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DUS characterization of various sorghum genotypes (*Sorghum bicolor* L. Moench) on the basis of midrib colour

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Abstract
The present study was conducted on 25 sorghum genotypes grown in Randomized Block Design during Kharif 2015 to evaluate, categorize and classify them for fodder yield and quality traits. Registration and protection can be granted to a variety only if it conforms to the criteria of Distinctness, Uniformity and Stability. New variety has to Distinct-Uniform-Stable (DUS) in its characteristics. Observations were recorded on eighteen variables involving morphological, quality. Out of 25 genotypes, nine genotypes were grouped under yellow green and remaining sixteen genotypes were under greyed purple. Ten genotypes were without stigma anthocyanin colouration and remaining fifteen genotypes had stigma anthocyanin colouration. On the basis of total plant height, stem girth, number of tillers, number of leaves, green fodder yield and dry fodder yield genotypes were classified and genotype CSV 21F, HJ 260, IS 2205, S 490, S 651, SSG 59-3 showed maximum plant height, number of leaves, number of tillers, stem girth, green fodder yield and dry fodder yield.

Keywords: Sorghum, DUS, midrib

Introduction
Sorghum (Sorghum bicolor L. Moench) was originated in Africa is one of the five top cereal crops in the world. It's extremely drought tolerant ability makes it an excellent choice for arid and dry areas. It's quick growing habit, high yield, regeneration potential, better palatability, digestibility and drought tolerance makes it good choice of fodder for farming community on which the livestock industry depends. It can grow in the areas where all other major cereal crops could not grow successfully.
In India, the area under cultivated sorghum is 5.82 million hectare with production of 5.39 million ton and productivity 926 kg/ha. In Haryana, 72 thousand hectares area was under sorghum with production of 40 thousand tons and productivity 500 kg/ha (Anonymous, 2014-2015) [1].
Brown midrib (bmr) is a visible marker which is associated with the reduction of lignin in corn, sorghum and pearl millet. Intensity of the coloration is not a measure of reduction in lignin content although it is an indicator that the bmr gene is present.
There are at least four genes that exist in sorghum which produce a brown midrib reaction, three of these genes were identified at Purdue University in 1978 and other exists in World Collection of Sorghum (Porter *et al*, 1978) [2].
There is a need of consolidated system in the country to protect such a vast variability present in the species and proper sharing of benefits derived out of them. In this context, Government of India under the obligation of the TRIPS agreement has passed the Protection of Plant Varieties and Farmers' Rights Act, 2001 (PPV&FR Act) to encourage public/private investment in research and development of new plant varieties by giving protection to the plant varieties against unauthorized multiplication of seeds or propagating materials for a specified period. The plant varieties must fulfill the distinctiveness, uniformity and stability (DUS) criteria for protection under the Act and hence, there is a need to characterize sorghum varieties according to DUS test guidelines for sorghum prescribed by PPV and FR Authority. Keeping this in view, the study was taken up with the objective to characterize genotype for DUS testing in forage sorghum varieties for their protection under the PPV& FR Act.

Methods and material
Twenty five forage sorghum genotypes Bmr1, Bmr-2, Bmr-3, Bmr-4, Bmr-5, COFS 29, HJ 513, HC 260, IS 2205, IS 2389, DUGGI, CSV 21F, S 490, S 437, S 651, G 46, SSG 593, HC 136, HC 171, HJ 541, PC 5, PC 7, PC 8, ICSV 700, HC 308 were used in present study.

The material was collected from Forage Section, Department of Genetics and Plant Breeding CCSHAU, Hisar and sowing was done on July 4, 2015. The field experiment was conducted at Research Area of Forage Section, Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar. Observations were recorded on different quantitative variables.

Morphological character as per DUS parameters

	Parameters	States	Stage of observation
1	Seedling : Anthocyanin colouration of coleoptiles	Yellow green Greyed purple	Seedling 7-8 days after sowing
2	Leaf sheath : Anthocyanin colouration	Yellow green Greyed purple	5th leaf
3	Leaf : Midrib colour (5th fully developed leaf)	White Yellow green Greyed yellow Greyed purple	5th leaf
4	Plant : Time of panicle emergence (50% of the plants with 50% anthesis**)**	Very early (<56 days) Early (56-65 days) Medium (66-75 days) Late (76-85 days) Very late (>85 days)	Panicle emergence
5	Plant : Natural height of plant upto base of flag leaf	Very short (<76 cm) Short (76-150 cm) Medium (151-225 cm) Tall (226-300 cm) Very tall (>300 cm)	Panicle emergence
6	Flag leaf: Yellow colouration of midrib	Absent Present	Panicle emergence
7	Lemma: Arista formation	Absent Present	Flowering
8	Stigma: Anthocyanin colouration	Absent Present	Upper portion of the panicle at the end of flowering
9	Stigma: Yellow colouration	Absent Present	Flowering
10	Stigma: Length	Short (<1mm) Medium (1-2mm) Long (>2mm)	Flowering
11	Flower with pedicel: Length of flower	Very short Short Medium Long Very long	Flowering
12	Anther: Length	Short (<3mm) Medium (3-4mm) Long (>4mm)	Flowering
13	Anther: Colour of dry anther	Yellow orange Orange Orange red Grayed orange	End of flowering Flowering
14	Number of leaves per plant	Less (<15) Medium (15-40) More (>40)	Physiological maturity
15	Stem girth (cm)	Small (<2 cm) Medium (2 – 4 cm) Large (> 4 cm)	Physiological maturity
16	Number of tillers per plant	Less (< 2) Medium (2-5) More (> 5)	Physiological maturity
17	Panicle: Length of branches (middle third of panicle)	Short (<5.1 cm) Medium (5.1-10 cm) Long (10.1-15 cm) Very long (>15 cm)	Physiological maturity
18	Panicle: Density at maturity (ear head compactness)	Very loose Loose Semi loose Semi compact Compact	Physiological maturity
19	Panicle: Shape	Reversed pyramid	Physiological maturity

		Panicle broader in upper part Symmetric Panicle broader in lower part Pyramidal	
20	Neck of panicle : Visible length above sheath	Absent or very short (<5.1 cm) Short (5.1-10 cm) Medium (10.1-15 cm) Long (15.1-20 cm) very long (>20cm)	Physiological maturity
21	Glume : Length	Very short (25% of grain covered) Short (50% of grain covered) Medium (75% of grain covered) Long (100% of grain covered) Very long (longer than the grain)	Physiological maturity
22	Grain : Threshability	Freely threshable (<11% unthreshed grain) Partly thresahble (11 – 50% unthreshed grain) Difficult to thresh (>50% unthreshed grain)	Maturity
23	Caryopsis : Colour after threshing	White RHS 155 Greyed white RHS 156 Yellow white RHS 158 Yellow orange RHS 14-20 Greyed orange RHS 200	After threshing
24	Grain : Shape (in dorsal view)	Narrow elliptic Elliptic Circular	After threshing
25	Grain : Shape in profile view	Narrow elliptic Elliptic Circular	After threshing
26	Grain : Size of mark of germ	Very small Small Medium Large Very large	After threshing
27	Grain : Texture of endosperm (in longitudinal section)	Fully vitreous (100% corneous) ¾ vitreous (75% corneous) Half vitreous (50% corneous) ¾ farinaceous (25% corneous) Fully farinaceous (0% corneous)	After threshing
28	Grain : Colour of vitreous albumen	Greyed yellow RHS 160-162 Greyed orange RHS 166 Greyed purple RHS N 187	After threshing
29	Grain: Luster	Non-lustrous Lustrous	After threshing

Result and discussion

(a) Classification on the basis of DUS characteristics

Sorghum genotypes were grouped into different classes on the basis of observation recorded as per guideline of Protection of Plant Varieties & Farmers Right Authority for morphological characters in the field at different stages of plant growth.

1. Seedling Anthocyanin Colouration of Coleoptiles

The classification of different genotypes on the basis of seedling anthocyanin colouration of coleoptiles was presented in Table 1. Nine genotypes were grouped under yellow green and remaining sixteen genotypes were under greyed purple.

Table 1: Classification of Sorghum genotypes on the basis of seedling anthocyanin colouration of colieoptiles

Yellow Green (9)	BMR-1, BMR-2, BMR-3, HJ 513, HC 260, HC 136, PC 7, HC 171, HJ 541
Grayed Purple (16)	BMR-4, BMR-5, PC 5, PC 8, COFS 29, IS 2205, IS 2389, DUGGI, CSV 21F, S 490, S 437, S 651, G 46, SSG 59-3, ICSV 700, HC 308 .

2. Leaf Sheath Anthocyanin Colouration

On the basis of leaf sheath anthocyanin colouration genotypes were classified into two categories. Eleven genotypes were yellow green and remaining fourteen genotypes were greyed purple in colour. The classification of genotypes has been presented in Table 2.

Table 2: Classification of sorghum genotypes on the basis of leaf sheath anthocyanin colouration

Yellow Green (11)	BMR-1, BMR-4, BMR-3, BMR-5, HJ 513, HC 260, HC 136, HJ 541, HC 171, PC 7, ICSV 700
Grayed Purple (14)	BMR-2, COFS 29, IS 2205, IS 2389, DUGGI, CSV 21F, S 490, S 437, S 651, G 46, SSG 59-3, PC 5, PC 8, HC 308

3. Leaf Midrib Colour (5th fully developed leaf)

Genotypes were classified on the basis of leaf midrib colour of 5th fully developed leaf in to four groups. Eight genotypes were white, eleven genotypes were having yellow green, two were grey yellow and four were grey purple in their leaf midrib colour. Brown midrib genotypes were either grey purple or grey yellow .The classifications of genotypes were represented in Table 3.

Table 3: Classification of Sorghum genotypes on the basis of leaf midrib colour of 5th fully developed leaf

White (8)	COFS 29, HJ 513, HC 260, IS 2205, IS 2389, DUGGI, S 490, S 651
Yellow green (11)	CSV 21F, PC 5, S 437, SSG 59-3, HC 136, HC 171, ICSV 700, HJ 541, PC 8, G 46, HC 308
Grey yellow (2)	BMR-3, PC 7
Grey purple (4)	BMR-1, BMR-2, BMR-5, BMR-4

4. Time to Panicle Emergence (50% of the plants with 50% of anthesis)

On the basis of time of panicle emergence genotypes were classified mainly in to four categories. Seven genotypes were early (>65days), SSG 59-3 was medium (66-75 days), eight genotypes were late (76-85 days) and remaining eight genotypes were very late (> 85 days) for panicle emergence. All brown midrib genotypes were early. The classifications of genotypes has been presented in Table: 4.

Table 4: Classifications of Sorghum genotypes on the basis of time of panicle emergence (50% of the plants with 50% anthesis)

Early (<65days) (7)	BMR-1, BMR-2, BMR-3, BMR-4, BMR-5, HC 260, ICSV 700
Medium (66-75 days) (2)	DUGGI, SSG 59-3
Late (76-85 days) (8)	HC 308, PC 5, PC 7, IS 2205, IS 2389, CSV 21F, S 490, S 651
Very late (>85 days) (8)	C0FS 29, HJ 513, HJ 541, S 437, PC 8, G 46, HC 136, HC 171

5. Height of the plant up to the Base of flag Leaf

Classification of genotypes on the basis of plant height up to the base of flag leaf has been presented in Table 5. Thirteen genotypes were tall, eight genotypes were having medium and four genotypes had short height and it was interesting to note that four out of five brown midrib genotypes were short and remaining one was medium.

Table 5: Classification of sorghum genotypes on the basis of height of plant up to the base of flag leaf

Short (76-150cm) (4)	BMR-1, BMR-3, BMR-4, BMR-5
Medium (151-255cm) (8)	BMR-2, HC 260, DUGGI, ICSV 700, S 651, PC 5, PC 7, PC 8
Tall (226-300 cm) (13)	IS 2389, S 490, COFS 29, HJ 513, IS 2205, S 437, G 46, SSG 59-3, HC 136, HC 171, HJ 541, HC 308, CSV 21F

6. Flag leaf yellow colouration of midrib

On the basis of flag leaf yellow colouration of midrib genotypes were classified into two categories. Fifteen genotypes were with white mid rib and remaining genotypes were with yellow green midrib colour. In brown midrib genotypes, yellow colouration was absent. The classification of genotypes has been presented in Table 6.

Table 6: Classification of Sorghum genotypes on the basis of flag leaf yellow colouration of midrib

Absent (15)	BMR-1, BMR-2, BMR-3, BMR-4, BMR-5, COFS 29, HJ 513, HC 260, IS 2205, G 46, SSG 59-3, PC 5, PC 7, PC 8, ICSV 700
Present (10)	IS 2389, HC 136, HC 171, HJ 541, DUGGI, CSV 21F, S 490, S 437, S 651, HC 308

7. Lemma Arista Formation

Twenty five genotypes were classified on the basis of lemma arista formation were grouped into two categories. Nineteen had presence of lemma arista and in remaining had absent lemma arista was absent. In all five brown midrib lines lemma arista was absent. The classification of genotypes has been presented in Table: 7.

Table 7: Classification of Sorghum genotypes on the basis of lemma arista formation

Present(19)	BMR-1, BMR-3, BMR-5, COFS 29, S 490, S 437, S 651, G 46, SSG 59-3, HC 136, HC 171, HJ 541, PC 7, IS 2205, IS 2389, CSV 21F, ICSV 700, HC 308, HJ 513
Absent (6)	BMR-2, BMR-4, HC 260, DUGGI, PC 5, PC 8

8. Stigma Anthocyanin Colouration

On the basis of stigma anthocyanin colouration genotypes were classified into two categories. Ten genotypes were without stigma anthocyanin colouration and remaining fifteen genotypes had stigma anthocyanin colouration. The classification of genotypes has been presented in Table 8.

Table 8: Classification of Sorghum genotypes on the basis of stigma anthocyanin colouration

Absent (10)	BMR-2, BMR-4, IS 2205, DUGGI, G 46, HC 136, HC 171, PC 5, PC 8, ICSV 700
Present(15)	BMR-1, BMR-3, BMR-5, COFS 29, HJ 513, HC 260, IS 2389, CSV 21F, S 490, S 437, S 651, SSG 59-3, HJ 541, PC 7, HC 308

9. Stigma Yellow Colouration

Classification of genotypes on the basis of stigma yellow colouration had been presented in Table 9. Fourteen genotypes were without yellow colouration and remaining eleven genotypes were having yellow colouration in their stigma.

Table 9: Classification of Sorghum genotypes on the basis of stigma yellow colouration

Absent (14)	BMR-2, BMR-3, BMR-5, HJ 513, HC 260, IS 2205, S 437, S 651, G 46, HC 136, HC 171, HJ 541, PC 5, ICSV 700
Present (11)	BMR-1, BMR-4, COFS 29, IS 2389, DUGGI, CSV 21F, S 490, SSG 59-3, PC 7, PC 8, HC 308

10. Stigma Length

On the basis of stigma length genotypes were grouped into two groups. Fourteen genotypes were having > 2mm stigma length and remaining eleven had 1-2 mm stigma length. All brown midrib genotypes had medium stigma length *i.e.* (1-2 mm). The classification of genotypes was represented in Table 10.

Table 10: Classification of Sorghum genotypes on the basis of stigma length

Medium (1-2 mm) (11)	BMR-1, BMR-2, BMR-3, BMR-4, BMR-5, HC 260, DUGGI, CSV 21F, S 651, PC 8 ICSV 700
Long (>2 mm) (14)	COFS 29, HJ 513, IS 2205, IS 2389, S 490, S 437, G 46, SSG 59-3, HC 136, HC 171, HJ 541, PC 5, PC 7, HC 308

11. Flower with Pedicel Length of Flower

On the basis of flower with pedicel length of flower genotypes were grouped into three groups. Six genotypes were medium, 10 genotypes were with long pedicel and remaining nine genotypes were with very long pedicel length. Brown midrib genotypes had either medium or long pedicel length. The classification of genotypes has been presented in Table 11.

Table 11: Classification of Sorghum genotypes on the basis of flower with pedicel length of flower

Medium (6)	BMR-2, BMR-3, HJ 513, HC 260, DUGGI, S 651
Long (10)	BMR-1, BMR-4, BMR-5, S 490, S 437, HC 136, HC 171, HJ 541, PC 7, HC 308
Very long (9)	COFS 29, IS 2205, IS 2389, PC 8, CSV 21F, G 46, SSG 59-3, PC 5, ICSV 700

12. Anther Length

On the basis of anther length genotypes were classified into two categories. Four Genotypes had medium anther length and remaining twenty one genotypes had short anther length. Four brown midrib genotypes *i.e.* BMR-1, BMR-2, BMR-3 and BMR-5 has short anther length whereas fifth genotytpe *i.e.* BMR-4 had medium anther length. The classification of genotypes on the basis of anther length has been presented in Table 12

Table 12: Classification of Sorghum genotypes on the basis of anther length

Short (<3 mm) (21)	HC 260, DUGGI, S 437, HC 136, HC 171, PC 5, PC 7, BMR-2, BMR-3, BMR-5, ICSV 700, HC 308, S 490, IS 2389, COFS 29, HJ 513, SSG 59-3, HJ 541, BMR-1, S 651, PC 8
Medium (3-4 mm) (4)	BMR-4, IS 2205, CSV 21F, G 46

13. Anther Colour of Dry Anther

On the basis of anther colour of dry anther genotypes were categerized into four groups. Twelve genotypes were yellow orange, four genotypes were orange, five genotypes were orange red and remaining four genotypes were with grayed orange anther colour. All brown midrib genotypes had orange red anther color of dry anther except BMR-4 which had yellow orange color of dry anthers. The classification of genotypes was represented in Table 13.

Table 13: Classification of Sorghum genotypes on the basis of anther colour of dry anther

Yellow orange (12)	BMR-4, HC 260, IS 2205, DUGGI, S 437, G 46, HC 136, HC 171, PC 5, PC 7, HJ 541, PC 8
Orange (4)	ICSV 700, HC 308, S 490, IS 2389
Orange red (5)	BMR-2, BMR-3, BMR-5, BMR-1, S 651
Grayed orange (4)	COFS 29, HJ 513, CSV 21F, SSG 59-3

14. Panicle Length of Branches

Classification of genotypes on the basis of panicle length of branches had been presented in Table 14. Genotypes were classified into four categories; genotypes BMR-2, BMR-3 and HC 136 had short (< 5.1 cm); fourteen genotypes had medium (5.1-10 cm); five genotypes had long (10.1-15cm) and genotypes COFS 29, ICSV 700 and SSG 59-3 had very long panicle length of branches.

Table 14: Classification of Sorghum genotypes on the basis of panicle length of branches

Short (<5.1 cm) (3)	HC 136, BMR-2, BMR-3
Medium(5.1-10cm) (14)	S 437, HC 308, HJ 513, IS 2205, S 490, HJ 541, HC 171, BMR-1, BMR-4, BMR-5 ,CSV 21F, PC 5, PC 7, PC 8
Long (10.1-15 cm) (5)	G 46, IS 2389, HC 260, DUGGI, S 651
Very long (> 15 cm) (3)	COFS 29, SSG 59-3, ICSV 700

15. Panicle Density at Maturity

On the basis of panicle density genotypes were classified into five categories. Two genotypes had very loose; four genotypes had loose; eight genotypes had semi loose; nine genotypes had semi compact and genotypes HC 136 and BMR-2 had compact in their panicle density. The classifications of genotypes have been presented in Table 15.

Table 15: Classification of genotypes on the basis of panicle density at maturity

Very loose (2)	SSG 59-3, COFS 29
Loose (4)	DUGGI, IS 2389, CSV 21F, G 46,
Semi loose (8)	BMR-3, HJ 513, IS 2205, S 490, S 437, S 651, HJ 541, HC 171
Semi compact (9)	PC 7, ICSV 700, HC 260, BMR-1, BMR-5, PC 5, PC 8, HC 308, BMR-4
Compact (2)	BMR-2, HC 136

16. Panicle Shape

Genotypes classified on the basis of panicle shape have been presented in Table 16. Nine genotypes had symmetrical panicle; seven had panicle broader in lower part and seven genotypes had pyramidal in their panicle shape and BMR-5 and S 651 had panicle broader in upper part.

Table 16: Classification of sorghum genotypes on the basis of panicle shape

Symmetrical (9)	BMR-1, BMR-2, BMR-3, S 490, HJ 541, PC 5, PC 8, HC 308, CSV 21F
Panicle broader in upper part (2)	BMR-5, S 651
Panicle broader in lower part (7)	BMR-4, HJ 513, HC 260, IS 2205, S 437, HC 136, PC 7
Pyramidal (7)	COFS 29, IS 2389, DUGGI, G 46, SSG 59-3, HC 171, ICSV 700

17. Neck of Panicle Visible above Sheath

On the basis of neck of panicle visible above sheath genotypes were classified into four categories. Seven genotypes had very short (<5.1 cm); eight genotypes had short (5.1- 10 cm); five genotypes had medium (10.1-15 cm) and five genotypes had long (15.1-20 cm) neck of panicle visible above sheath. The classification of genotypes has been presented in Table 17.

Table 17: Classification of genotypes on the basis of neck of panicle visible above sheath

Absent or very short (<5.1 cm) (7)	BMR-1, DUGGI, S 490, S 437, HJ 541, PC 8, HC 308
Short (5.1-10 cm) (8)	BMR-2, HC 136, PC 5, BMR-4, BMR-5, IS 2205, CSV 21F, PC 7
Medium (10.1-15 cm) (5)	BMR-3, HC 171, HJ 513, S 651, G 46
Long (15.1-20 cm) (5)	SSG 59-3, HC 260, IS 2389, COFS 29, ICSV 700

18. Glume Length

Genotypes classified on the basis of glume length have been presented in Table 18. Two genotypes had very short; seven genotypes had short; ten genotypes had medium; three genotypes had long and three genotypes had very long glume**.**

Table 18: Classification of Sorghum genotypes on the basis of glume length

Very short (25% of grain covered) (2)	BMR-1, BMR-4
Short (50% of grain covered) (7)	BMR-2, HJ 513, S 490, HC 136, G 46, HJ 541, PC 5
Medium (75% of grain covered) (10)	BMR-3, BMR-5, HC 260, IS 2389, IS 2205, HC 308, PC 8 HC171, S 437,CSV 21F
Long (100% of grain covered) (3)	PC 7, SSG 59-3, S 651
Very long (longer than the grain) (3)	COFS 29, DUGGI, ICSV 700

19. Caryopsis Colour

On the basis of caryopsis colour genotypes were classified into four categories. Two genotypes had white; fifteen genotypes had yellow white; two genotypes had yellow orange and remaining six genotypes had grayed orange caryopsis color. The classification of genotypes has been presented in Table 19.

Table 19: Classification of genotypes on the basis of caryopsis colour

White (2)	IS 2205, S 490
Yellow white (15)	BMR-1, BMR-3, BMR-4, PC 5, PC 7, PC 8, HC 308, S 651, HC 136, HC 171, BMR-5, HJ 513, HC 260, S 437, HJ 541
Yellow orange (2)	BMR-2, CSV 21F
Grayed orange (6)	COFS 29, DUGGI, IS 2389, G 46, SSG 59-3, ICSV 700

20. Grain Shape in Dorsal view

On the basis of grain shape in dorsal view classification of genotypes has been presented in Table 20. Genotypes were divided into three categories; thirteen genotypes were circular; seven genotypes were elliptic and remaining five genotypes were narrow elliptic in their grain shape in case of dorsal view. All brown midrib genotypes had circular grain shape except BMR-5 which has narrow elliptic shape.

Table 20: Classification of Sorghum genotypes on the basis of Grain shape in dorsal view

Circular (13)	BMR-1, BMR-2, BMR-3, BMR-4, IS 2205, S 490, HC 260, PC 7, PC 8, HC 136, PC 5, ICSV 700, CSV 21F
Elliptic (7)	IS 2389, S 437, HC 308, HJ 513, S 651, HC 171, HJ 541
Narrow elliptic (5)	COFS 29, DUGGI, G 46, SSG 59-3, BMR-5

Threshability

On the basis of threshability genotypes were classified into three categories. Six genotypes were freely threshable; fourteen genotypes were partly threshable and remaining five genotypes were difficult to thresh. The classification of genotypes has been presented in Table 21

Table 21: Classification of Sorghum genotypes on the basis of threshability

Freely threshable (<11% unthreshed grain) (6)	BMR-4, BMR-5, BMR-2, HJ 513, DUGGI, PC 5
Partly threshable (11-50% unthreshed grain) (14)	BMR-1, BMR-3, HC 260, HC 136, HC 171, HJ 541, IS 2389, PC 7, PC 8, IS 2205, CSV 21F, S 490, G 46, ICSV 700
Difficult to thresh (> 50% unthreshed grain) (5)	COFS 29, S 437, S 651, SSG 59-3, HC 308

22. Grain shape in profile view

On the basis of grain shape in profile view classification of genotypes has been presented in Table 22. Seven genotypes were circular; fourteen genotypes were elliptic; remaining four genotypes were narrow elliptic in their grain shape.

Table 22: Classification of Sorghum genotypes on the basis of grain shape in profile view

Circular (7)	BMR-3, HJ 513, IS 2205, S 490, HC 136, PC 5, ICSV 700
Elliptic (14)	BMR-1, BMR-2, BMR-4, BMR-5, HC 260, IS 2389, CSV 21F, S 437, S 651, HC 171, HJ 541, PC 7, PC 8, HC 308
Narrow elliptic (4)	COFS 29, DUGGI, G 46, SSG 59-3

23. Grain size of mark germ

Genotypes classified in three categories on the basis of grain size of mark of germ have been presented in Table 23. Ten genotypes had medium; eleven genotypes had large and four genotypes had small grain size of mark germ.

Table 23: Classification of Sorghum genotypes on the basis of grain size of mark germ

Small (4)	HC 260, DUGGI, S 651, PC 8
Medium (10)	BMR-2, BMR-4, BMR-5, CSV 21F, S 490, S 437, HJ 541, PC 5, PC 7, HC 308
Large (11)	BMR-1, BMR-3, COFS 29, HJ 513, IS 2205, IS 2389, G 46, SSG 59-3, HC 136, HC 171, ICSV 700

24. Grain texture of endosperm

On the basis of grain texture of endosperm genotypes were classified into four categories. Genotype COFS 29 had 100% vitreous endosperm; two genotypes had ¾ vitreous; fifteen genotypes had ½ vitreous and seven genotypes had ¾ farinaceous texture of endosperm. The classification of genotypes has been presented in Table 24.

Table 24: Classification of Sorghum genotypes on the basis of grain texture of endosperm**.**

Vitreous (1)	COFS 29
¾ Vitreous (2)	BMR-3, IS 2205
½ Vitreous (15)	BMR-2, BMR-4, BMR-5, HJ 513, HC 260, IS 2389, CSV 21F, S 490, S 437, S 651, SSG 59-3, PC 5, PC 7, PC 8, ICSV 700
¾ Farinacus (7)	BMR-1, DUGGI, G 46, HC 136, HC 171, HJ 541, HC 308

25. Grain colour of Vitreous albumen

On the basis of grain colour of vitreous albumen genotypes were classified into three categories. Sixteen genotypes had greyed yellow; seven genotypes had greyed orange; and remaining two genotypes had greyed purple colour of vitreous albumen. The classification of genotypes has been presented in Table 25.

Table 25: Classification of Sorghum genotypes on the basis of grain colour of vitreous albumen**.**

Grayed Yellow (16)	BMR-1, BMR-3, BMR-4, BMR-5, HJ 513, HC 308, S 490, PC 5, PC 7, HC 136, HC 171, HJ 541, HC 260, IS 2205, DUGGI, CSV 21F
Grayed Orange (7)	BMR-2, S 437, S 651, G 46, SSG 59-3, PC 8, ICSV 700
Grayed Purple (2)	COFS 29, IS 2389

Grain luster

On the basis of grain luster genotypes were categories into two groups. Eleven genotypes were having lusterous grain and remaining fourteen genotypes were having non lusterous grain. The classifications of genotypes has been presented in Table 26**.**

Table 26: Classification of sorghum genotypes on the basis of grain luster

Lusterous (11)	BMR-4, BMR-5, HJ 513, HC 260, IS 2205, S 490, S 437, HC 171, HJ 541, PC 5, HC 308
Non Lusterous (14)	BMR-1, BMR-2, BMR-3, COFS 29, IS 2389, DUGGI, ICSV 700, PC 8, CSV 21F, S 651, G 46, SSG 59-3, HC 136, PC 7

Conclusion

Being dual purpose crop, sorghum is grown as a grain crop for human consumption and feed and fodder for livestock in different parts of the world. Hence, this crop has special significance after wheat, rice and maize among world's cereals. Likewise, in Northern parts of India, sorghum is grown mainly for fodder production, whereas in the central and southern parts of the country this crop is the major source of staple food. Genetic improvement is largely dependent upon the variability present in the crop. Therefore, the present investigation was undertaken in forage sorghum with the objective to assess genetic diversity in sorghum accessions on the basis of fodder yield and quality.

Out of 25 genotypes, nine genotypes were grouped under yellow green and remaining sixteen genotypes were under greyed purple. On the basis of leaf sheath anthocyanin colouration genotypes were classified into two categories. Eleven genotypes were yellow green and remaining fourteen genotypes were grayed purple in colour. Eight genotypes were white, eleven genotypes were having yellow green, two were grey yellow and four were grey purple in their leaf midrib colour. Brown midrib genotypes were either grey purple or grey yellow.

Flag leaf yellow colouration of midrib genotypes were classified into two categories. Fifteen genotypes were with white mid rib and remaining genotypes were with yellow green midrib colour. In brown midrib genotypes, yellow colouration was absent. Nineteen had presence of lemma arista and in remaining had absent lemma arista was absent. In all five brown midrib lines lemma arista was absent. Ten genotypes were without stigma anthocyanin colouration and remaining fifteen genotypes had stigma anthocyanin colouration. Fourteen genotypes were without yellow colouration and remaining eleven genotypes were having yellow colouration in their stigma.

Twelve genotypes were yellow orange, four genotypes were orange, five genotypes were orange red and remaining four genotypes were with greyed orange anther colour. All brown midrib genotypes had orange red anther colour of dry anther except BMR-4 which had yellow orange colour of dry anthers.

Two genotypes had white; fifteen genotypes had yellow white; two genotypes had yellow orange and remaining six genotypes had greyed orange caryopsis colour. Eleven genotypes were having lustrous grain and remaining fourteen genotypes were having non lustrous grain.

On the basis of total plant height, stem girth, number of tillers, number of leaves, green fodder yield and dry fodder yield genotypes were classified and genotype CSV 21F, HJ 260, IS 2205, S 490, S 651, SSG 59-3 showed maximum plant height ,number of leaves, number of tillers, stem girth, green fodder yield and dry fodder yield , respectively

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