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Registration of Newly Released Durum Wheat (*Triticum turgidum*) Variety "Jarra" in Ethiopia

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ABSTRACT

Breeder's primary objective is developing a new crop varieties including durum wheat that are high yielding, high quality, stress tolerant, uniform, stable and demand based. Including two checks eighteen durum wheat genotypes were studied for three years at Sinana on main station and Agarfa locations. Jarra is newly released durum wheat variety developed crossing made at Sinana Agricultural Research Center. Including two checks eighteen genotypes were evaluated for three consecutive years. Statistical analysis (Gen stat) revealed that, Jarra gave the highest grain yield (5 tha^{-1}) compared with other genotypes. Moreover, Jarra is the most preferable variety and more accepted for production. Totally, Jarra variety recommended for production for wide agro-ecological range mid to highland areas of Ethiopia.

Keywords: *Disease Reaction, Quality, Importance and Durum Wheat.*

1. Introduction

Wheat is the main source of food, feed and industrial raw materials and is grown on about 222 million hectares worldwide, with a world production of around 771 million tons in 2020/2021 cropping season [1]. Similarly in Ethiopia durum wheat is produced on large area of land. From the total wheat area in Ethiopia was reported to be about 2.1 million hactares, of which durum wheat accounts for approximately 20-25% [2].

Durum wheat (*Triticum turgidum* ssp. durum), known as macaroni wheat, is a tetraploid wheat species (2n = 4x = 28, AABB genome) primarily used for macoroni, pasta, couscous, and locally some types of bread. The domestication of wheat/durum wheat was a key step in the Neolithic agricultural revolution and has played a crucial role in global food [3 , 4]. This crop/durum wheat itself was derived from domesticated *dicoccum*/emmer wheat through mutations that eliminated hulled grains, giving rise to free-threshing tetraploid forms such as *T. turgidum* ssp.[5]. Through the long-time evolution, this species has acquired a diverse set of characteristics [6]. Ethiopia is one of a center of diversity for tetraploid wheat [7]. Hence, the species exhibits tremendous variability for different traits, including resistance to *Septoria tritici* blotch and different diseases[8].

Durum wheat importance was linked to its wide adaptation to different agro-ecologies but, also to the high yields resulting from genetic improvement through different breeding methodologies[9]. Durum wheat genetic selection began, as a consequence of the actions of the durum wheat producers/farmers who choose the best ear for the next planting season, and after realized by breeders following the genetic laws with the main aim to obtain populations adapted to different agro-ecolies and with acceptable quality and grain yield of durum wheat [10, 11, 12]. In addition to the start of modern breeding during 20th century; many conditions such as climatic factors, soil fertility and nutrient management, different agronomic practices, market dynamics and disease pressure focused on selection of resistance varieties were radically changed the characteristics of durum wheat [13, 14, 10, 15, 16, 17]. So the success of durum wheat breeding programs in releasing high yield, resistance and quality cultivars able to compete with bread wheat and fulfills highly emerging past-macaroni industries across wide world.

Generally, durum wheat plays a critical role in food security and industrial processing. Despite major advances in breeding, several gaps remain that hinder durum wheat productivity and quality improvement are; narrow genetic base, abiotic stress tolerance, biotic stress resistance, grain quality and end-use traits, low-input adaptation. This state, continuous improves and release of acceptable varieties with high yield, quality, tolerant to biotic and abiotic stresses as well as adapted varieties to wider environmental range. Totally the objective of this paper presents the overall performances of newly released durum wheat variety Jarra suitable for optimum areas of Bale Zone and similar agro ecologies of, Ethiopia.

2. Materials and Methods

Including two checks (Bulala and Ingilize) eighteen durum wheat lines obtained from durum wheat crossing made at Sinana Agricultural Research Center (SARC) were tested for three consecutive years (2020-2023). The trial was evaluated at two locations namely; Sinana and Agarfa representing durum wheat production areas of Ethiopia. All experimental locations are characterized by bi-modal rainfall pattern. Randomized complete block design having three replications was used for the evaluation of the trial. The plot size was 6 rows of 2.5m long (3m^2) with 0.2m inter-row spacing. Finally, two candidates (tate/dire 2012BSnR/DWC-21 and tate/ dire2012BSnR/ DWC-4) were selected from 18 tested genotypes that were verified across environments. The two selected genotypes were verified at multi locations and tested along with two recently released varieties with Begna and Bulala as standard checks.

The experiment was conducted during 2023/4 at four locations (Sinana, and Agarfa) two sites at each location. None replicated 10m x 10m plot size was used for evaluation of genotypes. For this study the seed rate used was 150 kg/ha^{-1}. Similarly, 200kg^{-1} and 150kg/ha^{-1} Urea and NPSB were applied for the trial respectively. Based on recommendation 1/3rd Urea was applied at planting time and the remaining 2/3rd Urea was applied at plant tillering stage. Planting was done by hand drilling and weed managements were controlled by using hand weeding as well as herbicide called Pallas 45OD was used at recommended rate and time of application. Finally for variety release, Farmers participatory variety selection was allowed. Similarly, NVRC committee was evaluated all locations and decided Jarra to release for production.

2.1. Materials Origin and Evaluations

Jarra is a new durum wheat variety with the pedigree of tate/dire2012BSnR/DWC-21 that originated from durum wheat crossing made at Sinana Agricultural Research Center. As a result of Jarra (tate/dire2012BSnR/DWC-21) consistently out-yielded, quality and wider adapted, it was verified during 2023/4 main cropping season. Consequently, Jarra variety showed superior agronomic performances over standard checks Begna and Bulala at all studied locations. After Jarra evaluated by the National Variety Releasing Committee (NVRC) across studied areas it; was decided to release for the mid to highland areas of Southeastern Ethiopia.

3. Results

3.1. Morphological Characteristics

The newly released variety Jarra exhibited superior agronomic performance across all tested locations (Sinana, and Agarfa). It is characterized by medium plant height (89.2 cm), erect growth habit, good tillering capacity, and long compact ears. Jarra reached heading in 69 days and physiological maturity in 135 days (Table, 1). Its thousand kernel weight (TKW) was 34.13 g and hectoliter weight (HLW) 82.40 kg/hl, both superior to the standard checks. Jarra has Medium height, good tillering capacity, lodging tolerant, open leaf growth and erect stem growth habit, good plant stand, compact ear type, slightly long seed, tuff stem are governed by this variety. Some parameters describe Jarra variety and adaptation areas are listed in Supplementary Table 1.

Table 1. Combined data analyzed of 18 durum wheat genotypes tested for three consecutive years (2020-2023)

SN.	Pedigree	Agronomic performance						Disease reaction	
		DH	DM	PLH	GY	TKW	HLW	YR	SR
1	obsa/dire2012BSnR/DWC-3	66	133	81.33	4.3	34.52	80.04	5ms	20s
2	ejersa/obsa2012BSnR/DWC-20	67	133	88.83	4.3	35.23	81.18	10ms	15s
3	ejersa/obsa2012BSnR/DWC-20	65	134	86.28	4.0	35.43	79.31	10ms	20s
4	tate/dire2012BSnR/DWC-23	65	133	78.50	3.8	30.40	78.24	15ms	15s
5	toltu/dire2012BSnR/DWC-8	67	133	79.28	3.8	31.68	80.33	10ms	50s
6	tate/dire2012BSnR/DWC-9	68	134	80.22	3.9	31.57	81.31	10ms	40s
7	**tate/dire2012BSnR/DWC-4**	**68**	**133**	**83.28**	**4.7**	**33.17**	**82.04**	**5ms**	**10ms**
8	tate/toltu2012BSnR/DWC-16	66	133	83.72	4.3	39.00	82.04	15ms	30s
9	tate/toltu2012BSnR/DWC-10	63	133	83.50	3.5	39.63	81.62	20s	25s
10	ejersa/obsa2012BSnR/DWC-25	63	133	81.61	3.7	32.32	78.67	10ms	25s
11	Bulala	62	132	86.28	4.0	36.39	78.56	10ms	50s
12	ejersa/obsa2012BSnR/DWC-18	66	132	77.94	4.4	31.43	80.10	trms	10ms
13	**tate/dire2012BSnR/DWC-21**	**69**	**134**	**89.22**	**5.0**	**34.13**	**82.40**	**5ms**	**10ms**
14	ejersa/obsa2012BSnR/DWC-23	68	134	90.11	4.5	35.64	81.22	10ms	15s
15	ejersa/obsa2012BSnR/DWC-19	64	133	79.44	4.0	30.19	78.49	10ms	20s
16	ejersa/obsa2012BSnR/DWC-28	67	134	80.28	3.8	29.51	79.98	10ms	15s
17	tate/dire2012BSnR/DWC-2	66	133	95.72	4.0	33.20	80.76	20s	30s
18	Ingilize	63	133	113.28	3.9	39.48	79.64	20s	10s
Mean		**66.0**	**133.0**	**85.5**	**4.1**	**34.1**	**80.3**		
CV%		**21.0**	**3.1**	**1.7**	**6.5**	**9.3**	**2.9**		
SE		**0.7**	**4.2**	**4.8**	**30.8**	**10.0**	**5.3**		
LSD%		**0.6**	**1.4**	**1.4**	**3.6**	**2.1**	**1.5**		

Note:-*DH: days for heading, DM: days for mature, PLH: plant height (cm), TKW: thousand kernel weight (gm), HLW: hector-liter weight(kg/hl), GY: grain yield, SR: stem rust (%), YR: yellow rust (%), S: Susceptible, MS: moderate susceptible, Mr: Moderate tolerant, Trms: tolerant and moderately susceptible , Trmr: Trace with moderately resistant, R: Resistant, CV(%): Coefficient of variations, SE: standard error, LSD: Least significant differences.*

3.2. Grain Yield Performance

Grain yield of Jarra ranged from 5.0–5.6 t/ha under research fields and 4.7–5.0 t/ha under farmers' fields, surpassing the standard checks Bulala and Ingilize (Table, 2). Combined three-year data (2020–2023) indicated that Jarra yielded 56.3% higher than Bulala and 66.7% higher than Ingilize at Sinana during 2020 (Table 3). The highest yield (5.6 t/ha) was recorded in 2021 at Sinana (Table, 2).

Table 2. Mean yield performance of 18 durum wheat genotypes evaluated under nine Environments, tha^{-1}

Genotypes	Mean grain yield at each environment (tha^{-1})						Mean
	Year 2020		Year 2021		Year 2022		
	Sin	Agf	Sin	Agf	Sin	Agf	
G1	1.63	3.20	4.46	2.95	3.64	2.17	2.99
G2	3.67	4.52	5.42	3.84	4.47	3.95	3.68
G3	4.13	4.07	5.29	3.08	2.80	4.50	3.39
G4	3.60	4.28	4.58	2.55	3.82	3.02	3.19
G5	3.89	3.61	5.22	2.99	4.86	1.99	3.25
G6	4.00	3.25	4.85	3.32	4.42	3.43	3.27
G7	**4.93**	**4.35**	**5.43**	**4.63**	**4.96**	**4.26**	**4.51**
G8	3.82	4.40	5.57	3.47	4.37	2.32	3.38
G9	1.87	4.43	4.33	1.99	2.73	2.41	2.95
G10	4.40	4.04	3.60	3.47	4.01	2.90	3.24
G11	3.19	4.02	4.82	3.16	5.36	3.28	3.39
G12	3.36	4.23	5.03	3.81	4.67	3.96	3.63
G13	**5.20**	**5.47**	**6.20**	**5.13**	**5.23**	**5.03**	**5.14**
G14	4.50	4.31	5.03	4.01	5.17	3.80	3.66
G15	2.62	4.27	4.56	2.57	3.91	3.05	3.43
G16	3.75	4.22	4.78	2.63	3.65	3.95	3.06
G17	3.74	4.21	6.03	3.87	4.12	3.23	3.99
G18	2.97	3.59	4.70	3.88	4.82	3.71	3.35
Mean	**3.63**	**4.14**	**4.99**	**3.41**	**4.28**	**3.39**	**3.53**

***Note**: tha^{-1}: ton per hector, G: Genotype, Sin: Sinana, Agf: Agarfa*

Table 3. Statistical analysis of yield data

Years	Locations	EMS	Total yield of proposed Candidate **(t/ha)tate/dire2012SnR/DWC-21 (*Candidate#1 plot#13*)**	Percent of *candidate* over Bulala in the trial	Percent of *candidate* over Ingilize in the trial
2020	Sinana	0.50	5.0	56.3%	66.7%
	Agarfa	0.66	5.0	25.0%	38.0%
2021	Sinana	0.53	5.6	16.7%	19.1%
	Agarfa	0.73	4.8	50.0%	23.1%
2022	Sinana	0.93	5.1	-5.6%	6.3%
	Agarfa	0.51	4.7	42.4%	27.0%

3.3. Quality Characteristics

Jarra exhibited desirable quality traits with 13.3% protein content and 25.9% gluten, meeting flour industry standards. Its amber seed color, higher hectoliter weight, and high TKW make it a preferred variety for semolina and pasta production. Similarly the released variety has amber seed color that recorded 45.1g for thousand kernel weight and 83.9 kg/L for test weight (Table 4).

Table 4. Mean studied traits verified over locations

Genotypes	Yield and phenology traits				Quality traits					Disease reaction		
	DH	DM	PLH	GY	Protein	Gluten	Mc	TKW	HLW	YR	SR	LR
Benga	66	140	85.8	4.8	13.0	27.6	12.3	36.0	83.0	10ms	5ms	0
Jarra	68	138	88.3	5.1	13.3	25.9	11.9	36.0	82.5	5ms	10ms	0
Bulala	59	142	87.1	4.1	11.6	21.5	12.2	36.3	78.6	10ms	10s	0

***Note:** Mc; moisture content*

3.4. Disease Reaction

Across all test locations, Jarra showed moderate resistance to major wheat diseases, including yellow rust (5% MS) and stem rust (10% MS). It was also tolerant to lodging and major insect pests. Generally, among studied genotypes Jarra variety has adequate tolerant to all the three rusts of stem, yellow and leaf rusts (Table 2 and 4).

3.5. Stability Performance

Stability analysis using the Eberhart and Russell (1966) model confirmed that Jarra (G13) had a unity regression coefficient (bi=1) with high mean yield, indicating wide adaptability and stable performance across multiple environments (Table 5).

Table 5. AMMI Stability Value

Genotypes	Mean	ASV	rASV	rYSI	GSI	IPCAg[1]	IPCAg[2]
G1	4.498	0.5615	11	3	14	-0.29446	-0.13283
G2	3.936	1.3120	20	13	33	-0.69273	0.27276
G3	3.748	1.0767	19	20	39	0.44862	-0.68448
G4	4.307	0.6645	16	5	21	-0.31147	-0.32959
G5	4.026	0.4089	7	12	19	-0.21597	-0.0844
G6	4.036	0.4486	8	11	19	0.24215	0.00557
G7	4.070	0.3310	5	10	15	0.07282	-0.30221
G8	5.394	0.1775	4	1	5	0.08138	-0.0937
G9	3.836	0.9929	18	19	37	0.51336	0.28513
G10	3.904	0.1409	3	18	21	0.07397	0.03277
G11	3.912	0.5326	10	17	27	-0.21374	0.35622

G12	5.199	0.5774	12	2	14	-0.08957	0.55301
G13	**4.124**	**0.7270**	**17**	**8**	**25**	**0.39146**	**-0.05044**
G14	4.084	0.1374	2	9	11	0.03577	-0.12035
G15	4.436	0.0520	1	4	5	-0.028	0.00375
G16	3.913	0.5087	9	16	25	0.23797	0.25371
G17	4.251	1.6019	13	6	19	-0.85721	-0.20987
G18	3.926	0.6482	15	14	29	0.34613	0.09463
G19	3.926	0.6333	14	15	29	0.21795	0.48794
G20	4.153	0.3463	6	7	13	0.04157	-0.33761

***Note**: G: Genotype, ASV: AMMI Stability Value, rRasv: rank of AMMI Stability Value: GSI: Genotype selection index*

4. Discussion

The superior performance of Jarra across multiple years and locations demonstrates its genetic potential for high yield, disease tolerance, and adaptability to mid- and high-altitude areas of Southeastern Ethiopia. Its performance over standard checks highlights the progress made in durum wheat breeding at Sinana Agricultural Research Center.

The early-to-medium maturity (69 DH, 135 DM) ensures that Jarra escapes terminal drought, which is common in Bale Zone. The variety's good tillering ability, erect growth habit, and high test weight are desirable traits for both farmers and processors.

The significant yield advantage (up to 56.3% over Bulala and 66.7% over Ingilize) suggests that Jarra can contribute to bridging the national wheat production gap. Its protein (13.3%) and gluten content (25.9%) satisfy flour milling requirements, supporting local value chain development.

Moreover, Jarra's moderate resistance to yellow rust and stem rust provides durable protection under natural field conditions, reducing the need for fungicide application and lowering production costs.

Finally, the stability analysis confirmed Jarra's wide adaptation and reliability across different environments, making it suitable for large-scale production. The combined yield, quality, and disease tolerance traits make Jarra a strong candidate for commercial cultivation and an important addition to Ethiopia's durum wheat portfolio.

5. Recommendation and variety maintenance

After the variety evaluated across different environments it is officially released in 2024. The newly released durum wheat variety Jarra will be maintained by foundation of the seed SARC/OARI.

6. Conclusion

Developing and release of commercial variety includes high yielding, disease-resistant, desired quality, wide adaptability and uniformity is the main goal of one breeder. The newly released variety was evaluated at multi-locations for three consecutive years and well performed. Similarly it was verified at different environments and evaluated for yield performances, disease reaction and for adaptability at studied environments. In this regard, the released variety has preferred characteristics; moderately disease resistant, high yielder, amber seed color, high protein content, lodging and pest tolerant all over locations. Generally, Jarra out yielded than standard checks, Bulala and Benga that consequently, it was officially released for large-scale production.

Abbreviations: SARC: Sinana Agricultural Research Center
STB: Septoria Tritici Blotch
N: Nitrogen
NPS (B): Nitrogen, Phosphorus, Sulfur and Boron
NVRC: National Variety Releasing Committee
tha^{-1}: Ton per hector
OARI: Oromia Agricultural Research Institute
CIMMYT: International Maize and Wheat Improvement Center

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Conflicts of Interest

The authors declare no competing interests.

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Data Availability Statement

All important datasets are incorporated throughout the article.

Ethics Statement

This research did not involve human participants, animal subjects, or any material that requires ethical approval.

Author Contributions

Mulatu Aberra is research staff of cereal research department at Oromia Agricultural Research Institute contributed designing; conducted field experiment; data analyze and summarize and full write up of this trial.

Supplementory Table 1

Table 1. Agronomic and morphological characteristics of newly released durum wheat variety Jarra

COMPONENT	DESCRIPTOR
1. Name of variety	Jarra
2.Pedigree	tate/dire2012SnR/DWC-21
3. Adaptation area	3a. Mid and high land areas
	3b. Rainfall: 750-1550mm
4. Planting date	Mid July - late August based on-set of rainfall
5. Days for heading (DH)	69
6. Days for mature (DM)	135
7. Plant height	Medium (89.2cm)
8. Growth habit	Erect
9. Thousand kernel weight	34.13 gm
10. Seed colour	Amber color
11. Hectoliter weight	82.40Kg/L
12. Crop pest and disease reaction	Tolerant to major wheat diseases and pests
13. Grain yield (t ha^{-1})	20a. Research field: 5.0 _ 5.6 t ha^{-1}
	20b. Farmers field: 4.7 _ 5.0 tha^{-1}
14. Year of released	2024

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