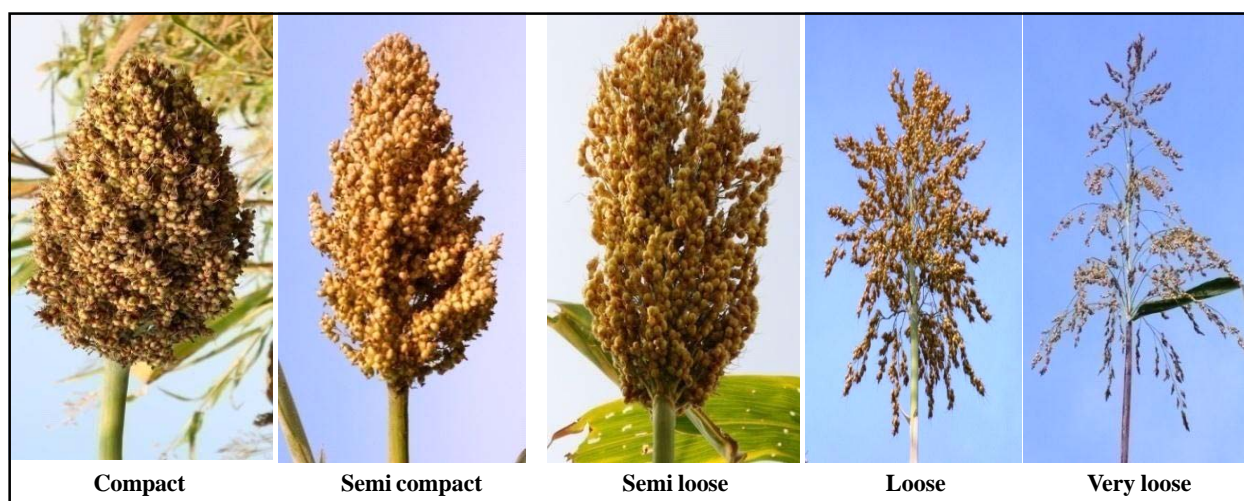


PLATE 7: Panicle density at maturity.

TABLE 9  
Sorghum genotypes are classified on the basis of panicle density at maturity

Very loose (3)	SOR 668, SOR 6408, IS 285831
Semi loose (15)	IS 285913, G-800, IS 3244, SSG 233, GP-318, PGN 9, SOR 5578, IS 40398, IS 5127, IS 2919, IS 651, GP-298, PGN 56, SOR 5449, IS 40717
Loose (11)	SOR 5504, IS 585176, SOR 6453, GP-236, GP-237, IS 3299, GP-311, PGN 66, Dairy green, SOR 5510, IS 3947
Semi compact (19)	GFS 5, IS 1004, IS 585159, IS 585186, IS 144849, SOPPON, GP-297, SUENT, SPV 2191, IS 40921, IS 1328, IS 608, HC 260, S713, SH1591, HJ 541, HC308, HJ 513, HC 171
Compact (1)	HC136

or awnless. On the basis of presence/absence of awns, the sorghum genotypes were grouped into two categories *viz.* awn presence or absence. Out of 49 genotypes, 14 were awnless and 35 genotypes were awned (Table 11).

### Grain Luster

After threshing sorghum genotypes were characterized on the basis of grain luster which grouped these genotypes into two classes. Twenty seven grain or seed observed as lustrous while remaining 22 were non lustrous (Plate 9; Table 12). This characterization are in accordance of Ram *et al.*, (1998), Nagaraja *et al.*, (2000), Selvaraju and Sivasubramaniam (2000), Thangavel *et al.*, (2005).

### Grain Colour

The sorghum genotypes were classified into four groups on the basis of grain colour *i.e.* grayed orange (5 genotypes), white (12 genotypes), yellow orange (6 genotypes) and yellow white (26 genotypes), given in Plate10 & Table13. These findings can be validated by the studies of Selvaraju and Sivasubramaniam (2000), Thangavel *et al.*, (2005).

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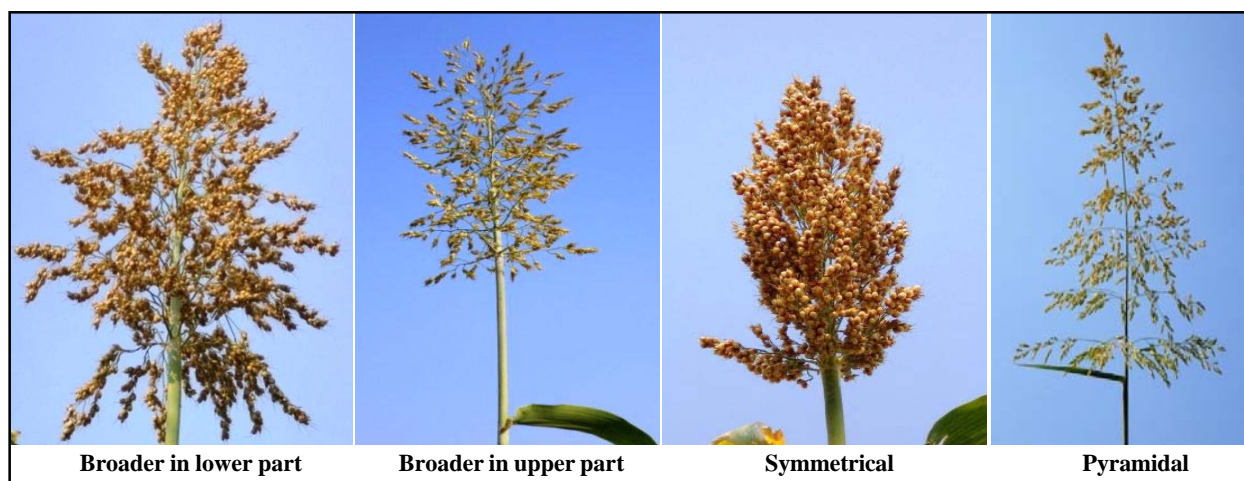


PLATE 8: Panicle shape.

TABLE 10  
Classification of sorghum genotypes on the basis of panicle shape

Panicle broader in lower part (8)	IS 585159, IS 285831, G-800, IS 3299, GP-311, PGN 56, IS 40398, HC136
Panicle broader in upper part (13)	IS 585176, SOR 6453, IS 3244, GP-298, SUENT, GP-318, SPV 2191, PGN 9, SOR 5578, IS 40921, IS 608, HC 171, HC 260
Pyramidal (10)	IS 285913, SSG 233, SOPPON, Dairy green, IS 3947, IS 2919, IS 1004, HJ 513, HJ 541, S713
Symmetrical (18)	GFS 5, SOR 5504, SOR 668, SOR 6408, IS 585186, IS 144849, GP-236, GP-237, GP-297, PGN 66, SOR 5449, SOR 5510, IS 40717, IS 5127, IS 1328, IS 651, HC 308, SH 1591

TABLE 11  
Sorghum genotypes are classified on the basis of presence /absence of the awns

Absent (14)	IS 144849, GP-237, GP-297, GP-311, PGN 66, PGN 9, Dairy green, IS 40398, IS 40717, IS 40921, IS 3947, IS 608, HC 260, HJ 541
Present (35)	GFS 5, SOR 5504, SOR 668, SOR 6408, IS 585159, IS 585176, IS 585186, SOR 6453, IS 285831, IS 285913, GP-236, G-800, IS 3244, IS 3299, SSG 233, SOPPON, GP-298, PGN 56, SUENT, GP-318, SPV 2191, SOR 5449, SOR 5510, SOR 5578, IS 5127, IS 1328, IS 2919, IS 651, IS 1004, HC 171, HC136, HC 308, HJ 513, S713, SH1591



PLATE 9: Grain luster.

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TABLE 12  
Grain luster classification of sorghum genotypes

Lustrous (27)	SOR 5504, SOR 668, IS 585159, IS 585186, SOR 6453, IS 144849, IS 285831, G-800, IS 3299, SSG 233, GP-311, SUENT, PGN 66, Dairy green, SOR 5510, SOR 5578, IS 40398, IS 40717, IS 3947, IS 5127, IS 2919, IS 651, IS 1004, HC 171, HC136, HJ 513, HJ 541
Non lustrous (22)	GFS 5, SOR 6408, IS 585176, IS 285913, GP-236, GP-237, IS 3244, SOPPON, GP-297, GP-298, PGN 56, GP-318, SPV 2191, PGN 9, SOR 5449, IS 40921, IS 1328, IS 608, HC 260, HC 308, S713, SH 1591



PLATE 10: Grain colour.

TABLE 13  
On the basis of grain color sorghum genotypes are classified as

Greyed orange (5)	GFS 5, SOR 6408, IS 585176, SSG 233, SOPPON
White (12)	SOR 5504, IS 585186, SOR 6453, IS 285831, SUENT, IS 2919, IS 1004, HC 171, HC 260, HJ 513, HJ 541, S713
Yellow orange (6)	IS 285913, IS 3244, IS 3299, GP-298, IS 40921, IS 3947
Yellow white (26)	SOR 668, IS 585159, IS 144849, GP-236, GP-237, G-800, GP-297, GP-311, PGN 56, GP-318, SPV 2191, PGN 66, PGN 9, Dairy green, SOR 5449, SOR 5510, SOR 5578, IS 40398, IS 40717, IS 5127, IS 1328, IS 651, IS 608, HC 136, HC 308, SH 1591

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