Registration of '*Jabaa*' Sorghum [*Sorghum bicolor* (L). Moench] Variety

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Abstract

Background: Sorghum [*Sorghum bicolor* (L). Moench] is a climate-resilient cereal crop that thrives in harsh environments where other cereal crops cannot perform well. In Ethiopia, sorghum can grow in a wide range of altitudes ranging from lowlands to highlands. It is currently serving as an important food security crop, and it is used for food, animal feed, and its stalks for constructing rural hut houses. Despite such merits, the production and productivity of the crop is hampered by a lack of acceptable sorghum varieties meeting the requirements of farmers and the market.

Objective: The study aimed to identify and develop high-yielding, stable, and disease-tolerant sorghum variety with farmer and market-preferred seed color for wider production and use.

Materials and Methods: Twenty sorghum genotypes including standard check variety (*Bonsa*) were evaluated using Randomized Complete Block Design (RCBD) with three replications at Bako, Gute, and Bilo areas during 2017–2019 under rain-fed conditions. All agronomic practices were applied per recommendation. Data were collected on phenological, agronomic, and yield traits, then subjected to analysis of variance.

Results: The results of the study have revealed that there were significant variations among the tested sorghum genotypes, with [ETSL 101259 (Acc. 200161)] named "*Jabaa*" being the most superior to the other genotypes with a mean grain yield of 3.9 t ha^{-1} and other merits. Additive Main effect and Multiplicative Interaction (AMMI) and Genotype and Genotype by Environment (GGE) bi-plot also indicated that this genotype [ETSL101259 (Acc. 200161)] was found to be the most stable and high-yielding among the tested genotypes. In addition, *Jabaa* is a white-seeded variety exhibiting disease tolerance and meeting the criteria for farmers' preference and market demand. Furthermore, "*Jabaa*" showed about a 44.4% yield advantage over the best standard check variety, *Bonsa*.

Conclusion: The results of the present study revealed that, among the tested genotypes, *Jabaa* [ETSL101259 (Acc. 200161)] was found to be a high yielder, stable and tolerant to sorghum foliar and panicle diseases, and resistant to bird attacks and lodging. Furthermore, the variety's white grain color has a high demand in the market and is an additional merit. Having such merits, the Ethiopian Variety Release Standing Committee has officially approved [ETSL101259 (Acc. 200161)] release of the new variety with the breeder name "*Jabaa*" for wider cultivation and use in Ethiopia.

Keywords: Diseases; Genotype; Sorghum; Stability; Variety; Yield

1. Introduction

Sorghum is the fifth most important cereal crop globally, cultivated on 40.8 million hectares, with a total production and average grain yield of 57.6 million metric tons and 1.4 tons ha^{-1}, respectively. Africa has contributed significantly to world sorghum production, with 29.1 million hectares in total production yielding 29.6 million metric tons (FAOSTAT, 2022). Sorghum is a significant grain crop with widespread agroecological adaptation in Ethiopia. It is grown in the highlands, lowlands, and semi-arid regions of Ethiopia with a range of altitudes (500 to 2300 meters above sea level), especially in moisture-stressed areas where other cereal crops perform the least. It is the main staple food crop on which the lives of millions of poor Ethiopians depend. Ethiopia is the third largest producer of sorghum in Africa behind Nigeria and Sudan with 1.6 million hectares, a total production of 4.2 million metric tons with an average grain yield of 2.5 t ha^{-1} (FAOSTAT, 2022).

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Oromia regional state is the top producer of sorghum in Ethiopia, with about 2.2 million households producing sorghum on 612,806 hectares of land, yielding 16 million metric tons (CSA, 2022). However, the current productivity of sorghum in Ethiopia is 2.5 t ha^{-1}, significantly below the potential yield of 7.2 t ha^{-1} (FAOSTAT, 2022). The low yield of sorghum production is associated with both biotic and abiotic stresses. Furthermore, the limited availability of high-yielding and stable cultivars that are tolerant to abiotic and biotic stresses is the leading constraint (Kebede Dessalegn *et al.*, 2023).

Intermediate and low-altitude areas in the western and southwestern parts of Ethiopia provide sufficient moisture and other climatic conditions for optimal sorghum production (Weerasooriya *et al.*, 2016). However, sorghum production in these regions faces additional hurdles, particularly from foliar and panicle diseases, as a result of which significant losses in yields occur. Moreover, efforts to introduce improved sorghum varieties to these areas have been hindered by challenges such as susceptibility to diseases like grain mold and various leaf diseases (Weerasooriya *et al.*, 2016, Nida *et al.*, 2019). Additionally, bird attacks, lodging problems, maturation periods that do not align with erratic rainfall conditions, and lack of farmer-preferred traits such as grain quality and grain size are other bottlenecks (Girma Mengistu *et al.*, 2019). Despite attempts by the Bako Agricultural Research Center to release improved sorghum varieties, widespread adoption has been limited, primarily due to the leading climate change. Addressing these challenges is crucial to enhancing sorghum production and improving food security in western Ethiopia. Therefore, this study aimed to identify and develop high-yielding, disease-resistant, and stable sorghum varieties from local sorghum landraces and elite lines to boost sorghum production and productivity to sustain profitable production of the crop and enhance food security in the region.

2. Varietal Origin and Evaluation

Jabaa [ETSL 101259 (Acc. 200161)] was originally collected by the Ethiopian Biodiversity Institute (EBI) from Oromia Regional State, West Haraghe Zone, Tulo district, Ethiopia. ETSL 101259 pedigree name was given by Ethiopian sorghum national program while Acc. 200161 is the original pedigree named by Ethiopian Biodiversity Institute (EBI) at the time of collection. Then, the variety was developed through intensive selection. *Jabaa* and other nineteen sorghum pipeline genotypes including the standard check variety *Bonsa* were evaluated at Bako, Gute, and Bilo areas during 2017–2019. The brief descriptions of the testing sites along with respective sites' metrological data are presented in Table 1.

Table 1. Description of the testing sites.

Environment	Longitude	Latitude	Altitude (m a.s.l.)	Annual rainfall (mm)	Min−Max T°
Bako	37° 09'E	09° 06'N	1650	1215.45	14.1–28.4 °C
Bilo	37° 00'E	08° 54'N	1762	1368.00	14.2–27.4 °C
Gute	36° 09'E	09° 06'N	1915	1431.00	14.1–27.0 °C

Note: *m a.s.l. = Meter above sea level; Min T° =Minimum temperature; and Max T° = Maximum temperature.*

3. Agronomical and Morphological Characteristics

The released variety, *Jabaa* [ETSL101259 (Acc. 200161)] is characterized by a white seed color, an average weight of 26.1 g per 1000 seeds, an average plant height of 225.3 m, and took about 150 days to mature (Tables 3 and 4).

4. Yield Performance

The multi-location and multi-year evaluations at Bako, Gute, and Bilo (2017–2019) data records indicated that *Jabaa* [ETSL101259 (Acc. 200161)] was found to be a high yielder and more stable variety with a grain yield amounting to 3.9–4.2 t ha^{-1} and 3.5–3.8 t ha^{-1} on the research stations (Table 2) and farmers' fields (Table 4), respectively.

Table 2. Mean grain yield (t ha^{-1}) and disease reaction of sorghum genotypes across locations and years during 2017−2019 cropping seasons in Ethiopia.

Genotype	Bako		Bilo			Gute					
	2018	2019	2017	2018	2019	2018	2019	Mean	ANTH	GM	TLB
ETSL 101168	5.9	3.4	1.4	3.4	2.6	5	2.7	3.5	3	2	2
ETSL 101757	4.6	1.6	1.7	2.0	1.7	4.5	2.7	2.7	4	1	3
10 line 2A	3.8	0.9	1.5	2.0	0.2	5.5	3.1	2.4	4	2	2
ETSL 101343	5.0	2.0	3.1	2.2	1.5	4.7	2.4	3.0	3	1	1
8 line 2C	4.2	1.3	1.8	1.0	0.4	2.3	2.6	1.9	5	2	3
ETSL 101066	4.0	2.6	2.9	2.4	2.5	4.5	3.4	3.2	3	1	2
ETSL 101327	3.9	2.4	2.4	2.7	1.9	4.7	2.1	2.9	4	1	2
ETSL 101691	5.1	3.1	2.9	3.8	2.5	5.4	3.0	3.7	3	2	2
ETSL 100548	4.9	1.1	2.2	2.1	1.1	4.2	1.6	2.5	4	1	3
ETSL 100618	4.8	2.6	3.7	2.6	2.6	5.7	4.0	3.7	3	2	2
ETSL 100657	4.9	2.3	3.2	3.4	2.2	5.0	3.4	3.5	3	2	2
ETSL 100621	4.7	2.7	2.6	2.2	1.3	4.2	3.1	3.0	3	1	2
ETSL 100406	4.7	2.9	1.7	2.2	1.9	3.5	3.1	2.9	4	2	3
ETSL 101581	4.4	2.7	3.4	1.5	1.2	5.2	2.1	2.9	3	2	2
ETSL 100124	4.7	3.1	4.3	2.6	2.8	3.6	3.0	3.4	3	1	2
16 line 1A	4.0	1.2	2.7	2.2	0.4	4.2	1.9	2.4	4	2	2
8 line 2A	5.8	2.9	2.8	3.9	1.9	6.0	3.4	3.8	2	1	2
ETSL 101259	6.7	3.0	3.3	2.4	2.9	5.6	3.6	3.9	2	1	2
ETSL 100587	5.4	2.7	2.4	2.5	1.8	1.8	2.2	2.7	3	2	2
Bonsa	4.2	1.7	2.7	2	2.6	2.4	3.6	2.7	3	1	2
Mean	4.8	2.3	2.6	2.5	1.8	4.4	2.8	3	3.3	1.5	2.2
LSD	1.3	0.6	0.6	0.5	0.4	0.9	0.8	0.3	0.5	−	1.3
CV (%)	16.1	15	14.5	12.8	14.1	11.7	16.4	5.9	6.9	10.2	11.2
F-test at 5%	**	**	**	**	**	**	**	**	**	ns	*

Note: ** = *Highly significant at P ≤ 0.01;* * = *Significant at P ≤ 0.05;* ns = *Non-significant at P ≤ 0.05; ANTH = Anthracnose (1–5 scale); GM = Grain mold (1–5 scale); TLB= Turcicum leaf blight (1–5 scale); LSD = Least significant difference; and CV = Coefficient of variation (%).*

5. Stability Analysis

The GGE biplot and AMMI analysis showed that Jabaa [ETSL101259 (Acc. 200161)] was high-yielding and stable, which resulted in about 44.4 % (3.9 t ha^{-1}) yield advantage over the standard check *Bonsa* (2.7 t ha^{-1}) by about 44.4% (Table 2, Figures 1 and 2). Consistent with this result, Eberhart and Russell (1966) also revealed that *Jabaa* variety showed a regression coefficient (bi) closer to unity and thus is a more stable and widely adaptable variety than the remaining genotypes (data not presented). The detailed genotype by environment interaction and stability analysis of this activity during its Regional Variety Trial (RVT) was published (Chemeda Birhanu *et al.,* 2021).

Table 3. Mean agronomic performance of sorghum genotypes across environments during 2017−2019 cropping seasons in Ethiopia.

Entry number	Genotype	DF	DM	PH	TKW	PL	PY
1	ETSL 101168	90.2	149.3	248.7	24.0	25.2	82.9
2	ETSL 101757	83.0	147.0	192.8	27.2	18.3	61.1
3	10 line 2A	95.2	153.9	148.1	19.0	24.2	70.5
4	ETSL 101343	89.2	148.5	256.4	25.5	18.1	67.5
5	8 line 2C	89.7	153.9	129.1	26.6	23.7	64.6
6	ETSL 101066	89.6	152.2	219.8	32.3	26.2	63.7
7	ETSL 101327	89.0	149.8	278.5	30.4	23.8	66.7
8	ETSL 101691	89.2	152.0	264.2	26.4	26.8	89.7
9	ETSL 100548	96.8	154.8	200.5	24.4	22.0	83.4
10	ETSL 100618	84.2	152.0	271.1	28.2	25.4	88.5
11	ETSL 100657	88.9	151.6	229.2	28.1	22.1	102.2
12	ETSL 100621	86.9	154.2	233.5	29.7	21.8	78.5
13	ETSL 100406	86.7	148.0	234.7	28.3	21.1	68.3
14	ETSL 101581	89.3	147.3	235.1	23.5	25.6	76.4
15	ETSL 100124	82.7	147.2	239.9	31.8	28.1	84.3
16	16 line 1A	93.8	155.2	199.1	25.9	23.1	63.2
17	8 line 2A	90.0	156.1	234.4	24.5	27.2	95.8
18	ETSL 101259	94.0	152.3	225.3	26.1	21.3	98.0
19	ETSL 100587	84.3	163.3	225.8	27.8	26.2	63.5
20	Bonsa	94.7	156.7	196.1	25.6	19.8	67.5
	Mean	89.4	152.3	223.1	26.8	23.5	76.8
	LSD	6.6	–	30.9	2.9	2.5	13.8
	CV	12.2	20.8	22.8	18.0	17.7	29.5
	F-test at 5%	**	ns	**	**	**	**

Note: ** = *Highly significant at P ≤ 0.01;* ns = *Non-significant at P ≤ 0.05; DF = Days to flowing; DM = Days to maturity; PH = Plant height (cm); TKW = Thousand kernel weight; Pl = Panicle length (cm); PY = Panicle grain weight (gm); LSD = Least significant difference; and CV = Coefficient of variation (%).*

Table 4. Agronomic and morphological description of "*Jabaa*" sorghum variety.

Crop	Sorghum [*Sorghum bicolor* (L). Moench]
Variety	*Jabaa* [ETSL101259 (Acc. 200161)]
Agronomic and morphological characteristics	
Adaptation area	Bako, Gute, Bilo Boshe, and Uke and similar areas of agro-ecologies of Ethiopia
Altitude (m a.s.l.)	1500–1900
Rainfall (mm)	1100–1200
Seed rate (kg ha^{-1})	12
Spacing (cm)	75 (between rows) and 20 (between plants)
Sowing date	Early to mid-May
Fertilizer rate (kg ha^{-1})	• NPS: 100 (at sowing), • Urea: 100 (½ of the total does at sowing and the rest ½ at 35 days after planting)
Days to flowering	194
Days to maturity	150
Thousand kernel weight (g)	26.1
Plant height (cm)	225.3
Seed color	White
Inflorescence compactness	Compact
Crop pest reaction	Tolerant to major sorghum diseases (anthracnose, grain mold, leaf blight, rust, and smut) and bird attack
Grain yield (ton ha^{-1})	•Research station: 3.9–4.2 •Farmers' field: 3.5–3.8
Year of release	2022
Breeder/maintainer	Bako Agricultural Research Center

6. Reaction of Released Variety to Disease

The variety was evaluated in western Ethiopia, where environmental conditions (high precipitation, humidity, and warm temperature) exacerbate foliar and panicle diseases. *Jabaa* exhibited tolerance to anthracnose, grain mold, and leaf blight, which are important sorghum diseases (Table 2).

7. Conclusion and Recommendation

It is concluded that [ETSL101259 (Acc. 200161)] sorghum genotype was found to be superior in terms of yield, stability, pest tolerance, and acceptable seed color to the other tested genotypes. Thus, this genotype has a yield advantage of 44.4 % over the standard check variety (*Bonsa*). Having such merits, the Ethiopian Variety Release Standing Committee has officially approved this genotype as a new variety with breeder name "*Jabaa*" for Western Oromia and similar agroecological zones in Ethiopia. However, the variety has to be delivered to the target users.

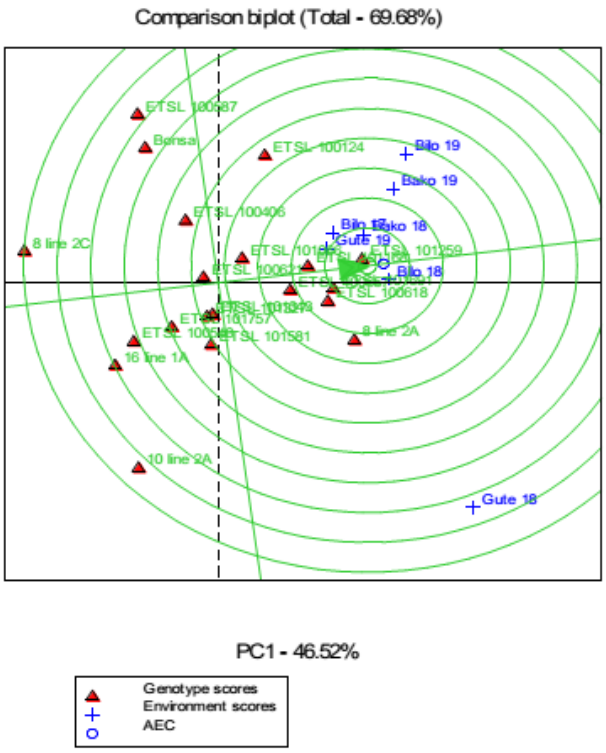

Figure 1. GGE Biplot analysis showing mean grain yield stability of sorghum genotypes and environments in Ethiopia.

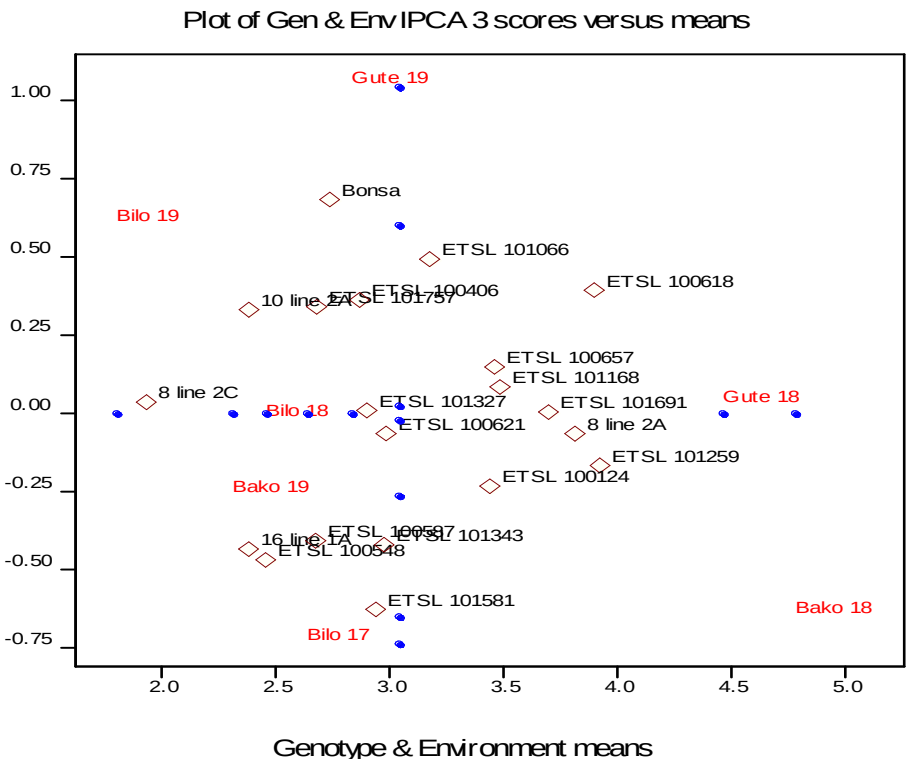

Figure 2. AMMI Biplot showing genotypes grain yield stability and preferential adaptation over the environment.

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