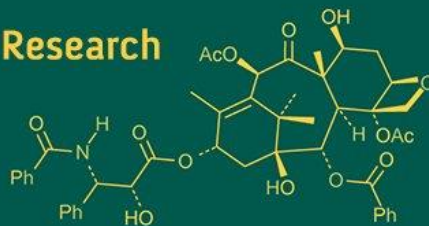
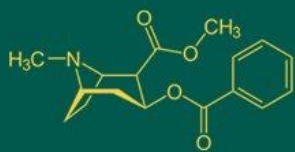


International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2026): 5.29
IJABR 2026; SP-10(6): 1008-1016
www.biochemjournal.com
Received: 26-04-2026
Accepted: 29-05-2026

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Assessment of morphological diversity in sorghum genotypes through DUS descriptors

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DOI: <https://www.doi.org/10.33545/26174693.2026.v10.i6SI.8762>

Abstract

Distinctness, Uniformity and Stability (DUS) testing is widely used method for varietal characterization. It is a standardized system to describe plant varieties based on their morphological traits. In sorghum, these DUS descriptors include traits recorded from the seedling stage through vegetative, flowering, panicle, and grain stages which help in distinguishing genotypes and maintaining varietal identity.

In the present study, 42 sorghum genotypes from RARS, Palem were taken and evaluated using 33 DUS descriptors, and their frequency distribution is calculated. The results revealed that the presence of variability among genotypes, with 6 characters being monomorphic, 18 dimorphic, 7 trimorphic, and 2 tetramorphic. Variation was observed across vegetative, flowering, panicle, and grain traits, indicating the usefulness of these descriptors for effective characterization. This identified variability can be further utilized for selecting diverse parents and for developing improved sorghum varieties through breeding programmes.

Keywords: DUS characterisation, sorghum, morphological descriptors

1. Introduction

Sorghum (*Sorghum bicolor* (L.) Moench) is an important cereal crop belonging to the family Poaceae and ranks as the fifth most important cereal globally. It is believed to have originated and been domesticated in Africa around 5000-8000 years ago, with the Indian subcontinent serving as a secondary center of origin where considerable genetic diversity is observed (Elangovan, 2010) [3]. Cultivated sorghum (*S. bicolor* subsp. *bicolor*) is diploid with chromosome number of, $2n = 2x = 20$ and it follows the C_4 photosynthetic pathway unlike rice, which enables efficient carbon assimilation under high temperature conditions.

The crop is well known for its outstanding agronomic performance and wide adaptability, as it can grow under diverse environmental conditions including drought, high temperatures, high altitudes, and saline-alkaline or marginal soils. Due to its resilience under adverse conditions, sorghum serves as an important "failsafe" crop in the global agroecosystem (Paterson, 2008) [7]. It is considered as a multipurpose crop used for food, feed, fiber, and bioenergy. The grain is utilized for human consumption and animal feed, while the stem serves as a source of fiber, fuel, and more recently, as feedstock for cellulosic ethanol production (Wang *et al.*, 2016) [20].

Sorghum is called by different names across different regions as "great millet" and "guinea corn" in West Africa, "kafir corn" in South Africa, "dura" in Sudan, "mtama" in East Africa, "jowar" in India, and "kaoliang" in China (Sanjana Reddy, 2017) [14]. It is known as "king of millets" and in Ayurveda it is traditionally referred to as "Yavanala" (due to its nutritional properties) (Varshanth and Harikrishnan, 2025) [19]. Globally, Sorghum production is expected to reach 63.5 million metric tonnes in the 2025/2026 marketing year. India ranks fourth in position, contributing about 7% of overall production after the United States, Nigeria, and Brazil, with an estimated production of 4.6 million metric tonnes in approximately 4 million hectares area. (USDA-FAS, 2025) [18].

Genetic variability is a prerequisite for any crop improvement and it is primarily derived from germplasm resources. Germplasm represents the total gene pool of a species, including landraces, obsolete cultivars, wild relatives, and weedy forms, and, for efficient utilisation in breeding programs, it must be systematically evaluated, characterised, and documented.

In India, the Protection of Plant Varieties and Farmers' Rights (PPV&FRA) Act, 2001^[8], grants intellectual property rights to plant breeders, researchers and farmers who develop new or extant plant varieties. Under this Act, varieties must fulfil the criteria of Novelty, Distinctness, Uniformity, and Stability (DUS) for registration. DUS testing plays an important role in knowing the identity and uniqueness of varieties by providing detailed characterisation, which is essential for their protection and identification. Sorghum is among the first 12 crop species notified for registration under the PPV&FR Act (Prajapati *et al.*, 2018)^[9].

Therefore, the present study was undertaken to evaluate and characterize sorghum germplasm based on 33 DUS descriptors in order to identify distinct, uniform, and stable genotypes for effective utilization in breeding programs.

2. Materials and methods

The experiment was conducted using 42 sorghum germplasm accessions (Table 1) during the *kharif* season of 2025-26 at the Regional Agricultural Research Station, Palem (16.51558 °N, 78.24911 °E). The experiment was

laid out in a randomized complete block design (RCBD) with three replications. Each genotype was sown in three rows of 4 m length in each replication. Recommended agronomic practices, including application of fertilizers as per package of practices and intercultural operations such as thinning and weeding, were followed to raise a healthy crop. A total of 33 DUS descriptors were recorded at different stages of crop growth, primarily based on visual observations. The traits included seedling anthocyanin coloration of coleoptile, leaf sheath anthocyanin coloration, leaf midrib colour, time of panicle emergence, plant height up to base of flag leaf, flag leaf midrib coloration, lemma arista formation, stigma anthocyanin coloration, stigma yellow coloration, stigma length, flower length with pedicel, anther length, anther colour (dry), glume colour, total plant height, stem diameter, leaf blade length and width, panicle length (without peduncle), panicle branch length, panicle density at maturity, panicle shape, visible neck length of panicle above sheath, glume length, grain thresh ability, caryopsis colour after threshing, 1000-grain weight, grain shape (dorsal and profile), grain germ mark size, endosperm texture, grain colour of vitreous albumen, and grain lustre.

Table 1: List of genotypes used in the study

1	PSV 301	22	PSV 757
2	PSV 312	23	PSV 758
3	PSV 313	24	PSV 769
4	PSV 319	25	PSV 767
5	PSV 320	26	PSV 770
6	PSV 321	27	PSV 771
7	PSV 401	28	PSV 801
8	PSV 412	29	PSV 802
9	PSV 416	30	PSV 851
10	PSV 852	31	PSV 803
11	PSV 853	32	PSV 817
12	PSV 854	33	PSV 852
13	PSV 856	34	PSV 853
14	PSV 29563	35	PSV 854
15	PSV 29937	36	PSV 855
16	PSV 29958	37	PSV 719
17	PSV 29933	38	PSV 702
18	PSV 6000	39	PSV 712
19	PSV 6010	40	PSV 711
20	PSV 6007	41	CSV 41
21	PSV 759	42	PSV 512

3. Results and discussion

The present investigation was carried out using 42 sorghum genotypes (Table 1). DUS descriptors were recorded for all genotypes following the guidelines provided in Plant Variety Journal of India (2007) to evaluate the extent of distinctiveness among them. A total of 33 morphological characters were observed and documented. The frequency distribution for each character was computed and presented in Table 2, and the genotypes exhibiting each state of the respective descriptors are presented in Table 3. For the trait seedling: anthocyanin colouration of coleoptile, the majority of genotypes (38) exhibited yellow-green colouration, whereas a smaller proportion (4) showed grayed-purple colouration. Similar findings were reported by Raghuvanshi *et al.* (2014)^[10], who observed that out of seventeen varieties studied, twelve exhibited green coleoptile colour, while the remaining five showed purple colouration. Among the vegetative traits, for leaf sheath anthocyanin colouration, 35 genotypes (83.33%) exhibited yellow-green

colouration, while 7 genotypes (16.66%) showed grayed-purple colouration. The leaf midrib colour observed at the fifth leaf stage showed two categories: white (RHS 155-N155) in 19 genotypes (45.23%) and yellow-green (RHS 144-N144) in 23 genotypes (54.76%). Based on plant natural height and its total height, the genotypes were grouped into three categories: short (30 genotypes; 71.42%), medium (11 genotypes; 26.19%), and tall (1 genotype; 2.38%). The majority of genotypes (31) showed absence of flag leaf yellow colouration of midrib, whereas 11 genotypes exhibited its presence. For stem girth (measured during physiological maturity at the lower one-third height of the plant), all 42 genotypes have medium diameter (2-4 cm). Regarding leaf blade length (third leaf from the top), 25 genotypes exhibited long leaves (61-80 cm), while 17 genotypes showed very long leaves (>80 cm). For leaf blade width, most genotypes were categorized as broad (23 genotypes; 54.76%; 6.1-8 cm), followed by very broad (17

genotypes; 40.47%), and only 2 genotypes (PSV 301 and 6001×6008) showed medium width (4.1-6 cm).

Similar studies were done by Shafiqurrahman *et al.* (2022) and Prajapati *et al.* (2018)^[9]. Bhusal *et al.* (2017)^[1] reported that, based on the evaluation of 33 morphological characters, distinct features can be seen in five genotypes, namely S-540, SSG 59-3, COFS 29, HC 136, and IS 18551, for traits such as plant height up to the base of the flag leaf, days to panicle emergence, leaf blade width, and panicle density at maturity. Similarly, Sangwan *et al.* (2005)^[13] observed that stem thickness was highest in PC 6 and lowest in PC 1, SSG 59-3, and MP Chari, while it was moderate in the remaining genotypes. They also reported narrow leaves in SSG 59-3 and MP Chari, whereas wider leaves were observed in other genotypes.

Coming to the flowering characters, the genotypes were classified based on time of panicle emergence (50% of plants with 50% flowering) into three groups. The majority of genotypes (22 out of 42) fell under the medium category, with days to flowering ranging from 66-75 days, followed by the late category (76-85 days) comprising 15 genotypes, while only 5 genotypes exhibited early flowering. With respect to arista presence, 40 genotypes showed absence, whereas only two genotypes (PSV 301 and PSV 719) exhibited its presence. Observations on stigma anthocyanin colouration and stigma yellow colouration revealed that all 42 genotypes possessed anthocyanin pigmentation and lacked yellow colouration. Based on stigma length, genotypes were classified into two categories, with majority of them (28 genotypes; 67%) showing short stigma (<1 mm), while 14 genotypes exhibited medium length (1-2 mm).

Reddy *et al.* (2008)^[12] also reported variation in time of panicle emergence ranging from 65 to 87 days. Swamy *et al.* (2018)^[17] emphasised that days to 50 per cent flowering is an important trait, as it showed a significant and positive association with grain yield per plant. Similar findings were reported by Chavan *et al.* (2018)^[2], who observed traits such as grayed-orange colour of dry anther (53.85%) and yellow-white glume colour (30.77%) and other among the studied genotypes.

Similarly, based on flower length with pedicel, genotypes were classified into two categories: medium (24 genotypes; 57%) and long (18 genotypes; 42.9%). For anther length, 37 genotypes were categorized as short, while 5 were medium. Regarding the colour of dry anther, most genotypes exhibited yellow-orange colouration (23 genotypes; 54.8%), whereas the remaining 19 genotypes (45.23%) showed grayed-orange colouration.

In the panicle traits, the panicle length (measured without peduncle) was grouped into short and medium categories. The majority of genotypes (34; 80.95%) exhibited medium panicle length (21-20 cm), while 8 genotypes (19.04%) were classified as short (11-20 cm). With respect to panicle branch length (measured from the middle third portion of the panicle), all genotypes exhibited medium length (5.1-10 cm). Similarly, all genotypes showed symmetric panicles. In terms of panicle compactness, 37 genotypes showed semi-loose density at maturity, while 5 genotypes showed semi-compact density. For panicle neck length (visible length above the sheath), variation was observed, with 20 genotypes (47.6%) falling under the short category (5.1-10 cm) and 22 genotypes (52.38%) under the medium category (10.1-15 cm). The genotypes were classified on the basis of

threshability in two categories viz., freely threshable (31 genotypes), partly threshable (11 genotypes).

Further variation was observed for glume colour and glume length. The glume colour, recorded at physiological maturity of the grain, was classified into two categories: grayed-yellow (10 genotypes; 23.80%) and grayed-orange (32 genotypes; 76.19%), with the latter being predominant. Based on glume length (measured as the extent of grain coverage at maturity), genotypes were grouped into three categories: short (50% grain coverage) comprising 22 genotypes, medium (75% grain coverage) with 18 genotypes, and long (100% grain coverage) represented by only two genotypes (PSV 851 and PSV 854).

After threshing, the genotypes were classified based on the caryopsis colour, 1000-grain weight, grain shape (dorsal and profile view), germ mark size, endosperm texture (longitudinal section), colour of vitreous albumen and grain lustre. Where, considerable variation was seen in caryopsis colour, with the majority of genotypes falling under yellow-white (24 genotypes; 57.14%), followed by yellow-orange (11 genotypes; 26.19%), grayed-white (6 genotypes; 14.28%), and grayed-orange (1 genotype; 2.38%). However, based on the 1000 grain weight all genotypes were in the range of 26-35 g, thereby falling in the medium category. Similar observations were reported by Joshi *et al.* (2009)^[5] in their study on 26 forage sorghum varieties.

Based on grain shape in dorsal view, three categories were observed: elliptic (26 genotypes; 62%), circular (11 genotypes; 26.19%) and narrow elliptic (5 genotypes; 11.9%). Whereas grain shape in profile view, genotypes were grouped into two categories, with the majority being elliptic (24 genotypes; 57.14%) followed by narrow elliptic (18 genotypes; 42.86%). The germ mark size also showed variation, with most genotypes having small germ marks (26 genotypes; 61.9%), followed by medium (15 genotypes; 35.7%), and only one genotype (PSV 6007) exhibiting a large germ mark. For endosperm texture (observed through longitudinal section), 24 genotypes were classified as $\frac{3}{4}$ vitreous, 10 as half vitreous, and 8 as $\frac{3}{4}$ farinaceous. The colour of vitreous albumen showed that the majority of genotypes (35) were grayed-yellow, while 7 were grayed-orange. Finally, based on grain lustre, genotypes were classified into non-lustrous and lustrous types, with the majority being non-lustrous (24 genotypes; 57.14%), while 18 genotypes were lustrous (e.g., PSV 312, PSV 321, PSV 412, PSV 416, PSV 29563, PSV 29933, etc.).

Similar studies were reported by Reddy *et al.* (2006)^[11] and Elangovan *et al.* (2014)^[4], who evaluated 236 minicore accessions using 33 morphological traits. Their findings indicated the predominance of traits such as elliptic grain shape in dorsal view, elliptic grain shape in profile view, medium germ mark size, 25% corneous endosperm texture, grayed-orange colour of vitreous albumen, and non-lustrous grains among the accessions. Further, Santiya *et al.* (2025) characterized sorghum genotypes and identified promising grain types based on traits such as earliness (<64 days) and higher grain weight (>31 g), including genotypes like TNS 682 and RPHT 14. Similar characterization studies have also been reported in pearl millet by Nehra *et al.* (2016)^[6].

The findings of the present study are in close agreement with these reports, indicating that the observed variability and trait distribution follow similar patterns, thereby confirming the reliability and relevance of DUS-based characterization in sorghum.

Table 2: Different DUS characters recorded and frequency distribution observed

S.no	Parameters	States	Scale	No.	percent
1	Seedling: Anthocyanin colouration of coleoptiles	Yellow green (RHS 144-144N)	1	38	90.47
		Grayed purple (RHS 183-187)	2	4	9.52
2	Leaf sheath: Anthocyanin colouration	Yellow green (RHS 144-144N)	1	35	83.33
		Grayed purple (RHS 183-187)	2	7	16.66
3	Leaf: Mid rib colour (5 th fully developed leaf)	White (RHS 155- N 155)			
		Yellow green (RHS 144 - N144)	1	19	45.23
		Grayed yellow (RHS 162)	2	23	54.76
		Grayed purple (RHS 183-187)	3	0	0
4	Plant: Time of panicle emergence (50% of the plants with 50% anthesis)	Very early (<56 days)	4	0	0
		Early (56-65 days)	3	5	11.90
		Medium (66-75 days)	5	22	52.38
		Late (76-85 days)	7	15	35.71
		Very late (>85 days)	9	0	0
5	Plant: Natural height of plant up to base of flag leaf	Very short (<76 cm)	1	0	0
		Short (76-150 cm)	3	30	71.42
		Medium (151-225 cm)	5	11	26.19
		Tall (226-300 cm)	7	1	2.38
		Very tall (>300 cm)	9	0	0
6	Flag leaf: Yellow colouration of midrib	Absent	1	31	73.80
		Present	5	11	26.19
7	Lemma: Arista formation	Absent	1	40	95.23
		Present	5	2	4.76
8	Stigma: anthocyanin colouration	Absent	1	0	0
		Present	5	42	100
9	Stigma: Yellow colouration	Absent	1	42	100
		Present	5	0	0
10	Stigma: Length	Short (<1 mm)	3	28	66.66
		Medium (1-2 mm)	5	14	33.33
		Long (>2 mm)	9	0	0
11	Flower with pedicel: Length of flower	Very short	1	0	0
		Short	3	0	0
		Medium	5	24	57.14
		Long	7	18	42.85
		Very long	9	0	0
12	Anther: Length	Short (<3 mm)	3	37	88.09
		Medium (3-4 mm)	5	5	11.90
		Long (>4 mm)	7	0	0
13	Anther: Colour of dry anther	Yellow orange	1	23	54.76
		Orange	2	0	0
		Orange red	3	0	0
		Grayed orange	4	19	45.23
14	Glume: Colour	Green white	1	0	0
		Yellow white	2	0	0
		Grayed yellow	3	10	23.80
		Grayed orange	4	32	76.19
		Grayed red	5	0	0
		Grayed purple	6	0	0
15	Plant: Total height	Very short (<76 cm)	1	0	0
		Short (76-150 cm)	3	30	71.42
		Medium (151-225 cm)	5	11	26.19
		Long (226-300 cm)	7	1	2.38
		Very long (>300 cm)	9	0	0
16	Stem: Diameter (at lower one third height of plant)	Small (>2 cm)	3	0	0
		Medium (2-4 cm)	5	42	100
		Large (>4cm)	7	0	0
17	Leaf: Length of blade (the third leaf from top including flag leaf)	Short (< 41 cm)	3	0	0
		Medium (41-60 cm)	5	0	0
		Long (61-80 cm)	7	26	61.90
		Very long (>80 cm)	9	16	38.09
18	Leaf: Width of blade (the third leaf from top including flag leaf)	Narrow (<4.1 cm)	3	0	0
		Medium (4.1-6.0 cm)	5	2	4.76
		Broad (6.1-8.0 cm)	7	23	54.76

		Very broad (>8.0 cm)	9	17	40.47
19	Panicle: Length without peduncle	Very short (<11 cm)	1	0	0
		Short (11-20 cm)	3	8	19.04
		Medium (21-30 cm)	5	34	80.95
		Long (31-40 cm)	7	0	0
		Very long (>40 cm)	9	0	0
20	Panicle: Length of branches (middle third of panicle)	Short (<5.1 cm)	3	0	0
		Medium (5.1-10 cm)	5	42	100
		Long (10.1-15 cm)	7	0	0
		Very long (>15 cm)	9	0	0
21	Panicle: Density at maturity (ear head compactness)	Very loose	1	0	0
		Loose	3	0	0
		Semi loose	5	37	88.09
		Semi compact	7	5	11.90
		Compact	9	0	0
22	Panicle: Shape	Reversed pyramid	1	0	0
		Panicle broader in upper part	2	0	0
		Symmetric	3	42	100
		Panicle broader in lower part	4	0	0
		Pyramidal	5	0	0
23	Neck of panicle: Visible length above sheath	Absent or very short (<5.1cm)	1	0	0
		Short (5.1-10 cm)	3	20	47.61
		Medium (10.1-15 cm)	5	22	52.38
		Long (15.1-20 cm)	7	0	0
		Very long (>20cm)	9	0	0
24	Glume: Length	Very short (25% of grain covered)	1	0	0
		Short (50% of grain covered)	3	22	52.38
		Medium (75% of grain covered)	5	18	42.85
		Long (100% of grain covered)	7	2	4.76
		Very long (longer than the grain)	9	0	0
25	Grain: Threshability	Freely threshable (<11% unthreshed grain)	1	31	73.80
		Partly threshable (11-15% unthreshed grain)	5	11	26.19
		Difficult to thresh (>50% unthreshed grain)	7	0	0
26	Caryopsis: Colour after threshing	White 155	1	0	0
		Greyed white 156	2	6	14.28
		Yellow white 158	3	24	57.14
		Yellow orange 14-20	4	11	26.19
		Greyed orange 200	5	1	2.38
27	Grain: Weight of 1000 grains	Very low (<16 g)	1	0	0
		Low (16-25 g)	3	0	0
		Medium (26-35 g)	5	42	100
		High (36-45 g)	7	0	0
		Very high (>45 g)	9	0	0
28	Grain: Shape (in dorsal view)	Narrow elliptic	1	5	11.90
		Elliptic	2	26	61.90
		Circular	3	11	26.19
29	Grain: Shape in profile view	Narrow elliptic	1	18	42.85
		Elliptic	2	24	57.14
		Circular	3	0	0
30	Grain: Size of mark of germ	Very small	1	0	0
		Small	3	26	61.90
		Medium	5	15	35.71
		Large	7	1	2.38
		Very large	9	0	0
31	Grain: Texture of endosperm (in longitudinal section)	Fully vitreous (100% corneous)	1	0	0
		¾ vitreous (75% corneous)	3	24	57.14
		Half vitreous (50% corneous)	5	10	23.80
		¾ farinaceous (25% corneous)	7	8	19.04
		Fully farinaceous (0% corneous)	9	0	0
32	Grain: Colour of vitreous albumen	Grayed yellow RHS 160-162	1	35	83.33
		Grayed orange RHS 166	2	7	16.66
		Grayed purple RHS N 187	3	0	0
33	Grain: Lustre	Non-lustrous	1	24	57.14
		Lustrous	5	18	42.85

4. Conclusion

In the present study, 33 morphological DUS descriptors were employed to characterize the sorghum genotypes, showing considerable variation across different vegetative, flowering, panicle, and grain traits enabling effective grouping based on phenotypic similarities and differences. Such characterization provides a valuable foundation for selecting diverse parental lines in breeding programmes,

thereby facilitating the creation of greater genetic variability through crosses selected between distinct groups and genotypes possessing contrasting traits. The variation observed from this study is useful not only for the development of new, distinct varieties but also for supporting cultivar improvement and germplasm conservation efforts aimed at enhancing sorghum productivity.

Table 3: Classification of sorghum genotypes based on DUS descriptors

DUS Descriptor	States	Genotypes exhibiting the trait
Seedling: Anthocyanin colouration of coleoptile	Yellow green	PSV 301, PSV 312, PSV 313, PSV 319, PSV 320, PSV 321, PSV 401, PSV 412, PSV 416, PSV 852, PSV 853, PSV 854, PSV 856, PSV 29563, PSV 29937, PSV 29958, PSV 759, PSV 757, PSV 758, PSV 769, PSV 767, PSV 770, PSV 771, PSV 801, PSV 802, PSV 851, PSV 803, PSV 817, PSV 855, PSV 854, PSV 853, PSV 719, PSV 702, PSV 712, PSV 711, PSV 29933, PSV 512, CSV 41
	Grayed purple	PSV 6000, PSV 6010, PSV 6007, PSV 852
Leaf sheath: Anthocyanin colouration	Yellow green	PSV 301, PSV 312, PSV 313, PSV 319, PSV 320, PSV 321, PSV 401, PSV 412, PSV 416, PSV 852, PSV 853, PSV 856, PSV 29563, PSV 29937, PSV 29958, PSV 6000, PSV 6010, PSV 6007, PSV 759, PSV 758, PSV 770, PSV 771, PSV 801, PSV 851, PSV 817, PSV 852, PSV 855, PSV 854, PSV 853, PSV 702, PSV 712, PSV 711, PSV 29933, PSV 512, CSV 41
	Grayed purple	PSV 854, PSV 757, PSV 769, PSV 767, PSV 802, PSV 803, PSV 719
Leaf midrib colour	White	PSV 301, PSV 312, PSV 313, PSV 412, PSV 852, PSV 854, PSV 856, PSV 6000, PSV 6007, PSV 759, PSV 757, PSV 801, PSV 802, PSV 817, PSV 852, PSV 854, PSV 853, PSV 719, PSV 711
	Yellow green	PSV 319, PSV 320, PSV 321, PSV 401, PSV 416, PSV 853, PSV 29563, PSV 29937, PSV 29958, PSV 6010, PSV 758, PSV 769, PSV 767, PSV 770, PSV 771, PSV 851, PSV 803, PSV 855, PSV 702, PSV 712, PSV 29933, PSV 512, CSV 41
Plant: Time of panicle emergence	Early	PSV 313, PSV 401, PSV 6007, PSV 758, PSV 512
	Medium	PSV 301, PSV 312, PSV 320, PSV 321, PSV 416, PSV 854, PSV 856, PSV 29563, PSV 29958, PSV 6000, PSV 6010, PSV 757, PSV 767, PSV 855, PSV 854, PSV 853, PSV 719, PSV 702, PSV 712, PSV 711, PSV 29933, CSV 41
	Late	PSV 319, PSV 412, PSV 852, PSV 853, PSV 29937, PSV 759, PSV 769, PSV 770, PSV 771, PSV 801, PSV 802, PSV 851, PSV 803, PSV 817, PSV 852
Plant: Natural height of plant up to base of flag leaf	Short (76-150 cm)	PSV 301, PSV 312, PSV 313, PSV 319, PSV 320, PSV 321, PSV 401, PSV 412, PSV 416, PSV 852, PSV 853, PSV 854, PSV 29563, PSV 29937, PSV 29958, PSV 6000, PSV 6007, PSV 759, PSV 770, PSV 771, PSV 801, PSV 802, PSV 851, PSV 803, PSV 817, PSV 852, PSV 855
	Medium (151-225 cm)	PSV 856, PSV 6010, PSV 758, PSV 769, PSV 767, PSV 854, PSV 853, PSV 719, PSV 702, PSV 712, PSV 711, PSV 29933, PSV 512, CSV 41
	Tall (226-300 cm)	PSV 757
Flag leaf: Yellow colouration of midrib	Absent	PSV 301, PSV 312, PSV 313, PSV 319, PSV 320, PSV 321, PSV 401, PSV 856, PSV 29563, PSV 29937, PSV 6007, PSV 759, PSV 757, PSV 758, PSV 769, PSV 767, PSV 770, PSV 771, PSV 801, PSV 802, PSV 851, PSV 803, PSV 852, PSV 855, PSV 719, PSV 702, PSV 712, PSV 711, PSV 29933, PSV 512, CSV 41
	Present	PSV 412, PSV 416, PSV 852, PSV 853, PSV 854, PSV 6000, PSV 6010, PSV 29958, PSV 817, PSV 854, PSV 853
Lemma: Arista formation	Absent	PSV 312, PSV 313, PSV 319, PSV 320, PSV 321, PSV 401, PSV 412, PSV 416, PSV 852, PSV 853, PSV 854, PSV 856, PSV 29563, PSV 29937, PSV 29958, PSV 6000, PSV 6010, PSV 6007, PSV 759, PSV 757, PSV 758, PSV 769, PSV 767, PSV 770, PSV 771, PSV 801, PSV 802, PSV 851, PSV 803, PSV 817, PSV 852, PSV 855, PSV 854, PSV 853, PSV 702, PSV 712, PSV 711, PSV 29933, PSV 512, CSV 41
	Present	PSV 301, PSV 719
Stigma: Anthocyanin	Present	All genotypes
Stigma: Yellow colouration	Absent	All genotypes
Stigma: Length	Short (<1 mm)	PSV 301, PSV 312, PSV 313, PSV 319, PSV 320, PSV 321, PSV 416, PSV 852, PSV 853, PSV 856, PSV 6000, PSV 6010, PSV 6007, PSV 759, PSV 757, PSV 758, PSV 770, PSV 771, PSV 801, PSV 802, PSV 851, PSV 803, PSV 854, PSV 853, PSV 719, PSV 702, PSV 711, PSV 29933
	Medium (1-2 mm)	PSV 401, PSV 412, PSV 854, PSV 29563, PSV 29937, PSV 29958, PSV 769, PSV 767, PSV 817, PSV 852, PSV 855, PSV 712, PSV 512, CSV 41
Length of flower	Medium	PSV 301, PSV 312, PSV 313, PSV 319, PSV 320, PSV 321, PSV 852, PSV 853, PSV 854, PSV 6000, PSV 6010, PSV 6007, PSV 801, PSV 802, PSV 851, PSV 803, PSV 817, PSV 854, PSV 853, PSV 719, PSV 702, PSV 712, PSV 711, PSV 29933
	Long	PSV 401, PSV 412, PSV 416, PSV 856, PSV 29563, PSV 29937, PSV 29958, PSV 759, PSV 757, PSV 758, PSV 769, PSV 767, PSV 770, PSV 771, PSV 852, PSV 855, PSV 512, CSV 41
Anther: Length	Short (<3 mm)	PSV 301, PSV 313, PSV 319, PSV 320, PSV 321, PSV 401, PSV 412, PSV 416, PSV 852, PSV 853, PSV 854, PSV 856, PSV 29937, PSV 29958, PSV 6000, PSV 6010, PSV 6007, PSV 759, PSV 757, PSV 758, PSV 769, PSV 767, PSV 801, PSV 802, PSV 851, PSV 803, PSV 817, PSV 852, PSV 855, PSV 854, PSV 853, PSV 719, PSV 702, PSV 712, PSV 711, PSV 29933, CSV 41
	Medium (3-4 mm)	PSV 312, PSV 29563, PSV 770, PSV 771, PSV 512
Colour of dry anther	Yellow orange	PSV 301, PSV 312, PSV 313, PSV 319, PSV 320, PSV 321, PSV 416, PSV 852, PSV 853, PSV 854, PSV 856, PSV 6000, PSV 6010, PSV 6007, PSV 801, PSV 802, PSV 803, PSV 817, PSV 719, PSV 702, PSV 712, PSV 711, PSV 29933
	Grayed	PSV 401, PSV 412, PSV 29563, PSV 29937, PSV 29958, PSV 759, PSV 757, PSV 758, PSV 769, PSV 767,

	orange	PSV 770, PSV 771, PSV 851, PSV 852, PSV 855, PSV 854, PSV 853, PSV 512, CSV 41
Glume: Colour	Grayed orange	PSV 301, PSV 412, PSV 313, PSV 319, PSV 320, PSV 321, PSV 416, PSV 852, PSV 853, PSV 854, PSV 856, PSV 29563, PSV 29937, PSV 29958, PSV 6007, PSV 759, PSV 757, PSV 758, PSV 769, PSV 767, PSV 770, PSV 801, PSV 802, PSV 803, PSV 817, PSV 852, PSV 853, PSV 719, PSV 702, PSV 712, PSV 512, CSV 41
	Grayed yellow	PSV 312, PSV 401, PSV 6000, PSV 6010, PSV 771, PSV 851, PSV 855, PSV 854, PSV 711, PSV 29933
Total height	Short	PSV 301, PSV 312, PSV 313, PSV 319, PSV 320, PSV 321, PSV 401, PSV 412, PSV 416, PSV 852, PSV 853, PSV 854, PSV 29563, PSV 29937, PSV 29958, PSV 6000, PSV 6007, PSV 759, PSV 770, PSV 771, PSV 801, PSV 802, PSV 851, PSV 803, PSV 817, PSV 852, PSV 855
	Medium	PSV 856, PSV 6010, PSV 758, PSV 769, PSV 767, PSV 854, PSV 853, PSV 719, PSV 702, PSV 712, PSV 711, PSV 29933, PSV 512, CSV 41
	Long	PSV 757
Stem: Diameter	Medium (2-4cm)	All genotypes
Leaf: length	Long (61-80cm)	PSV 301, PSV 312, PSV 313, PSV 319, PSV 320, PSV 321, PSV 401, PSV 412, PSV 416, PSV 854, PSV 856, PSV 29563, PSV 29937, PSV 6000, PSV 6007, PSV 759, PSV 769, PSV 767, PSV 770, PSV 771, PSV 802, PSV 851, PSV 852, PSV 854, PSV 719
	Very long (>80cm)	PSV 852, PSV 853, PSV 29958, PSV 6010, PSV 757, PSV 758, PSV 801, PSV 803, PSV 817, PSV 855, PSV 853, PSV 702, PSV 712, PSV 711, PSV 29933, PSV 512, CSV 41
Leaf: Width	Medium	PSV 301, PSV 767,
	Broad	PSV 312, PSV 313, PSV 319, PSV 320, PSV 321, PSV 412, PSV 416, PSV 854, PSV 856, PSV 29563, PSV 29937, PSV 6000, PSV 6007, PSV 758, PSV 771, PSV 801, PSV 802, PSV 851, PSV 803, PSV 817, PSV 719, PSV 711, PSV 512
	Very broad	PSV 401, PSV 852, PSV 853, PSV 29958, PSV 6010, PSV 759, PSV 757, PSV 769, PSV 770, PSV 852, PSV 855, PSV 854, PSV 853, PSV 702, PSV 712, PSV 29933, CSV 41
Panicle: Length without peduncle	Short (11-20cm)	PSV 312, PSV 313, PSV 319, PSV 852, PSV 6000, PSV 758, PSV 767, PSV 802
	Medium (21-30cm)	PSV 301, PSV 320, PSV 321, PSV 401, PSV 412, PSV 416, PSV 853, PSV 854, PSV 856, PSV 29563, PSV 29937, PSV 29958, PSV 6010, PSV 6007, PSV 759, PSV 757, PSV 769, PSV 770, PSV 771, PSV 801, PSV 851, PSV 803, PSV 817, PSV 852, PSV 855, PSV 854, PSV 719, PSV 702, PSV 712, PSV 711, PSV 29933, PSV 512, CSV 41
Panicle: Length of branches	Medium (5.1-10cm)	All genotypes
Panicle: Density at maturity	Semi loose	PSV 312, PSV 802, PSV 852, PSV 853, PSV 29933
	Semi compact	PSV 301, PSV 313, PSV 319, PSV 320, PSV 321, PSV 401, PSV 412, PSV 416, PSV 852, PSV 853, PSV 854, PSV 856, PSV 29563, PSV 29937, PSV 29958, PSV 6000, PSV 6010, PSV 6007, PSV 759, PSV 757, PSV 758, PSV 769, PSV 767, PSV 770, PSV 771, PSV 801, PSV 851, PSV 803, PSV 817, PSV 855, PSV 854, PSV 719, PSV 702, PSV 712, PSV 711, PSV 512, CSV 41
Panicle: Shape	Symmetric	All genotypes
Neck of panicle	Short (5.1-10 cm)	PSV 301, PSV 312, PSV 313, PSV 319, PSV 320, PSV 321, PSV 401, PSV 412, PSV 416, PSV 29563, PSV 29937, PSV 29958, PSV 6000, PSV 6010, PSV 6007, PSV 759, PSV 757, PSV 801, PSV 802, PSV 851, PSV 852, PSV 855, PSV 512, CSV 41
	Medium (10.1-15 cm)	PSV 321, PSV 401, PSV 412, PSV 416, PSV 852, PSV 853, PSV 854, PSV 856, PSV 758, PSV 769, PSV 767, PSV 770, PSV 771, PSV 803, PSV 817, PSV 854, PSV 853, PSV 719, PSV 702, PSV 712, PSV 711, PSV 29933
Glume: Length	Short (50% of grain)	PSV 301, PSV 313, PSV 320, PSV 321, PSV 852, PSV 853, PSV 856, PSV 29563, PSV 29937, PSV 6000, PSV 6010, PSV 6007, PSV 759, PSV 757, PSV 771, PSV 802, PSV 803, PSV 817, PSV 719, PSV 712, PSV 711, CSV 41
	Medium (75% of grain)	PSV 312, PSV 319, PSV 401, PSV 412, PSV 416, PSV 854, PSV 29958, PSV 758, PSV 769, PSV 767, PSV 770, PSV 801, PSV 852, PSV 855, PSV 853, PSV 702, PSV 29933, PSV 512
	Long (100% of grain)	PSV 851, PSV 854
Grain: Threshability	Freely threshable	PSV 301, PSV 312, PSV 313, PSV 320, PSV 321, PSV 401, PSV 412, PSV 416, PSV 29563, PSV 29937, PSV 29958, PSV 6000, PSV 6010, PSV 6007, PSV 759, PSV 757, PSV 771, PSV 801, PSV 802, PSV 851, PSV 803, PSV 817, PSV 852, PSV 855, PSV 854, PSV 853, PSV 712, PSV 711, PSV 29933, PSV 512, CSV 41
	Partly threshable	PSV 319, PSV 852, PSV 853, PSV 854, PSV 856, PSV 758, PSV 769, PSV 767, PSV 770, PSV 719, PSV 702
Caryopsis: Colour	Yellow white	PSV 321, PSV 29563, PSV 771, PSV 801, PSV 852, PSV 719
	Yellow orange	PSV 313, PSV 320, PSV 401, PSV 412, PSV 416, PSV 852, PSV 853, PSV 854, PSV 856, PSV 6000, PSV 6010, PSV 6007, PSV 759, PSV 757, PSV 758, PSV 802, PSV 851, PSV 817, PSV 855, PSV 702, PSV 712, PSV 711, PSV 512, CSV 41
	Grayed white	PSV 301, PSV 312, PSV 319, PSV 29937, PSV 29958, PSV 769, PSV 767, PSV 770, PSV 803, PSV 853, PSV 29933
	Grayed orange	PSV 854
Weight of 1000 grains	Medium (26-35g)	All genotypes
Grain: Shape (in dorsal view)	Narrow elliptic	PSV 313, PSV 853, PSV 856, PSV 851, PSV 852
	Elliptic	PSV 312, PSV 319, PSV 320, PSV 321, PSV 852, PSV 29563, PSV 29937, PSV 29958, PSV 6010, PSV 759, PSV 769, PSV 767, PSV 770, PSV 771, PSV 802, PSV 817, PSV 855, PSV 854, PSV 853, PSV 719, PSV 702, PSV 712, PSV 711, PSV 29933, PSV 512, CSV 41
	Circular	PSV 301, PSV 401, PSV 412, PSV 416, PSV 854, PSV 6000, PSV 6007, PSV 757, PSV 758, PSV 801, PSV 803
Grain: Shape (in profile view)	Narrow elliptic	PSV 312, PSV 313, PSV 319, PSV 320, PSV 321, PSV 852, PSV 853, PSV 856, PSV 29958, PSV 6010, PSV 759, PSV 767, PSV 802, PSV 851, PSV 817, PSV 852, PSV 853, PSV 29933
	Elliptic	PSV 301, PSV 401, PSV 412, PSV 416, PSV 854, PSV 29563, PSV 29937, PSV 6000, PSV 6007, PSV 757, PSV 758, PSV 769, PSV 770, PSV 771, PSV 801, PSV 803, PSV 855, PSV 854, PSV 719, PSV 702, PSV 712, PSV 711, PSV 512, CSV 41

Size of mark of germ	Small	PSV 312, PSV 313, PSV 319, PSV 321, PSV 401, PSV 412, PSV 416, PSV 853, PSV 856, PSV 29563, PSV 29958, PSV 6010, PSV 769, PSV 770, PSV 801, PSV 802, PSV 851, PSV 803, PSV 817, PSV 852, PSV 855, PSV 854, PSV 853, PSV 719, PSV 702, PSV 712
	Medium	PSV 301, PSV 320, PSV 852, PSV 854, PSV 29937, PSV 6000, PSV 759, PSV 757, PSV 758, PSV 767, PSV 771, PSV 711, PSV 29933, PSV 512, CSV 41
	Large	PSV 6007
Texture of endosperm	$\frac{3}{4}$ vitreous	PSV 301, PSV 312, PSV 313, PSV 320, PSV 412, PSV 852, PSV 856, PSV 29563, PSV 29958, PSV 6000, PSV 6010, PSV 6007, PSV 759, PSV 758, PSV 769, PSV 767, PSV 770, PSV 801, PSV 851, PSV 852, PSV 853, PSV 702, PSV 712, PSV 29933
	half vitreous	PSV 319, PSV 853, PSV 854, PSV 29937, PSV 757, PSV 802, PSV 803, PSV 855, PSV 854, PSV 711
	$\frac{3}{4}$ farinaceous	PSV 321, PSV 401, PSV 416, PSV 771, PSV 817, PSV 719, PSV 512, CSV 41
Colour of vitreous albumen	Greyed yellow	PSV 301, PSV 313, PSV 319, PSV 320, PSV 321, PSV 401, PSV 412, PSV 416, PSV 852, PSV 853, PSV 854, PSV 856, PSV 29563, PSV 29937, PSV 29958, PSV 6000, PSV 6010, PSV 759, PSV 758, PSV 769, PSV 767, PSV 770, PSV 771, PSV 801, PSV 802, PSV 851, PSV 803, PSV 817, PSV 852, PSV 854, PSV 853, PSV 719, PSV 702, PSV 512, CSV 41
	Greyed orange	PSV 312, PSV 6007, PSV 757, PSV 855, PSV 712, PSV 711, PSV 29933
Grain: Lustre	Non lustrous	PSV 301, PSV 313, PSV 320, PSV 401, PSV 852, PSV 853, PSV 854, PSV 29937, PSV 29958, PSV 6007, PSV 759, PSV 757, PSV 767, PSV 770, PSV 771, PSV 802, PSV 817, PSV 853, PSV 719, PSV 702, PSV 712, PSV 711, PSV 512, CSV 41
	Lustrous	PSV 312, PSV 319, PSV 321, PSV 412, PSV 416, PSV 856, PSV 29563, PSV 6000, PSV 6010, PSV 758, PSV 769, PSV 801, PSV 851, PSV 803, PSV 852, PSV 855, PSV 854, PSV 29933

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