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DUS DISCRIPTOR OF SEVENTEEN FORAGE CULTIVARS OF SORGHUM [*Sorghum bicolour* (L.) Moench]

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ABSTRACT
In India, the Government enacted the legislation on Protection of Plant Varieties and Farmers Rights (PVP and FR) Act in 2001. The act provides protection of new varieties including extant-notified and farmer's varieties. Novelty, Distinctness, Uniformity and Stability are the essential requirements for grant of protection to all the new varieties. Under the PVP and FR Act 2001 of India, it requires registration of varieties based on three principles know as DUS (Distinctness, Uniformity and Stability) criteria. The DUS testing principles are used for the protection of variety and award of Plant Breeder's Rights (PBR), a system of intellectual property protection which is available to breeders of all types of crops. On practical level, DUS assessment of agricultural crops generally involves growing field crops under appropriate ambient conditions, and recording various morphological characteristics of the seed and/or growing plants. Laboratory and green house tests can also be involved (Mauria, 2000) and the new (candidate) varieties are compared with existing varieties that are kept as reference collection. The experimental material consisted of seventeen forage sorghum cultivars. Morphogenetic characterization of varieties based on characteristics of seedling, plant and matured seed were conducted for deriving comparative description of sorghum varieties, as per National Test Guidelines for DUS testing. Morphogenetic characterization based on DUS testing ,to distinguish between seventeen varieties of forage sorghum, twenty six essential morphogenetic characteristics, of seedling, plant (vegetative stage and at maturity) and matured seeds, as per the National Guideline for DUS test of Sorghum, were considered. 3Character wise elaboration of results for distinguishing forage sorghum varieties are done. It was possible to distinguish all the seventeen varieties included in the present study on the basis of grouping characteristics based on physiology of plant its morphology and seed color.

KEYWORDS: *Sorghum bicolour*, PVP & FR, Distinctness, Uniformity and Stability.

INTRODUCTION

Sorghum [*Sorghum bicolour* (L.) Moench) is one of the major crop of the world. It is known under variety of names such as, great millet and guinea corn in West Africa, Kafir corn in South Africa dura in Sudan, mtama in Eastern Africa and jowar in India. It is originated in Africa. The largest diversity of cultivated and wild sorghum is in Africa (Doggett, 1988; De Wet and Harlan, 1971; De Wet, 1977). According to Vavilov, Indian subcontinent is considered to be secondary centre of origin of sorghum (Dorofeev, 1992). It is cultivated on an area of 45.6 mha in the world. India alone accounts for 9.6 mha. Sorghum can be grown in a wild range of ecological conditions and yield well under unfavourable conditions of drought stress and high temperatures. It is mainly grown for food and fodder purpose. It is preferred over other non-leguminous fodder due to its high yielding capacity, better quality and palatability and its utilization in various forms *i.e.*, green fodder, stover, silage and hey. Besides food and fodder it is also used for preparation of alcoholic beverages, fibres, sugar and syrup. In India, the Government in enacted the legislation on Protection of Plant Varieties and Farmers Rights (PVP and FR) Act in 2001. The act provides protection of new varieties including extant-notified and farmer's varieties. Novelty, Distinctness, Uniformity and Stability are the essential requirements for grant of protection to all the new varieties. The grant of Plant Breeder's Rights (PBR) under this Act entitle the breeder/his successor, agent, licensee to exclude others from producing, offering for sale, marketing, distributing, export or import of propagating material of the protected varieties for a period of 15 years for annuals and 18 years for vines and trees. The act provide all researchers the rights to use a protected variety as an initial source for creating another variety without prior approval of holder of Plant Breeders Rights, provided that such use does not involve repeated use of the protected variety as a parental line or multiplication of lilts propagating material for commercial nature. Plant Breeder's Right will help in stimulating research and developing new varieties of plants facilitating growth of seed industry to ensure high quality seeds to farmers for accelerating agricultural growth. The Act also entitles the farmers to save, use, sow, resow, exchange, share or sell farm produce including seed of a protected variety. However, this right does not cover the sale of branded seeds of a protected variety. In India, The intensive crop improvement programmes have resulted in the development of a large number of varieties in all crop species. Under the PVP and FR Act 2001 of India, it requires registration of varieties based on three principles know as DUS (Distinctness, Uniformity and Stability)

criteria. The DUS testing principles are used for the protection of variety and award of Plant Breeder's Rights (PBR), a system of intellectual property protection which is available to breeders of all types of crops. On practical level, DUS assessment of agricultural crops generally involves growing field crops under appropriate ambient conditions, and recording various morphological characteristics of the seed and/or growing plants. Laboratory and green house tests can also be involved (Mauria, 2000) and the new (candidate) varieties are compared with existing varieties that are kept as reference collection. During the past 30 years, various techniques have been used for analysis of genetic variability at the molecular level in plants. As per DUS Guidelines, seed protein profiles (Ladizinsky and Hymowitz, 1979) are still powerful tools for determining genetic homology at the molecular level and for solving problems of varietal differentiation in systematic manner. According to Cook *et al.* (1983), electrophoresis is the choosiest method to resolve protein polymorphism. Polyacrylamide gel electrophoresis (PAGE) was introduced by Raymond and Weintraub (1959). A simple vertical slab gel electrophoresis was constructed by Beileski and Reid (1968). This technique commonly used in developing genetic fingerprint of crop varieties, inbred lines and hybrids through specific 'Banding pattern' is based on the principle that any charged particle migrates towards the electrode the opposite sign under externally applied electric field. The rate of migration is affected by large number of factors such as strength of field, net charge, size and shape of molecules, ionic strength, viscosity, pH of buffer system, of buffer system land its concentration, concentration of acrylamide and bisacrylamide, running duration and temperature (Dadlani and Varier, 1993). Keeping in view the importance of sorghum as one of the potential forage crops to be covered under Plant Variety Protection and Farmer's Right Act 2001 and usefulness of information on various genetic parameters for the improvement of breeding programme, seventeen forage sorghum cultivars were used for the present study which was undertaken with objective to provide a detailed description of extant-notified and promising forage sorghum varieties, on a comparative basis following morphogenetic characteristics, for development of database for DUS test in forage sorghum.

MATERIALS & METHODS

The experimental material consisted of seventeen forage sorghum cultivars *viz.*, UP Chari 2, Pant Chari 3, Pant Chari 4, Pant Chari 5, Pant Chari 6, CSH 20MF, HC171, HC 260, HC 308, HC 136, GFS 4, GFS 5, SSG 59, Pusa Chari 23, UPFS 38, S437-1 and CSV 15. The details of experimental material are given in Table 1. Morphogenetic characterization of varieties based on characteristics of seedling, plant and matured seed and biochemical characterization through electrophoresis (SDS-PAGE), based on total storage seed proteins, were conducted for deriving comparative description of sorghum varieties, as per National Test Guidelines for DUS testing. Besides, study of genetic parameters *viz.*, variability, heritability, character correlation and genetic divergence was also conducted considering characters of economic importance.

TABLE 1- Details of varieties under DUS testing

Sl.No.	Name of varieties	Specification
1.	S437-1	Non released forage sorghum single cut variety from Hisar.
2.	UPFS 38	Non released forage sorghum single cut variety from Pantnagar
3.	CSH 20MF	Released forage sorghum multicut cut hybrid from Pantnagar
4.	CSV 15	Released and notified dual purpose sorghum variety from NRCS.
5.	Pant Chari 6	Released multicut variety from Pantnagar
6.	HC 136	Research and notified forage sorghum single cut variety from Hisar
7.	HC 171	Released and notified forage sorghum single cut variety from Hisar
8.	HC 260	Released and notified forage sorghum multicut variety from Hisar
9.	HC 308	Released and notified forage sorghum single cut from Hisar
10.	SSG 59-3	Released and notified forage sorghum multicut variety from Hisar
11.	Pusa Chari 23	Released and notified forage sorghum multicut variety from IARI
12.	UP Chari 2	Released and notified forage sorghum single cut variety from Pantnagar
13.	Pant Chari 3	Released and notified forage sorghum single cut variety from Pantnagar
14.	Pant Chari 4	Released and notified forage sorghum single cut variety from Pantnagar
15.	Pant Chari 5	Released and notified forage sorghum single cut variety from Pantnagar
16.	GFS 4	Released and notified forage sorghum variety from Surat (Gujarat)
17.	GFS 5	Released and notified forage sorghum variety from Surat (Gujarat)

The experimental material was planted in a Randomized Block Design with three replications during Kharif. Each variety was sown in a plot area of 21.6 square meters (6 rows of 6 meter length spaced 60 centimeters apart). Recommended cultural practices were adopted to raise a healthy crop. Observational procedure for characterization of varieties was done on two basis *i.e.*, morphogenetic characterization and biochemical characterization. Qualitative characteristics observations on fourteen qualitative characteristics were recorded on the basis of visual assessment of either single plant or group of plants. For qualitative characteristics difference between two varieties was considered to be clear and distinct if the expression of one or more characteristic fall in two different states given in the Test Guidelines. For qualitative characters, no statistical methods are needed for interpretation of data. Details of qualitative characteristics along with states of expression and scores for each state are given in Table 2.

TABLE-2: Qualitative characteristics for DUS testing

Sl.No.	Characteristics	States	Score	Stage of observation	Type of assessment
1.	Seedling Anthocyanin colouration	Green purple	1 2	Seedling	VS
2.	Leaf sheath Anthocyanin colouration	Tan Red Purple	1 2 3	5 leaf stage	VS
3.	Leaf: mid rib colour (5th fully developed leaf)	White Dull green Yellow Brown Purple	1 2 3 4 5	Panicle emergence	VS
4.	Flag leaf: intensity of green colouration of mid rib	Paler Same colour Darker	1 2 3	Panicle emergence	VS
5.	Flag leaf: extension of discolouration of midrib	Absent or very Weak Weak Medium Strong Very strong	1 3 5 7 9	Panicle emergence	VG
6.	Flag leaf: yellow colouration of midrib	Absent or weak Medium Strong	1 5 9	Panicle emergence	VS
7.	Lemma: arista formation	Absent or weak Medium Strong	1 5 7	Flowering	VG
8.	Stigma: anthocyanin colouration	Absent or weak Medium Strong	1 5 9	Flowering	VS
9.	Stigma: yellow colouration	Absent or weak Medium Strong	1 5 7	Flowering	VS
10.	Glume colour	Green Straw Brown Light red Red Yellow Purple Black	1 2 3 4 5 6 7 8	Physiological maturity of grain	VG
11.	Stalk juiciness	Juicy Dry	1 2	Physiological maturity	VS
12.	Panicle density at maturity (ear head compactness)	Very loose Loose Semi loose Semi compact Compact	1 3 5 7 9	Maturity	VG
13.	Panicle shape	Reverse pyramid Panicle broader In upper part Symmetric Panicle broader In lower part Pyramidal	1 2 3 4 5	Maturity	VG
14	Caryopsis colour	White Chalky white Pearly white Yellow Red Light brown Dark brown	1 2 3 4 5 6 7	After threshing	VG

VS= Visual assessment by observation of individual (Single) plant or plant parts
VG= Visual assessment by a single observation on group of plants or plant parts

Observations on quantitative characteristics were recorded on ten randomly selected plants from each variety in each replication. The data were recorded on following streak marked measured morphogenetic characters for variety characterization along with other agronomic characteristics including yield and nutritional quality,

namely, stem diameter (cm), days to 50% flowering (time of panicle emergence), days to maturity, plant height (cm), number of nodes, number of intact leaves, leaf length (cm), leaf width (cm), leaf area (cm2), panicle length(cm), Neck of panicle visible length above sheath: Panicle exertion (cm), panicle breadth (cm), anther length (cm), stigma length(cm), panicle weight (g), 1000-grain weight* (g), threshing percentage (thresh ability).

EXPERIMENTAL RESULTS

A critical and complete analysis of experimental data recorded on seventeen varieties for different characters are revealed the results which are presented in Table 3. Morphogenetic characterization based on DUS testing , to distinguish between seventeen varieties of forage sorghum, twenty six essential morphogenetic characteristics, of seedling, plant (vegetative stage and at maturity) and matured seeds, as per the National Guideline for DUS test of Sorghum, were considered. The characterization of varieties under different states of expression of characters is presented in Table 3Character wise elaboration of results for distinguishing forage sorghum varieties are presented here under.

The seedling anthocyanin colouration of coleoptile indicated that varieties were classified into two states namely green and purple. Out of seventeen varieties, twelve varieties had green colour of coleoptile and rest five showed purple colour. The leaf sheath anthocyanin colouration revealed that twelve varieties had tan colour leaf sheath and five varieties showed purple colour leaf sheath. Four varieties showed white midrib colour. Majority of varieties had dull green colour of midrib. One variety Pant Chari 5 had brown colouration of midrib. One variety showed very early (<56 days) panicle emergence, two varieties had early (56-65 days) panicle emergence. Medium (65-75 days) duration for panicle emergence was observed in three varieties. Most of the varieties showed late duration (76-85 days) for panicle emergence.

Majority of varieties had very weak or weak discolouration of midrib. Six varieties had very weak, while seven varieties had weak extension of discolouration of midrib of flag leaf. Medium discolouration of midrib was shown by four varieties .The intensity of green colouration of midrib as compared to blade was paler for most of the varieties. Nine varieties had pale colouration of midrib. However, eight varieties had same colour of midrib as that of blade. Six varieties showed absent or weak yellow colouration of midrib of flag leaf. The remaining eleven varieties showed medium yellow colouration of midrib. The study of lemma arista formation (awn) revealed that eight Varieties are classified under absent or weak lemma arista formation category. Medium arista formation was shown by four varieties. Five varieties showed strong lemma arista formation or development of awns. Stigma anthocyanion colouration was absent or weak in all the seventeen varieties. None of the varieties were found to have medium or strong stigma anthocyanin colouration. The study of stigma yellow colouration revealed that most of the varieties had medium yellow colouration of stigma. Nine varieties had medium yellow colouration of stigma, while seven varieties showed absent or weak yellow colouration of stigma. One variety during fall in the category of strong yellow colouration of stigma. The study of stigma length showed that three varieties had short stigmas. Medium stigma length was shown by majority of varieties. Only one variety had shown long length of stigma. Estimates of anther length revealed that only one variety had short anther. Rest all the sixteen varieties had medium length of anther. None of the variety showed green glume colour. The six varieties showed straw coloured glumes. Five varieties showed brown colour of glume light red and red glume colour was shown by one variety. Yellow and purple glume colour was shown by one variety. The black colour was exhibited by two varieties

Plant height was divided into five classes of which none of the varieties fell into very short and short height classes. The three varieties during were recorded as medium height varieties. The four varieties were of long height. Rest of the varieties had very long height. The study of stem diameter revealed ten varieties have very small (thin) stem diameter. Remaining seven varieties had medium thick stem diameter. None of the varieties was found to have large (thick) stem diameter. Analyses of stalk juiciness showed that majority of the sorghum varieties under study were juicy. Only four varieties were observed as corky varieties. The sweetness of stalk studied revealed that all the seventeen varieties fell under the category of sweet variety. Most of the varieties had long length of leaf blade. Seven varieties were found to have very long length of leaf blade. The study of width of leaf blade revealed that only one variety had narrow leaf blade and six varieties had medium width of leaf blade. Seven varieties had broad leaf blades. Rest of the varieties fell in the classes of very broad leaf blade. The measured estimates of panicle length revealed that none of the varieties had very short panicle length while short panicle length was recorded in three varieties. Ten varieties had medium panicle length. Long panicle length was recorded in four varieties. None of the varieties were recorded to have very long panicle length .The study of panicle density at maturity showed that semi loose panicle density was observed in two varieties. Nine varieties had semi compact panicle density while compact panicles were observed in six varieties .One variety had panicles which were broader in upper parts. Symmetrical panicles were observed in ten varieties. Neck of panicle length visible above sheath, was absent or very short in five varieties. It was short in four varieties and medium length of panicle neck was recorded in two varieties. Long neck of panicle was observed in four varieties. Two varieties were recorded to have very long neck of panicle visible above sheath. Study of thresh ability showed that none of the varieties had freely threshable grains. Two varieties had partly threshable grains. Fifteen varieties were found to be difficult to thresh varieties. The forage sorghum varieties taken for the study had a wide range of caryopsis colour recorded after threshing. Two varieties showed white caryopsis colour. Chalky white caryopsis colour was observed in six varieties and two varieties showed pearly white caryopsis colour. Yellow colour of caryopsis was observed in only one variety.

TABLE-3: Morphological characterization of forage sorghum varieties for UDS Test (*Kharif*, 2004)

S. No.	Characteristics	States	Notes	Varieties
1.	Seedling: anthocyanin coloration of coleoptiles	Green	1	CSV 15, UP Chari 2, HC 260, GFS 5, Pant Chari 6, CSH 20 MF, Pant Char, 5, Pant Chari 3HC 171, HC 308, UPSF 38, S 537-1
		Purple	2	SSG 59-3, Pant Chari 4, GFS 4, HC 136, Pusa Chari 23
2.	Leaf sheath: anthocyanin coloration	Tan	1	CSV 15, Pant Chari 5, UP Chari 2, Pant Chari 3, HC 171, HC 308, CSH 20 MF, Pant Chari 6 UPSF 38, HC 260, S 437-1 GFs 5
		Red	2	-
		Purple	3	Pant Chari 4, GFS 4, SHG 59-3, Pant Chari 23, HC 136
3.	Leaf: mid rib colour (5^{th} fully developed leaf)	White	1	UPSF 38, HC 260, SSG 59-3, Pant Chari 23
		Dull green	2	GFS 5, CSW 15, Pant Chari 6, S 437-1, UP Chari 2, HC 171, Pant Chari 3, CSH 20 MF, HC 136, HC 308, Pant Chari 4
		Yellow	3	GFS 4
		Brown	4	Pant Chari 5
		Purple	5	-
4.	Plant: time of panicle emergence (50% of the plants with complete panicle emergence)	Very early (<56 days)	1	Pant Chari 23
		Early (56-65 days)	3	GFS 4, SSG 59-3
		Medium (66-75 days)	5	CSH 20 MF, CSV 15, HC 260, GFS 5
		Late (76-85 days)	7	HC 308, UP Chari 2, Pant Chari 4, Pant Chari 5, Pant Chari 6, HC 171, S 437-1, UPFS 38,
		Very late (> 85 days)	9	HC 136, Pant Chari 3
5.	Flag leaf: extension of discoloration of midrib	Absent or very weak	1	Pant Chari 5, HC 171, HC 136, HC 308, S 437-1, GFS 5
		Weak	3	Pant Chari 3, Pant Chari 6, HC 260 Pant Chari 4, GFS 4, UPFS 38, Pusa Chari 23
		Medium	5	CSV 15, Pant Chari 2, SSG 59-3, CSH 20 MF
		Strong	7	-
		Very strong	9	-
6.	Flag leaf: intensity of green colorations of midrib compared to blade (if not discolored)	Paler	1	UP Chari 2, Pant Chari 3, HC 171, HC 308, Pant Chari 23, GFS 4, CSH 20 MF, HC 260, SSG 59-3
		Same colour	2	Pant Chari 5, Pant Chari 6, Pant Chari, UPFS 38, S 437-1, CSV 15, HC 136, GFS 5
		Darker	3	-
7.	Flag leaf: yellow coloration of midrib	Absent of weak	1	Pant Chari 3, HC 171, HC 260, HC 136, UP Chari 2, GFS 4
		Medium	5	CSV 15, Pant Chari 5, Pant Chari 6, HC 308, CSH 20 MF, GFS 5, S 437-1, Pant Chari 23, SSG 59-3, UOPFS 38, Pant Chari 4
		Strong	9	-
8.	Lemma: anthocyanin colorations	Absent of weak	1	CSV 15, Pant Chari 3, Pant Chari 4, HC 308, UPFS 38, Pant Chari 23, GFS 4, CSH 20 MF
		Medium	5	UP Chari 2, S 437-1, GFS 5, Pant Chari 5
		Strong	9	Pant Chari 6, HC 260, SSG 59-3, HC 136, HC 171
9.	Stigma: anthocyanin colorations	Absent of weak	1	UP Chari 2, HC 171, Pant Chari 3, Pant Chari 4, Pant Chari 5, pant Chari 6, pusa Chari 23, SSG 59-3, GFS 4, GFS 5, CSV 15, HC 260, SC 308, HC 136, CSH 20 MF, UPFS 38, S 437-1
		Medium	5	-
		Strong	9	-
10.	Stigma: yellow colorations	Absent of weak	1	UP Chari 2, HC 171, Pant Chari 6, GFS 5, HC 308, Pant Chari 3, CSH 20 MF
		Medium	5	UPFS 38, S 437-1, HC 136, Pant Chari 4, GFS 4, CSV 15, Pant Chari 23, HC 260, SSG 59-3
		Strong	7	Pant Chari 5
11.	Stigma: length	Short	3	CSV 15, Pant Chari 5, UP Chari 2, Pant Chari 4, GFS 4, Pant Chari 3, HC 171, HC 260, GFS 5, HC 308
		Medium	5	CSH 20 MF, Pant Chari 6, UPFS 38
		Long	9	Pant Chari 23, HC 136, SSG 59-3, S 437-1
12.	Anther: length	Short	3	UP Chari 2, HC 171, CSH 20 MF, Pant Chari 23, HC 136, SSG 59-3, GFS 5
		Medium	5	CSV 15, Pant Chari 3, Pant Chari 6, HC 308, UPFS 38
		Long	9	Pant Chari 5, HC 260, S 437-1, Pant Chari 4, GFS 4
13.	Glume: colour	Green	1	-
		Straw	2	GFS 5, HC 260, S 437-1, UP Chari 2, CSV 15, Pant Chari 3
		Brown	3	Pant Chari 5, CSH 20 MF, UPFS 38, Pant Chari 6, HC 171
		Light red	4	GFS 4
		Red	5	HC 136
		Yellow	6	HC 308
		Purple	7	SSG 59-3
		Black	8	Pant Chari 23, Pant Chari 4
14.	Plant: total height (cm)	Very short (< 76)	1	-
		Short (76-150 cm)	3	-
		Medium (151-225 cm)	5	GFS 4, Pant Chari 3, CSH 20 MF, Pant Chari 6, CSV 15
		Long (226-300 cm)	7	Pant Chari 5, UP Chari 2, HC 171
		Very long (> 300 cm)	9	HC 260, HC 308, UPFS 38, Pant Chari 23, HC 136, SSG 59-3, Pant Chari 4,

				GFS 5
15.	Stem : diameter (at lower one third height of plant) (cm)	Small (< 2)	3	SSG 59-3, Pusa Chari 23, HC 171, GFS 4, UP Chari 2, HC 308, HC 260, S 437-1, Pant Chari 4, Pant Chari 6
		Medium (2-4 cm)	5	CSV 15, Pant Chari 5, Pant Chari 3, CSH 20 MF, UPFS 38, HC 136, GFS 5
		Large (> 4 cm)	7	-
16.	Stalk: Juiciness	Juicy	1	CSV 15, UP Chari 2, Pant Chari 3, Pant Chari 5, Pant Chari 6, Hc 171, HC 308, CSH 20 MF, S 437-1, HC 136, GFS 5, Pant Chari 4
		Dry	2	UPFS 38, HC 260, GFS 4, Pant Chari 23, SSG 59-3
17.	Stalk: sweetness	Sweet	1	CSV 15, HC 308, CSH 20 MF, Pant Chari 6, HC 136, Pant Chari 4, GFS 5, Pant Chari 5, Pant Chari 3, UP Chari 2, SSG 59-3, Hc 171, Hc 260, Pant Chari 23, GFS 4, S 437-1, UPFS 38
		Insipid	2	-
18.	Leaf: length of blade of the third from top	Short (< 41 cm)	3	-
		Medium (41-60 cm)	5	-
		Long (61-80 cm	7	UP Chari 2, Pant Chari 3, Pant Chari 5, Pant Chari 6, CSH 20 MF, GFS 4, GFS 5, UPFS 38, CSV 15, HC 308
		Very long (> 80 cm)	9	Pant Chari 4, HC 136, HC 171, HC 260, Pant Chari 23, SSG 59-3, GFS 5
19.	Leaf: width of blade of the third from top	Narrow (< 4.1 cm)	3	SSG 59-3
		Medium (4.1-6.0 cm)	5	Pant Chari 3, Pant Chari 4, UPFS 38, S 437-1, Pant Chari 23, GFS 4
		Broad (6.1-8.0 cm)	7	CSV 15, UP Chari 2, HC 171, HC 308, HC 260, Pant Chari 6, GFS 5
		Very broad (> 8.0 cm)	9	Pant Chari 5, HC 136, CSH 20 MF
20.	Panicle: length without peduncle (cm)	Very short (< 11 cm)	1	-
		Short (11-20 cm)	3	HC 136, Pant Chari 4, GFS 4
		Medium (21-30 cm)	5	CSV 15, Pant Chari 5, Pant Chari 6, UP Chari 2, Pant Chari 3, HC 308, UPFS 38, HC 260, s 437-1, Pant Chari 23
		Long (31-40 cm)	7	HC 171, CSH 20 MF, SSG 59-3, GFS 5
		Very long (> 40 cm)	9	-
21.	Panicle : density at maturity(ear head compactness)	Very loose	1	-
		Loose	3	-
		Semi loose	5	Pant Chari 4, GFS 4UP Chari 2, Pant Chari 3, HC 136, HC 260, HC 308, Pant Chari 23, S 437-1, UPFS 38, CSV 15
		Semi compact	7	
		Compact	9	Pant Chari 5, Pant Chari 6, CSH 20MF, HC 171, SSG 59-3, GFS 5
22.	Panicle : shape	Reversed pyramid	1	-
		Broader in upper part	2	HC-260
		Symmetric	3	CVS 15, Pant chari5, Pant chari5 6, HC308, CHS20MF, HC136, GFS5, UPFS38, Pant chari 4, SSG 59-3
		Panicle broader in lower part	4	UP Chari2, S 437-1, GFS-4, Pant Chari 3, HC 171, Pant Chari 23
		Pyramidal	5	-
23.	Neck of Panicle : Visible length above sheath (cm)	Absent or very short (<5.1cm)	1	CVS 15, HC 171, HC 308, Pant chari 6, HC 136
		Short (5.1-10cm)	3	Pant Chari 3, UPFS 38, CHS OMF, GFS 4
		Medium (10.1-15 cm)	5	Pant Chari 5, UP Chari 2
		Long(15.1-20cm)	7	S437-1, Pant Chari 23, Pant Chari 4, GFS 5
		Very long (>20cm)	9	HC 260,SSG 59-3
24	Threshability	Freely threshable (< 11% unthreshed grain)	1	-
		Partly threshable (11-50% unthreshed grain)	5	GFS 4, SSG 59-3
		Difficult to threshed (>50% unthreshed grain)	7	S 437-1, Pant chari 23, UP Chari 2, Pant chari 3, Pant chari 4, Pant chari 5,Pant Chari 6, CHS 20 MF, HC 136, HC 171, HC 260, HC 305, GFS 5,UPFS 38, CVS 15
25	Caryopsis: colour after threshing	White	1	Pant chari , HC 260, GFS 5
		Chaly white	2	UPFS 38, Pant Chari 4, GFS 4
		Pearly white	3	CVS15, S 437-1, Pant Chari 5, HC 171, HC 136, HC 308
		Yellow	4	UP Chari 2
		Red	5	-
		Light Brown	6	CSH 20 MF, SHF 59-3
		Dark brown	7	Pant Chari 6, Pant Chari 23
26	Grain weight of 1000 grains	Very low (<16g)	1	Pant Chari 6, Pusa Chari 23, SSG 59-3
		Low (16-25g)	3	Pant Chari4, HC 171, GFS 4, S 437-1
		Medium (26-35g)	5	Pant Chari 3, Pant Chari 5, CHS20 MF, HC 136, GFS 5, UPFS 38, CVS 15 UP Chari 2, HC 260, HC 308
		High (36-45g)	7	-
		Very high (> 45g)	9	-

DISCUSSION

Globalization and economic liberalization have opened up several new opportunities as well as challenges. While providing the appropriate climate for the seed industry to utilize available and perspective opportunities, safeguarding the interest of plant breeders and Indian farmers, protecting and conserving the agro-biodiversity must also be the central concern of present days. A regulatory system of new type is therefore needed which will encompass quality assurance

mechanisms coupled with facilitation of a vibrant and responsible seed industry. The principal objectives of Plant Varieties Protection and Farmers Right (PVP & FR) Act 2001, is to stimulate both private and public investment in the plant breeding research and enhance the interest of plant breeders as well farmers or farmer's community in the development of outstanding crop varieties, by granting variety protections rights. The "Extant varieties" that is, the varieties released and notified under section 5 of the Seeds Act 1966 may also be granted protection on request besides protection of new varieties if they fulfill the criteria of novelty, distinctness, stability and uniformity. Besides, distinguishing varieties on the basis of morphological characters under DUS test, ascertaining of distinctness of varieties at seed level may also be done on the basis of seed protein profiling through electrophoresis. Constant improvement of the best available genotypes for further enhancement in their yield potential through improvement of various factors is the major cause of concern to the plant breeder. Appropriate breeding methodologies that could successfully incorporate the favourable changes in the target genotypes should be adopted. Knowledge about the extent of genetic variability/diversity present in the breeding material, type of genetic association between various component traits and the heritability of different characters and their pattern of inheritance is essential for formulating a suitable breeding methodology for crop improvement. The present investigation was therefore carried out keeping in view the importance of DUS test for PVP & FR Act and to analyze a set of problems, concerning general research in forage sorghum. Fifteen extant notified varieties of forage sorghum developed at different places of India along with two promising elite lines (a total of 17 genotypes) were subjected to the study. The salient features of results are discussed as bellow:

DUS testing

DUS testing of crop varieties is a pre-requisite to ascertain designated characters of genotypes. This system of testing for distinctness, uniformity and stability generally referred as DUS test is also needed to characterize the released and notified extant varieties to make comparison and to establish clear cut identity of each variety under test for the purpose of registration of material under Plant Variety Protection Legislation. DUS tests are conducted to compare the varieties and the absolute determinations of the characteristics, certain characteristics of the plants that are observed to establish distinctness. For testing of varieties for distinctness based on measured characteristics there is a need to establish a minimum distance between varieties. The pair of varieties showing difference greater than minimum are said to be regarded as distinct in respect of that character. To determine the minimum difference, necessary to establish distinctness, the analysis of variance is used to calculate the Least Significant Difference (LSD) for comparing variety means. If over the years, mean difference between two varieties is greater than LSD, then the varieties are regarded to be distinct in respect of that character. In the present study recording was done for both visually observed qualitative character as well as quantitatively measured characters. One important character observed at seedling stage clearly distinguished Puss Chari 23, Pant Chari 4, He 136 and SSG 59-3 from all other varieties because of purple colouration of coleoptile. Similarly for leaf sheath anthocyanin colouration, the above four varieties along with GFS 4 fell in separate category of purple coloration as compared to tan coloration of rest of the varieties. Midrib colouration of fifth leaf also helped in clearly to distinguishing the varieties in two distinct groups as most of the varieties (except for UPFS 38, HC 260, SSG 59-3, Pusa Chari 23 and GFS 4, which showed white midrib), showed dull green midrib which was also incidentally found to be correlated with juiciness of stalk while the varieties having white midrib also had dry stalk.

The character lemma arista formation, which is the indicator of awn development also produced clear cut distinctness between varieties with majority of them either having absent or weak awns (CSV 15, UPFS 38, Pant Chari 4, CSH 2OMF, Pusa Chari 23) or strong awns (SSG 59-3, HC 136, Pant Chari 6, HC 260, HC 171). Rest of the varieties fell in category of medium awn. None of the varieties showed anthocyanin coloured stigma in both the years. However, for yellow colouration of stigma, the varieties Pant Chari 5 and UPFS 38 were distinct as compared to other varieties by showing strong yellow colouration.As far as the characteristics of varieties on the basis of panicle density (ear head compactness) are concerned, there was gradual variation from very loose to very compact category. Varieties SSG 59-3 and Pusa Chari 23 with very loose and HC 136, CSV 15 and Pant Chari 5 with compact panicle density were conspicuously distinct from others. Most of the varieties had symmetrical panicle shape but the varieties UPFS 38, SSG 59-3 and Pusa Chari 23 with pyramidal shaped panicles and Pant Chari 4 showing panicles broader in upper part were distinct. Most of the varieties fell in three categories of caryopsis colour i.e., chalky white, pearly white and light/ dark brown. The varieties Pant Chari 5, HC 171, CSV 15 and HC 308 with pearly white grain and all multicut type varieties viz. Pant Chari 6, CSH 20 MF, Pusa Chari 23 and SSG 59-3 with light brown or dark brown colour of caryopsis were distinct from rest of the varieties showing chalky white colour of caryopsis.

Distinctness of varieties on the basis of measured quantitative characters in general, may be established on the basis of difference between pair of varieties for a particular character. For distinctness the difference between pair of varieties is tested characterize through determining the minimum distance/difference based on analysis of variance and Least Square Difference (LSD). In the present investigation the Critical Difference (CD) estimated as per Randomized Block Design, was computed. The mean values for all the measured quantitative characters are presented in the Table 3 and their comparison for pair of varieties with CD values indicated different varieties showing distinctness for different characters. The results of important characters which were found to be able to differentiate the varieties are discussed here.

Stem diameter (cm)

Most of the varieties during both the years found to show small (thin) diameter of stems but the varieties Pant Chari 5, CSV 15, Pant Chari 3, UPFS 38 and hybrid CSH 2OMF were clearly distinct from other varieties as these varieties had medium to thick stem. It is also worth mentioning that the varieties Pant Chari 5, CSV 15, Pant Chari 3 and UPFS 38 were dual purpose type as compared to other varieties which were fodder type. The multicut type varieties SSG 59-3, Pusa Chari 25, HC 260 and Pant Chari 6 had invariably the small/thin stem with significantly low values of stem diameter.

Plant height (cm)

As all of the varieties were either completely fodder type or dual purpose type, therefore the variation in height was not great. However, GFS 4, UP Chari 2 and CSV 15 with reasonably medium height were quite distinct from very tall varieties like HC 136, Pusa Chari 23, Pant Chari 5, SSG 59-3 and Pant Chari 4.

Leaf blade length and width (cm)

Length and width of third leaf from the top also provide the measure for differentiating the varieties. Most of the varieties being fodder types had long and broad leaves. However, GFS 4 with short to medium leaves and Pant Chari 5 with very long leaves were quite distinct from others. Multicut varieties SSG 59-3, Pusa. Chari 23 and Pant Chari 6 due to sudan grass characteristics along with GFS 4, had narrow to medium width of leaf blade as compared to broad leaves observed in dual purpose types. Dual purpose varieties Pant Chari 5, CSV 15 and UPFS 38 alongwith HC 136, a pure fodder type variety due to very late flowering had more vegetative growth thus showing more height and leafiness especially the broad leaves.

Panicle length (cm)

Great variability in panicle length helped to differentiate the varieties in different states of expression. However, GFS 4, HC 136 and Pant Chari 4 with short panicles and SSG 59-3, HC 171 and Pusa Chari 23 with long to very long panicle were quite distinct from others.

1000-grain weight (g)

The variation for thousand grain weight was observed between three states of expression i.e., very low, low and medium. All multicut type varieties viz. SSG 59-3, Pusa Chari 23, Pant Chari 6 showed very low and dual purpose type viz., Pant Chari 5, CSV 15 and UPFS 38 had medium grain weight.

Categorization of varieties on the basis of these characters also varied during both he years due to slight difference in measurement levels and effect of environment leading to different states of expression.

Grouping of varieties and distinctness

The collection of varieties to be grown for DUS test should be divided into groups to facilitate the assessment of distinctness. Characteristics that are suitable for grouping purpose are those which are known from experience not to vary or vary only slightly, within a group. The various states of expression for these grouping characters should be fairly distributed with the collection of varieties.

In sorghum, as per the DUS Testing Guidelines, the following characteristics are being considered for grouping of varieties.

a. Time of panicle emergence
b. Plant height at maturity
c. Panicle shape
d. Caryopsis colour after threshing

On the basis of above grouping characteristics, it is revealed that among the seventeen varieties tested for distinctness, there was great variability for time of panicle emergence and panicle shape whereas less variability was observed for plant height and caryopsis colour. Accordingly, the distribution of varieties in different states of expression in a particular group was wide for panicle emergence and panicle shape and narrow for plant height and caryopsis colour.

Group 1

Time of panicle emergence: Very early group: GFS 4 and Pusa Chari 23

Sub Groups:

1(a) Height : long - GFS 4
1(b) Height : very long - Pusa Chari 23
1(c) Panicle : Symmetric - GFS 4
1(d) Panicle : Pyramidal - Pusa Chari 23
1(e) Caryopsis colour : Chalky white - GFS 4
1(f) Caryopsis colour : Light brown - Pusa Chari 23

Group 2

Time of panicle emergence: Early Group: CSH 20 MF, SSG 59-3, HC 260

Sub Groups:

2(a) Height : long - CSH 20 MF
2(b) Height : very long - SSG 59-3, HC 260
2(c) Panicle : Symmetric - CSH 20 MF
2(d) Panicle : Broader in lower part - HC 260
2(e) Panicle : Pyramidal - SSG 59-3
2(f) Caryopsis colour : White - HC 260
2(g) Caryopsis colour : Light brown - SSG 59-3, CSH 20 MF

Group 3

Time of panicle emergence: Medium Group: CSV 15, GFS 5

Sub Groups:

3(a) Height : medium - CSV 15
3(b) Height : Long - GFS 5
3(c) Panicle : Symmetric - CSV 15, GFS 5
3(d) Caryopsis colour : White - GFS 5
3(e) Caryopsis colour : Pearly white - CSV 15

Group 4

Time of panicle emergence: Late Group: Pant Chari, 6, Pant Chari 5, UP Chari 2, UPFS 38, Pant Chari 4, HC 308, S437-1

Sub Groups:

4(a) Height : Long - Pant Chair 6, Pant Chari 5, UP Chari 2, UPFS 38
4(b) Height : Very long - Pant Chari 4, HC 308, 5437-1
4(c) Panicle : Symmetric - Pant Chari 6, Pant Chari 5
4(d) Panicle : Broader in lower part - UP Chari 2, HC 308, 5437-1
4(e) Panicle : Broader in upper part - Pant Chari 4
4(f) Panicle : Pyramidal - UPFS 38
4(g) Caryopsis colour - Chalky white - Pant Chari 4, UP Chari 2, UPFS 38

4(h) Caryopsis colour : Pearly white - Pant Chair 5, HC 308, S437-1
4(i) Caryopsis colour : Dark brown - Pant Chari 6

Group 5

Time of panicle emergence: Very Late Group: Pant Chari 3, HC 136, HC 171.
Sub Groups:
5(a) Height: Long - Pant Chari. 3
5(b) Height : Very long - HC 136, HC 171
5(c) Panicle : Symmetric - HC 136
5(d) Panicle : Broader in lower part - HC 171, Pant Chari 3
5(e) Caryopsis colour : Chalky white - Pant Chari 3, HC 136
5(f) Caryopsis colour : Pearly white : HC 171

Therefore, it is possible to distinguish all the seventeen varieties included in the present study on the basis of grouping characteristics based on physiology of plant its morphology and seed colour.

Singh and Sharma (1996) also indicated the essentiality of DUS type test for notified extant varieties since the information.

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