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Morphological characterization of sorghum[*Sorghum bicolor* (L.) Moench] land race collected from western and south-western part of Ethiopia for DUS Traits

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A B S T R A C T
A total of 83-sorghum landraces collected from the western and south-western parts of Ethiopia were characterized using 22 morphological descriptors provided by PPV and FRA for DUS testing in sorghum. The aim of this research is to characterize Sorghum landraces morphologically for DUS traits collected from south-western Ethiopia. Results revealed diverse characters among the traits and the tested sorghum land races. The highest group was classified into 11 groups based on inflorescence compactness. The second diverse group was obtained by based on glume color traitssorghum landraces have six groups. The result divided the panicle exertion into five groups, the endosperm texture into five groups, the waxy bloom into four groups, the glume cover into three groups, and the leaf mid color into three groups. observed by each of the traits, endosperm color, grain luster, and grain form. The lowest (1 group) was characterized by stalk juiciness. All 83 (100%) tested landraces did not show the character of juiciness. Classification of genotypes based on DUS traits provided identification of key characteristics of various genotypes. Thus, the present clearly indicates the utilization of the PPV and FRA descriptors for the purpose of registration, maintenance, and protection of the collected sorghum land race.

Keywords*: DUS descriptors, land race, Morphological characterization*

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INTRODUCTION
The monocotyledon crop sorghum [Sorghum bicolor (L.) Moench] belongs to the Gramineae family. It is a naturally self-pollinated short-day plant with up to 30% spontaneous crosspollination depending on panicle kinds[1].Sorghums, both wild and cultivated, are diploid (2n = 2x = 20) and tropical in origin. It thrives in areas between the equator's 400N and 400S latitudes[2]. Sorghum is grown in both tropical and temperate settings, but it is most recognized for its tolerance to the world's semi-arid tropical (SAT) regions, which are prone to drought [1].

Sorghum is a staple food for more than 500 million people in 30 African and Asian countries. [3]. Sorghum is important for food security in Africa because of its drought tolerance and ability to withstand high temperatures and water logging. Because of its resistance to drought and other production constraints, sorghum is a key food and nutritional security crop for more than 100 million people in Eastern horn of Africa[4].

In Ethiopia, approximately 74% of total sorghum grain output is consumed at the household level, with the remaining being sold and used for seed at the local level. The grain is used to make a variety of local staple foods such as leavened bread (injera), porridge, and local beverages, all of which require specific grain quality characteristics. Additionally, the Stover, which is used for animal feed, fuel, and the construction of fences and shelters, is often valued as highly as grain yield, so farmers prefer taller varieties[5].

Planting of cereals Before the 1950s, it was made up of landraces, or local farmer's variety [6]. Landrace refers to a cultivated plant that has an unknown origin, is locally/environmentally suited, or has not undergone a rigorous breeding effort[7].Farmers have maintained and cultivated landrace variations for decades using a traditional method of selection. In a low-input agricultural system, an autochthonous landrace is a variety with a high capacity to endure biotic and a biotic stress, resulting in high yield stability and an intermediate yield level [8].

Ethiopia is known as one of the Vavilovian centers of origin, or diversification, for a variety of cultivated and wild crop species, including sorghum [9].Ethiopia has been identified as a center of origin and/or diversification for a number of grain crops, including sorghum. [10].

Sorghum is one of the most widely grown grains in the world. Over 95% of sorghum fields in Ethiopia are planted to landraces, and over 95% of the sorghum types farmed are farmer-selected landraces [11]. The wild (Sorghum bicolor subsp. arundinaceum) and cultivated sorghums are more likely to exchange genetic material since they both grow in sympathy with their wild and weedy cousins in most sorghum-growing areas of Ethiopia, primarily in the south-eastern and south-western regions [2]. Within a species, there was more genetic diversity, which was often taken as a measure of its ability to adapt to its new environment. As a result, biodiversity is a valuable resource for coping with environmental changes. Sorghum is one of the world's largest crop germplasm collections, with over 42,000 accessions[12,13].

The physical and genetic identification and classification of germplasm is made possible by characterization. Morphological characterization allows for the creation of a catalog of descriptors that are necessary for collection management or agricultural application[14]. Morphological characterization allows for the creation of a catalog of descriptors that are necessary for collection management or agricultural application[15]Therefore, a greater understanding of the genetic variety in sorghum crop species will undoubtedly aid in the morphological characterization of Sorghum germplasm for DUS features, as well as the future enhancement of this sorghum genetic architecture.

MATERIALS AND METHODS

The experiment was conducted at Assosa Agricultural Research Center on main growing season of 2017/18. Assosa Agricultural Research Center (AsARC) is located in the Benishangul-Gumuz Regional State at western part of Ethiopia which is 650 km far away from Addis Abeba and also its altitude 1547.The experimental material consists of 83 they have been maintained by farming community and research station and the experiment was planted in a randomized block design with three replications. The lines were grown in the 5 meter length with 75 cm (row to row) and the 15 cm (plant to plant) distance. All plots management practices were applied as per recommendation.

Data collection was made by randomly selecting and tagging 20 individual plants and a total of 22 traits such as leaf midrib color, waxy bloom ,Plant height up to base of flag leaf, Grain covering, glume color, Head compactness and shape, stalk juiciness, Inflorescence exertion, Tillering, Lodging, Over all plant aspect Shattering, grain size, endosperm color, Endosperm type, Endosperm texture, Gain plumpness, grain shape(profile view), Caryopsis/grain color, grain luster, Grain form and Threshebility was used for morphological characterization of landraces on the basis of DUS guidelines.

The accession used for the present study is listed in Table 1. The data was taken on the basis of DUS guidelines for Sorghum Distinctiveness for the traits were also checked for the all the genotypes. The descriptors and the time and way of taking data are described in Table 2. Grouping of sorghum germplasm was done by utilizing grouping characteristics which mentioned in the DUS test guidelines.

RESULT AND DISCUSSION

5th leaf stage

The color of the leaf midrib was used to differentiate genotypes at the fifth leaf stage. This character's genotypes were divided into three groups: white 27.71% (23 genotypes), yellow 68.67% (57 genotypes), and green 3.61% (3).These findings are consistent with those of[16,17].

Vegetative stage

Waxy bloom, which is a waxy coating on the surface of the internode that is somewhat present 42.16% (35 genotypes), medium48.19% (40 genotypes), substantially bloomy 8.43% (7genotypes), and entirely bloomy8.43% (7 genotypes) were used to define genotypes at the vegetative state 2.4%(2 genotypes). It has been experimentally proven that this waxy layer significantly reduces transpiration (20 to 30%), [18].It prevents water from clogging the stomata and preventing the passage of gases, according to [19].It also aids in the prevention of harm to the stem, blooms, and fruits by ants and other crawling insects. In regard to the process of production of the waxy covering, [18]has noted that that the wax did not come from chemical modification of the cuticle or other layers of the outer wall, as could be expected, but rather was a product of secretion.

Physiological Maturity stage

At maturity stage genotypes were characterized on the basis of five character the amount of grain covered by 25% glume cover computed 57.83% (48 genotypes),50% glume covered scored 32.53% (27genotypes) 75 and 100% glume cover 4.82% scored (4 genotypes).The second character was Glume color white1.20% (1genotypes),2.40% sienna(2 genotypes),20.48% red 36.14%(17genotypes) purple 40.96%(30 genotypes) and grey (34 genotype)(Table.2).

Genotypes were classified into eleven categories based on inflorescence compactness. Panicle is exceedingly flexible (typical of wild sorghum has scored 0.24% 2 genotypes), and primary branches are very loose and drooping 9.63% (8

genotypes) 7.22% (6 genotypes) loose erect primary branch, loose drooping primary branch 22.89 % (19 genotypes) Semi-loose erect primary branches 8.4% (7 genotypes), semi-loose drooping primary branches 19.27% (16 genotypes), semi-compact18.07% (15 genotypes), compact elliptic 10.8% (9 genotypes), compact oval 6.02%(5 genotypes),and half-broom corn 15.66% (13 genotypes).The number and growth of branches, or inflorescence architecture, is very important in this family because it directly affects s grain yield [20].There is no genotypes exhibit Stalk juiciness based on Stalk juiciness traits.

Genotypes were classified into four groups based on Panicle exertion: slightly exerted (2 cm but ligule of hag leaf definitely below inflorescence base16.86% (14 genotypes), (2-10cm between ligule and inflorescence base 36.14% (30 genotypes), well exerted (> 10 cm between ligule and inflorescence base39.74% (33 genotypes), and peduncle recurved (inflorescence below ligule and clearly exposed splitting 7.22 % (6 genotypes).

The genotypes were divided into three categories based on their threshability. The following genotypes were investigated: Very low83.13% (69 genotypes), low threshability1.20% (1 genotype), intermediate threshability10.84% (9 genotypes), and very high threshability4.81% (4 genotypes).The ease with which grains may be separated from panicles and glumes during threshing is a critical factor in sorghum utilization, especially in smallholder sorghum production when threshing is done by hand[21]. Some sorghum cultivars have grains that are securely connected to the panicle, making threshing difficult. As a result, a large portion of the grain is either rejected with the chaff, resulting in considerable postharvest losses, or gathered with the glumes still attached, resulting in significant quality and market value drop as the grains become less desirable to customers [21].

Based on the grain size genotypes of small size are 8.43% (7 genotypes), middle33.73% (28 genotypes), and large 57.83% (48 genotypes) sizes were identified. landraces were divided into two groups based on the endosperm color character: landraces with red color7.22% (6 genotypes) and genotypes with white color92.77% (77 genotypes). Based on endosperm type (47 genotypes) were normal types whereas 36 genotypes are waxy type 36 Variation in grain size, a major determinant of grain yield and quality in cereal crops, is determined by both the plant's genetic potential and the available assimilate to fill the grain in the absence of stress [22].

The genotypes were divided into five groups based on endosperm texture. There were 5 entirely corneous genotypes, 7 largely corneous genotypes, and 27 intermediate genotypes,23 genotypes that were largely starch and 21 genotypes that were fully starch. The genotypes were divided into two groups based on the grain plumpness trait. The number of dimple genotypes was 43, while the number of fat genotypes was 40. Based on Grain profile genotypes with narrow elliptic (8 genotypes), elliptic (25 genotypes), and 50 genotypes circular based on Grain profile. Based on various Caryopsis grain colors white 53.01(44 genotypes), yellow 30.12% (25 genotypes), red 6.02% (5 genotypes) and 10.84% (9 genotypes).

Grain luster are scored (75 genotypes) and not lustrous computed (8genotypes). Grain form twins (2 genotypes) and singles (81 genotypes).On the basis of tillering and lodging, 83 genotypes were found to have neither tillering nor lodging. On the basis of shattering genotypes, 2 groups were identified: 47 genotypes with a high level of shattering character and 36 genotypes with a low level of shattering character. Genotypes were classified into four groups based on plant agronomic aspects, with genotypes with high scores being placed in the first group (15 genotypes) There were 32 genotypes with an average score of 32, 24 genotypes with a below average score of 24, and 12 genotypes with a poor score of 12.

CONCULUSION

The present study shows that morphological description of 83-sorghum landraces based on the DUS descriptor can be effectively used for identification and grouping of sorghum landraces for further breeding programs. The results reveal that there is diverse character among the tested traits, Panicle shape is calculated as the highest group (11 groups), in contrast to stalk juiciness, which has the lowest (1 group), which means 83 (100%) of the tested landraces do not have the characteristics of juiciness. Using satisfied DUS criteria for all of these morphological descriptors protects the rights of plant breeders and farmers. Even though these morphological descriptors alone may not be sufficient for DUS criteria

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Conflicts of interest

There are no potential conflicts of interest

Table.1 List of Accession used for study

Plot#	Accession no	Plot#	Accession no	Plot#	Accession no	Plot#	Accession no	Plot#	Accession no
1	NJ 001	18	Ka018	35	Ya035	52	Ag055	69	Mok074
2	NJ 002	19	Ka019	36	Ya036	53	Bab056	70	Bam075
3	NJ 003	20	Ka020	37	Ya037	54	Bab057	71	Mok076
4	Boj004	21	Ka021	38	Ya038	55	Bab058	72	Mok079
5	Boj005	22	Ka022	39	ya039	56	Bab059	73	Mok081
6	Boj006	23	Ka023	40	Ya040	57	Ba060	74	Mok085
7	Boj007	24	Ka024	41	ya041	58	Ba061	75	Mok086
8	Boj008	25	Ka025	42	Ya042	59	Bab062	76	Bmb097
9	Boj009	26	Ka026	43	Ag044	60	Bab063	77	Bmb102
10	Ka010	27	Ka027	44	Ag045	61	Bab064	78	Rb109
11	Ka011	28	Ka028	45	Ag046	62	Ba065	79	Rb111
12	Ka012	29	Ya029	46	Ag047	63	Ba066	80	Ba118
13	Ka013	30	Ya030	47	Ag048	64	Ba067	81	Ba119
14	Ka014	31	Ya031	48	Ag049	65	Qon070	82	Ba120
15	Ka015	32	Ya032	49	Ag052	66	Qonn071	83	Ba121
16	Ka016	33	Ya033	50	Ag053	67	Qon072		
17	Ka017	34	Ya034	51	Ag054	68	Qon073		

Table.2 Descriptors used to characterize the present genotypes

No.	Parameters	States	Developmental stage
2.1	leaf midrib color	Yellow Green White	5thleaf stage
2.2	waxy bloom	Slightly present Medium Mostly bloom Completely bloom	Vegetative
2.3	Plant height up to base of flag leaf	Very short(<76cm) short (76-150 cm) medium (151-225 cm) tall (226-300 cm) very tall (>300 cm)	Panicle emergency
2.4	Grain covering	25% grain covering 50% grain covering 75%grain covering Grain fully covered Glumes longer than grain	Physiological maturity
2.5	glume color	White(whitegroup155D,155C,155B,155A)	Physiological maturity

2.6	Head compactness and shape	Very lax panicle(typical of wild sorghum) Very loose erect primary branches Loose erect primary branch Loose drooping Primary branch Semi-loose erect primary branch Semi compact elliptic Compact elliptic Compact oval Half broom corn Broom corn Others(not specify)	Physiological maturity
2.7	stalk juiciness	Juicy Not juicy	Physiological maturity
2.8	Inflorescence exertion		Flowering
2.9	Tillering	Absent Present	Physiological maturity
2.10	Lodging	Low Intermediate High	Physiological maturity
2.11	Over all plant aspect	Very good good average below average poor	Physiological maturity
2.12	Shattering	Very low Low Intermediate High Very high	Physiological maturity
2.13	grain size	Small Medium Large	After threshing
2.14	endosperm color	White Yellow	After threshing
2.15	Endosperm type	Normal Waxy Sugar	After threshing
2.16	Endosperm texture	Completely corneous Mostly corneous intermediate Mostly starch Completely starchy	After threshing
2.17	Gain plumpness	Dimple Plump	After threshing
2.18	grain shape(profile view)	Narrow elliptic elliptic circular	After threshing
2.19	Caryopsis/grain color	White(White group 155D 155C 155B 155A) Yellow (Yellow group 6 D 6C 6B 6A) Red(orange-Red- group164 B164 A164B164 A Brown(Browngroup33A33C33B33A33B33A) Buff greyed orange group(166B) Other	After threshing
2.20	grain luster	Absent	After threshing

		Present	
2.21	Grain form	Single Twins	After threshing
2.22	Threshebility	Freely threshable Partly threshable Difficult to thresh	After threshing

Accession no	Leaf midrib color	Waxy bloom	Plant height up to base of flag leaf	Grain covering	Glume color	Head compactness and shape	Stalk juiciness	Inflorescence exertion
NJ 001	White	Slightly present	Very tall	75% grain covered	Black	Semi loose drooping primary branches	Not juicy	Peduncle recurved
NJ 002	White	Slightly present	Very tall	25% grain covered	Grey	Semi loose drooping primary branches	Not juicy	Exerted 2-10cm
NJ 003	Yellow	Mostly bloom	Tall	25% grain covered	Grey	Compact elliptic	Not juicy	Well exerted> 10cm
Boj004	Yellow	Slightly present	Very tall	Grain fully covered	Grey	Half broom corn	Not juicy	Well exerted> 10cm
Boj005	White	Medium	Very tall	50% grain covered	Grey	Very lax panicle	Not juicy	Slightly exerted<2 cm
Boj006	White	Slightly present	Very tall	25% grain covered	Grey	Semi loose erect primary branches	Not juicy	Well exerted> 10cm
Boj007	Yellow	Medium	Very tall	25% grain covered	Black	Compact oval	Not juicy	Peduncle recurved
Boj008	Yellow	Slightly present	Very tall	25% grain covered	Black	Semi compact elliptic	Not juicy	Well exerted> 10cm
				25%		Loose		

				d				
Ka013	Yellow	Slightly present	Very tall	25% grain covered	Black	Semi loose drooping primary branches	Not juicy	Exerted 2-10cm
Ka014	Yellow	Medium	Very tall	25% grain covered	Red	Semi loose drooping primary branches	Not juicy	Slightly exerted<2 cm
Ka015	Yellow	Slightly present	Very tall	25% grain covered	Black	Semi loose drooping primary branches	Not juicy	Slightly exerted<2 cm
Ka016	Yellow	Slightly present	Very tall	25% grain covered	Purple	Loose erect primary branches	Not juicy	Well exerted> 10cm
Ka017	Yellow	Medium	Very tall	25% grain covered	Black	Semi compact elliptic	Not juicy	Well exerted> 10cm
Ka018	Yellow	Slightly present	Tall	25% grain covered	Purple	Semi loose drooping primary branches	Not juicy	Exerted 2-10cm
Ka019	Yellow	Slightly present	Very tall	25% grain covered	Purple	Semi loose drooping primary branches	Not juicy	Exerted 2-10cm
Ka020	Yellow	Medium	Very tall	25% grain covered	Purple	Very lax panicle	Not juicy	Exerted 2-10cm
Ka021	Yellow	Medium	Very tall	25% grain covered	Grey	Loose erect primary branches	Not juicy	Well exerted> 10cm
Ka022	Whit	Medium	Very	50% grain	Grey	Loose drooping	Not	Exerted 2-

Ka026	Yellow	Medium	Very tall	25% grain covered	Purple	Semi loose erect primary branches	Not juicy	Slightly exerted<2 cm
Ka027	Yellow	Medium	Very tall	50% grain covered	Purple	Loose erect primary branches	Not juicy	Exerted 2-10cm
Ka028	Yellow	Slightly present	Very tall	50% grain covered	Purple	Loose drooping primary branches	Not juicy	Slightly exerted<2 cm
Ya029	Yellow	Medium	Very tall	25% grain covered	Grey	Loose erect primary branches	Not juicy	Slightly exerted<2 cm
Ya030	Yellow	Medium	Very tall	50% grain covered	Purple	Loose erect primary branches	Not juicy	Well exerted> 10cm
Ya031	Yellow	Slightly present	Very tall	50% grain covered	Black	Loose drooping primary branches	Not juicy	Slightly exerted<2 cm
Ya032	Yellow	Medium	Very tall	25% grain covered	Black	Half broom corn	Not juicy	Exerted 2-10cm
Ya033	Yellow	Medium	Very tall	25% grain covered	Black	Compact oval	Not juicy	Peduncle recurved
Ya034	Yellow	Medium	Very tall	50% grain covered	Grey	Loose drooping primary branches	Not juicy	Well exerted> 10cm
Ya035	Yellow	Medium	Very tall	50% grain covered	Grey	Semi loose erect primary branches	Not juicy	Exerted 2-10cm
Ya036	Yellow	Mostly bloom	Tall	25% grain covere	Grey	Compact elliptic	Not juicy	Well exerted> 10cm

Ya040	Yellow	Slightly present	Very tall	Grain fully covered	Purple	Loose drooping primary branches	Not juicy	Well exerted> 10cm
ya041	Yellow	Slightly present	Very tall	25% grain covered	Purple	Very loose erect primary branches	Not juicy	Slightly exerted<2 cm
Ya042	White	Medium	Very tall	25% grain covered	Grey	Semi compact elliptic	Not juicy	Slightly exerted<2 cm
Ag044	White	Slightly present	Very tall	75% grain covered	Purple	Loose drooping primary branches	Not juicy	Slightly exerted<2 cm
Ag045	White	Slightly present	Very tall	25% grain covered	Black	Loose drooping primary branches	Not juicy	Slightly exerted<2 cm
Ag046	White	Slightly present	Very tall	75% grain covered	Black	Semi loose erect primary branches	Not juicy	Well exerted> 10cm
Ag047	Yellow	Slightly present	Tall	25% grain covered	Purple	Loose erect primary branches	Not juicy	Well exerted> 10cm
Ag048	Yellow	Medium	Very tall	25% grain covered	Grey	Half broom corn	Not juicy	Well exerted> 10cm
Ag049	Yellow	Medium	Very tall	50% grain covered	Grey	Compact oval	Not juicy	Peduncle recurved
Ag052	Yellow	Medium	Very tall	50% grain covered	Purple	Half broom corn	Not juicy	Well exerted> 10cm
Ag053	White	Slightly present	Very tall	50% grain covere	Black	Loose drooping primary	Not juicy	Well exerted>

Bab057	White	Medium	Very tall	50% grain covered	Grey	Semi compact elliptic	Not juicy	Well exerted> 10cm
Bab058	Yellow	Medium	Very tall	50% grain covered	Grey	Semi compact elliptic	Not juicy	Well exerted> 10cm
Bab059	Yellow	Medium	Very tall	50% grain covered	Grey	Semi compact elliptic	Not juicy	Exerted 2-10cm
Ba060	Yellow	Slightly present	Very tall	25% grain covered	Purple	Semi loose erect primary branches	Not juicy	Exerted 2-10cm
Ba061	White	Slightly present	Very tall	25% grain covered	Black	Semi loose drooping primary branches	Not juicy	Exerted 2-10cm
Bab062	White	Slightly present	Very tall	25% grain covered	Black	Semi compact elliptic	Not juicy	Exerted 2-10cm
Bab063	Yellow	Medium	Tall	25% grain covered	Grey	Semi compact elliptic	Not juicy	Exerted 2-10cm
Bab064	Yellow	Medium	Very tall	50% grain covered	Grey	Semi compact elliptic	Not juicy	Exerted 2-10cm
Ba065	Yellow	Completely Bloom	Medium	50% grain covered	Grey	Compact elliptic	Not juicy	Exerted 2-10cm
Ba066	Yellow	Medium	Very tall	25% grain covered	Purple	Compact elliptic	Not juicy	Exerted 2-10cm
Ba067	Yellow	Medium	Very tall	25% grain covere	Purple	Semi compact elliptic	Not juicy	Exerted 2-10cm

Qon072	White	Medium	Very tall	75% grain covered	Black	Semi compact elliptic	Not juicy	Slightly exerted<2 cm
Qon073	Yellow	Medium	Tall	75% grain covered	Grey	Very loose drooping primary branches	Not juicy	Slightly exerted<2 cm
Mok074	Yellow	Slightly present	Very tall	50% grain covered	Grey	Semi compact elliptic	Not juicy	Well exerted> 10cm
Bam075	Yellow	Medium	Very tall	25% grain covered	Grey	Semi compact elliptic	Not juicy	Well exerted> 10cm
Mok076	Yellow	Slightly present	Very tall	50% grain covered	Black	Semi loose drooping primary branches	Not juicy	Well exerted> 10cm
Mok079	Yellow	Slightly present	Very tall	25% grain covered	Black	Semi loose drooping primary branches	Not juicy	Well exerted> 10cm
Mok081	Yellow	Medium	Very tall	50% grain covered	White	Half broom corn	Not juicy	Exerted 2-10cm
Mok085	White	Mostly bloom	Tall	25% grain covered	Grey	Semi loose drooping primary branches	Not juicy	Exerted 2-10cm
Mok086	White	Mostly bloom	Very tall	50% grain covered	Grey	Semi loose drooping primary branches	Not juicy	Exerted 2-10cm
Bmb097	Yellow	Medium	Very tall	50% grain covered	Grey	Semi compact elliptic	Not juicy	Slightly exerted<2 cm

Ba118	Green	Slightly present	Very tall	25% grain covered	Black	Semi loose drooping primary branches	Not juicy	Well exerted> 10cm
Ba119	White	Medium	Very tall	75% grain covered	Grey	Very loose drooping primary branches	Not juicy	Well exerted> 10cm
Ba120	White	Mostly bloom	Medium	25% grain covered	Grey	Semi compact elliptic	Not juicy	Slightly exerted<2 cm
Ba121	Yellow	Medium	Very tall	Grain fully covered	Black	Semi loose erect primary branches	Not juicy	Exerted 2-10cm
Assosa-1	White	Medium	Medium	25% grain covered	Grey	Semi loose erect primary branches	Not juicy	Exerted 2-10cm
Adukara	Yellow	Medium	Medium	25% grain covered	Purple	Compact elliptic	Not juicy	Exerted 2-10cm

Accession no	Shattering	grain size	endosperm color	Endosperm type	Endosperm texture	Gain plumpness	grain shape(profile view	Caryopsis/ grain color	grain luster	Grain form	Threshebility
NJ 001	Very low	medium	white	Sugar	Mostly starch	Plump	Elliptic	Brown	Absent	single	Freely threshable
NJ 002	Very low	medium	white	Normal	Intermediate	Plump	Narrow elliptic	Brown	Absent	Single	Partly threshable
NJ 003	Very low	Large	white	Normal	Mostly starch	Dimple	Circular	Red	Absent	Single	Freely threshable
Boj004	Very low	Medium	white	Sugar	Completely starch	Plump	Elliptic	Brown	Absent	Single	Partly threshable
Boj005	Very low	large	White	Normal	Intermediate	Dimple	Circular	White	Present	Single	Freely threshable
Boj006	Very low	Medium	White	Normal	Intermediate	Plump	Elliptic	White	Absent	Single	Difficult threshable
Boj007	Very low	Medium	White	waxy	Completely corneous	Plump	circular	White	Absent	Single	Freely threshable
Boj008	Low	large	White	sugar	Mostly starch	Plump	circular	Red	Absent	Single	Freely threshable
Boj009	Very low	large	White	waxy	Intermediate	Plump	circular	Red	Absent	Single	Freely threshable
Ka010	Very low	Large	White	sugar	Mostly starch	Plump	circular	White	Absent	Single	Freely threshable
Ka011	Low	Large	White	sugar	Mostly starch	Dimple	circular	White	Absent	Single	Freely threshable
Ka012	Very low	Large	White	waxy	Mostly starch	Dimple	circular	White	Absent	Single	Freely threshable
Ka013	Very low	Large	White	sugar	Completely starch	Dimple	circular	White	Absent	Single	Freely threshable
Ka014	Low	medium	White	waxy	Intermediate	Dimple	circular	White	present	Single	Freely threshable
Ka015	Very low	large	White	sugar	Completely starch	Dimple	circular	Red	Absent	Single	Freely threshable
Ka016	Very low	medium	White	sugar	Completely starch	Dimple	elliptic	White	Present	Single	Freely threshable
Ka017	Very low	Large	White	Sugar	Completely starch	Dimple	circular	Red	Absent	Single	Freely threshable
Ka018	Very low	Large	White	waxy	Intermediate	Dimple	circular	Red	Absent	Single	Freely threshable

Ka019	Very low	Large	White	sugar	Completely starch	Dimple	circular	White	Absent	Single	Freely threshable
Ka020	Very low	Large	White	sugar	Mostly starch	Dimple	circular	White	Absent	Twins	Freely threshable
Ka021	Very low	Large	White	sugar	Completely starch	Dimple	circular	White	Absent	Twins	Freely threshable
Ka022	Very low	Large	White	Waxy	Completely starch	Dimple	circular	White	Absent	Single	Freely threshable
Ka023	Very low	Large	White	sugar	Completely starch	Dimple	circular	Red	Absent	Single	Freely threshable
Ka024	Very low	Large	White	waxy	Intermediate	Dimple	circular	White	Absent	Single	Freely threshable
Ka025	Very low	Large	White	sugar	Completely starch	Dimple	circular	Other	Absent	Single	Freely threshable
Ka026	Very low	Large	White	sugar	Intermediate	Dimple	circular	Other	Absent	Single	Freely threshable
Ka027	Very low	Large	White	waxy	Mostly corneous	Dimple	elliptic	Other	Absent	Single	Freely threshable
Ka028	Very low	Large	White	waxy	Mostly corneous	Plump	circular	Red	Absent	Single	Freely threshable
Ya029	Very low	medium	White	waxy	Intermediate	Plump	circular	White	Absent	Single	Freely threshable
Ya030	Very low	Large	White	Waxy	Intermediate	Dimple	circular	White	Absent	Single	Freely threshable
Ya031	Very low	Large	White	sugar	Completely starch	Plump	circular	Red	Absent	Single	Freely threshable
Ya032	Very low	Large	White	sugar	Completely starch	Dimple	elliptic	Red	Absent	Single	Freely threshable
Ya033	Very low	medium	White	Sugar	Intermediate	Plump	elliptic	White	Absent	Single	Freely threshable
Ya034	Very low	Large	White	sugar	Mostly starch	Plump	elliptic	Red	Absent	Single	Freely threshable
Ya035	Very low	Large	White	sugar	Mostly starch	Dimple	circular	Red	Absent	Single	Freely threshable
Ya036	Very low	Large	White	Sugar	Mostly starch	Plump	circular	Other	Absent	Single	Freely threshable
Ya037	Very low	Medium	White	Sugar	Mostly starch	Plump	circular	Red	Absent	Single	Freely threshable
Ya038	Very low	Large	White	Waxy	Mostly corneous	Dimple	circular	White	Absent	Single	Freely threshable

ya039	Very low	Medium	White	sugar	Mostly starch	Plump	circular	White	Absent	Single	Freely threshable
Ya040	Very low	large	White	waxy	Intermediate	Dimple	circular	Red	Absent	Single	Freely threshable
ya041	Very low	Large	White	Waxy	Intermediate	Dimple	circular	White	present	Single	Freely threshable
Ya042	Very low	medium	White	waxy	Intermediate	Dimple	circular	Other	Absent	Single	Freely threshable
Ag044	Very low	Large	White	Sugar	Mostly starch	Dimple	elliptic	Red	Absent	Single	Freely threshable
Ag045	Very low	Large	White	Sugar	Intermediate	Plump	circular	Red	Absent	Single	Freely threshable
Ag046	Very low	Small	White	waxy	Completely corneous	Plump	Narrow elliptic	White	Absent	Single	Freely threshable
Ag047	Very low	medium	Yellow	Sugar	Completely starch	Plump	elliptic	Brown	Absent	Single	Freely threshable
Ag048	Very low	Large	White	Waxy	Completely corneous	Dimple	circular	White	Absent	Single	Freely threshable
Ag049	Very low	medium	White	sugar	Completely starch	Plump	circular	White	Absent	Single	Freely threshable
Ag052	Very low	Large	White	sugar	Completely starch	Dimple	circular	White	Absent	Single	Freely threshable
Ag053	Very low	Large	White	sugar	Mostly starch	Plump	Narrow elliptic	White	Absent	Single	Freely threshable
Ag054	Very low	Medium	Yellow	waxy	Completely corneous	Plump	Narrow elliptic	Other	Absent	Single	Partly threshable
Ag055	Very low	small	white	waxy	Mostly corneous	Plump	Narrow elliptic	White	Absent	Single	Difficult threshable
Bab056	Very low	Small	yellow	waxy	Intermediate	Plump	circular	White	Absent	Single	Difficult threshable
Bab057	Very low	Medium	White	Sugar	Mostly starch	Dimple	circular	White	Absent	Single	Partly threshable
Bab058	Very low	medium	White	waxy	Mostly corneous	Dimple	Elliptic	Other	Absent	Single	Partly threshable
Bab059	Very low	Medium	White	Sugar	Completely starch	Plump	circular	White	Absent	Single	Freely threshable
Ba060	Very low	Large	White	sugar	Mostly starch	Dimple	Elliptic	White	present	Single	Freely threshable

Ba061	Very low	Medium	White	Sugar	Completely starch	Dimple	Elliptic	Red	Absent	Single	Freely threshable
Bab062	Very low	medium	White	Sugar	Completely starch	Dimple	Narrow elliptic	Red	Absent	Single	Freely threshable
Bab063	Very low	medium	yellow	sugar	Mostly starch	Dimple	circular	Other	Absent	Single	Freely threshable
Bab064	Very low	Large	White	sugar	Completely starch	Plump	circular	Red	Absent	Single	Freely threshable
Ba065	Very low	medium	white	sugar	Intermediate	Plump	circular	White	Absent	Single	Freely threshable
Ba066	Very low	Large	White	Sugar	Completely starch	Dimple	circular	White	Absent	Single	Freely threshable
Ba067	Very low	Large	yellow	sugar	Mostly starch	Plump	circular	White	Absent	Single	Freely threshable
Man068	Very low	Medium	yellow	sugar	Mostly starch	Plump	circular	White	Absent	Single	Freely threshable
Qon070	Very low	Large	White	Sugar	Mostly starch	Dimple	circular	White	Absent	Single	Freely threshable
Qonn071	Very low	Large	White	sugar	Mostly starch	Dimple	Elliptic	Red	Absent	Single	Freely threshable
Qon072	Very low	Large	White	waxy	intermediate	Dimple	elliptic	Red	Absent	Single	Freely threshable
Qon073	Very low	small	White	waxy	Mostly corneous	Plump	Narrow elliptic	White	present	Single	Partly threshable
Mok074	Very low	Medium	White	sugar	Intermediate	Plump	circular	White	Absent	Single	Freely threshable
Bam075	Very low	Large	White	Sugar	Mostly starch	Plump	circular	Red	Absent	Single	Freely threshable
Mok076	Very low	Medium	White	waxy	Intermediate	Dimple	circular	Other	Absent	Single	Freely threshable
Mok079	Very low	medium	White	Waxy	Intermediate	Plump	circular	White	Absent	Single	Freely threshable
Mok081	Very low	small	White	waxy	Mostly starch	Plump	elliptic	White	present	Single	Freely threshable
Mok085	Very low	Large	White	Sugar	Completely starch	Dimple	elliptic	Red	present	Single	Freely threshable
Mok086	Very low	medium	White	waxy	intermediate	Plump	circular	White	Absent	Single	Freely threshable
Bmb097	Very low	Large	White	sugar	Mostly starch	Plump	circular	Red	Absent	Single	Freely threshable

Bmb102	Very low	Medium	White	Waxy	Intermediate	Plump	elliptic	White	Absent	Single	Freely threshable
Rb109	Very low	Large	White	waxy	intermediate	Dimple	circular	White	Absent	Single	Freely threshable
Rb111	Very low	small	White	waxy	intermediate	Plump	Narrow elliptic	Red	Absent	Single	Partly threshable
Ba118	Very low	Large	yellow	waxy	Intermediate	Dimple	circular	White	Absent	Single	Freely threshable
Ba119	Very low	Large	White	waxy	Intermediate	Dimple	elliptic	White	Absent	Single	Freely threshable
Ba120	Very low	Large	White	sugar	Mostly starch	Plump	circular	White	Absent	Single	Freely threshable
Ba121	Very low	small	White	sugar	Completely starch	Plump	circular	White	Absent	Single	Difficult threshable
Assosa-1	Low	Medium	White	sugar	Mostly starch	Plump	circular	White	Absent	Single	Freely threshable
Adukara	Very low	Medium	White	sugar	Mostly starch	Plump	circular	Red	Absent	Single	Partly threshable

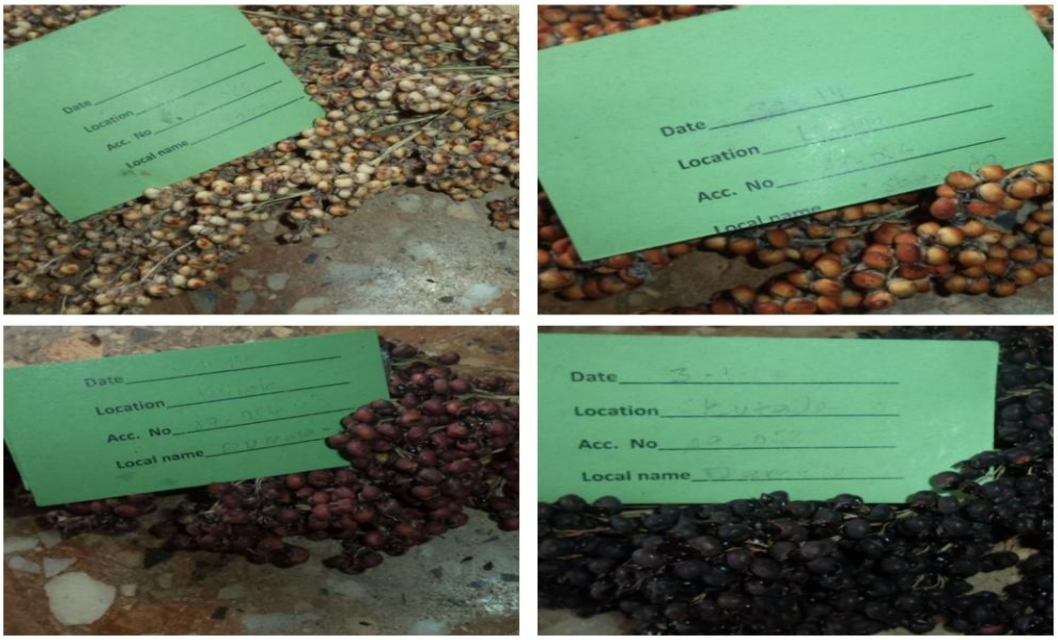

Fig. 1. Photo shows different caryopsis grain colors from the collected land race.

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