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Developing Improved Varieties of Bread Wheat and Registration of "Shaki" Variety

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Abstract

The wheat germplasm distributed globally by CIMMYT and ICARDA is the primary source of cultivars for developing countries and a highly valuable source of improved crossing parents for breeding programs and developing wide adaptable with high yielding, resistant to disease, and high-quality traits worldwide. Shaki (ETBW9089) variety was selected from the international nursery which was introduced from CIMMYT in 2015 and tested together with 50 other test genotypes including local and standard checks at a quarantine site in Ethiopia. The variety was mainly selected for best agronomic performance, wide adaptability, resistance to disease, and high yield potential. Shaki is adapted within the range of altitude 1900–2780 masl with annual rainfall amount receiving from 640–1290 mm. The new bread wheat variety Shaki is high yielding variety across wide environments. Shaki is a stable and adaptable wheat variety for different bread wheat-growing agro-ecologies of Ethiopia. Shaki variety produced 13.36% and 12.68% grain yield advantage over the standards checks Wane and Lemu, respectively. Shaki variety showed relative resistance to stem yellow and leaf rust as compared to wheat varieties under production at the medium to high land wheat-growing agro-ecologies. The genotype with pedigree name BABAX/LR42//BABAX/3/ER2000/4/BAVIS and selection history CMSA09M00434S-050ZTM-0NJ-099NJ-3RGY-0B was named Shaki after official release for commercial production by the national variety releasing committee in 2021. Replacement of susceptible bread wheat varieties and availing more alternatives bread wheat varieties to grow for resource-poor farmers is very crucial in the region.

Keywords: Genotype; Quarantine; Shaki; Variety

Introduction

Bread wheat (Triticum aestivum. L) is the most common cultivated wheat species-taking up to 95% of the wheat and staple food for consumers worldwide [1]. Wheat constitutes a staple food worldwide, providing ~20% of the total calories and proteins in human diets globally [2]. Wheat is one of the major cereals grown for use as food and industrial raw materials in Ethiopia. Bread wheat in Ethiopia is used in different forms such as bread, porridge, soup, and roasted grain. In addition to the grain, the straw of bread wheat is used for animal feed, thatching roofs, and bed decking [3]. Wheat is also a strategic commodity that generates farm income and improves food security status [4]. Wheat is grown across a diverse range of agroecology and Ethiopia has huge potential and suitable agro ecology for growing

wheat. Wheat is widely produced in the highlands and mid-altitudes of Ethiopia. In spite of the presence of wide agro-ecologies suitable for wheat production; elasticity of wheat to be grown from extreme lowlands to highlands; increased demand for wheat due to population growth, urbanization, and expansion of agro-industries; wheat production is left behind by 25 to 30% to its demand in Ethiopia [5].

According to Akcura et al., 2006 reports plant breeders are highly concerned with the development and release of high yielding, stable, and stresses resistant crop varieties. A stable genotype is one possessing constant performance irrespective of changes in environmental conditions [6,7]. A fruitfully developed new variety should be stable and broadly adaptable over a wide range of environments on top of high yielding potential [8]. Dia [9] reported that to identify superior genotypes across multiple environments plant breeders conduct trials across locations and years during the final stages of cultivar development. Several studies of genotype by environment interactions (GxE) and yield stability have been reported on wheat grown under different locations and conditions in Ethiopia [10-13]. Each variety has a genotype-specific ability to maintain performance over a wide range of environmental conditions [14].

Several varieties of bread wheat have been released for large-scale production in Ethiopia [5,15]. However, their high-yielding potential and rusts resistance ability will not last long mainly due to the stem and yellow rusts epidemic [16-18]. Yellow and stem rust diseases continued as the major biotic threat to wheat production in Ethiopia. Nowadays, Ethiopia has reached on stage where bread wheat cannot be produced without the application of fungicides, especially in wheat belt Zones like Arsi, West Arsi, and Bale Zones [19]. Hence, the Ethiopian Wheat Research Program introduces thousands of bread wheat germplasms annually from CIMMYT and ICARDA and evaluates germplasms under quarantine blocks and in a series of yield trials over locations and years.

Different varieties with rust resistance and high yielder were released in Ethiopia which will help to boost the farmer income and food security. However, most of these cultivars were out of production due to their susceptibility to rust. Plant breeders evaluate and select breeding material empirically for adaptation to wider environments every year. To enhance farm profitability through using of improved bread wheat technologies in Ethiopia, there is a need to develop climate-smart varieties which are high yielding varieties, rust-resistant, high yielder, and suitable for different cropping systems prevalent in different agro-ecological in the country. Therefore, the objective of the present paper is to develop improved varieties of bread wheat and register the "Shaki" variety.

Materials and Methods

Initially, in 2015, 50 genotypes were introduced from CIMMYT under 23HRWYT and planted in Ethiopia under a quarantine site. Based on agronomic performance, yield data, and disease resistance Shaki was selected and planted in an observation nursery in 2016, in preliminary variety trials in 2017, and in national variety trials for two consecutive years (2018-2019) with twenty-three advanced bread wheat genotypes and two standard checks at Kulumsa, Asasa, Robe Arsi, Bekoji, Areka, Holeta, and Adet. The advanced genotypes were selected or screened from observation nurseries and preliminary variety trials in the preceding years. The genotypes were arranged in alpha lattice design with a plot size of 6 rows of 2.5 m by 1.2 m (3 m^2) long and 0.2m inter-row spacing. Every plot was planted at a seed rate of 150 kg ha^{-1}. Except for the genetic and other environmental variations, other agronomic management practices were applied uniformly to each plot. Fertilizer was applied at the recommended rate for the specific location. Finally, data were collected for days to heading, days to maturity, plant height, thousand seed weight, hectolitre weight, and grain yield; and diseases data (stem rust, leaf rust, yellow rust, and septoria). Agronomic traits for multi environments were combined and analyses were carried out. Finally, based on the results for agronomic performance and disease resistance two candidate genotypes viz. ETBW9606 and ETBW9089 were selected and verified on farmer's fields along with two st. checks Hidase and Lemu in 2020. At the maturity stage, the National Variety Release Committee has evaluated the field with the farmers and proposed to release a candidate variety, ETBW9089 (Shaki) for official registration in the country as a commercial variety for the end-user.

Results and Discussion

Evaluations of Shaki variety

Shaki variety is high-yielding and resistant to diseases which allows it to thrive in a range of environments. This new variety development undergoes several stages of evaluation, before they're officially released, registered, and commercialized. The genotype with pedigree name BABAX/LR42//BABAX/3/ER2000/4/BAVIS and selection history CMSA09M00434S-050ZTM-0NJ-099NJ-3RGY-0B was named Shaki after official release for commercial production by the national variety releasing committee in 2021. Shaki variety was selected from the international nursery which was introduced from CIMMYT in 2015 and tested together with 50 other test genotypes including local and standard checks at a quarantine site in Ethiopia. As Shaki outshined many bread wheat lines obtained from ICARDA, CIMMTY, and local crossing in observation and preliminary yield trials, it had been advanced to a national variety trial to be tested

across wide locations over years to further test its overall performances. Shaki was evaluated for two years (2018-2019) at Kulumsa, Asasa, Robe Arsi, Bekoji, Areka, Holeta, and Adet stations and had a better mean grain yield than the standard check. The result of multi-location trials showed that Shaki had above-average grain yield performance across tested locations and years. Shaki consistently out-yielded other tested bread wheat genotypes over two years. Combined years over locations analysis revealed that it had produced a mean yield of 5.6 t/ha (Table 1). The candidate ETBW 9089 (Shaki) produced a 13.36% and 12.68% yield advantage over the standard check Wane and Lemu, respectively. Thus, ETBW 9089 (Shaki) was verified at ten locations (at on-station and two on-farms at each location) in 2020 for official release. Consequently, ETBW 9089 (Shaki) showed superior overall agronomic performances over the standard check Lemu and Hidasse. Likewise, it proved to be more resistant to stem yellow and leaf rust as compared to all or any currently produced varieties within the medium to high land a part of wheat growing agro-ecologies. Shaki is developed and released by the Kulumsa Agricultural Research Center for major wheat-growing areas of Ethiopia.

Agronomic and Morphological Characteristics of Shaki Variety

Shaki was adapted mid to high land-agro-ecologies of Ethiopia, within the range of altitude 1900–2780 masl. It gives a high yield under the range of 640–1290 mm annually. In an attempt to develop Shaki, higher yield, and resistance to major bread wheat diseases were important traits of consideration. Shaki was taken 67 days for heading and 127 days for maturing at the time of release (Table 2). The Shaki is comparatively taller than the standard varieties of Wane and Lemu varieties. . Shaki has better thousand kernel weight (48g) than standard check Wane (38 g), and Lemu (36 g) (Table 2). It possessed a 26.32% and 3.33% TKW advantage over Wane and Lemu variety at the time of release, respectively. Shaki has a better hectolitre weight than both Wane and Lemu varieties. It possessed a 6.2% and 3 % HLW advantage over Wane and Lemu variety at the time of release, respectively. Shaki is a stable, best-adapted variety with stable, high yield and good resistance to wheat rust in Ethiopia.

Figure 1: the performance of Shaki variety and seed.

Entry	Geno type	A.Robe-2018	Bekoji-2018	Kulumsa-2018	Adet-2018	Areka-2018	Holeta-2018	Holeta-2019	Asasa-2019	Bekoji-2019	Kulumsa-2019	A.Robe -2019	Mean
1	WANE	3.16	4.32	7.57	5.03	2.30	6.24	2.10	8.55	2.74	7.56	4.82	4.94
2	ETBW 9185	4.40	5.73	7.15	4.81	3.18	4.89	2.56	6.04	3.70	7.84	4.50	4.98
3	ETBW 9193	3.67	4.73	7.71	5.35	2.60	5.92	2.45	6.70	3.30	7.35	5.49	5.02
4	ETBW 9086	3.61	4.74	7.90	5.01	2.59	6.65	2.79	7.54	4.76	7.22	5.47	5.30
5	ETBW 9087	4.19	4.98	7.76	4.29	2.88	5.17	2.22	6.57	3.99	7.77	4.75	4.96
6	ETBW 9089	2.37	5.66	8.01	6.08	2.98	6.15	2.85	8.37	6.20	9.03	3.93	5.60
7	ETBW 9109	3.07	4.22	7.47	5.77	3.26	6.57	3.05	6.36	3.39	6.84	3.75	4.89
8	ETBW 9284	2.74	4.52	7.69	5.85	2.88	7.55	3.58	7.28	1.08	7.62	3.43	4.93
9	ETBW 9299	2.85	4.98	7.26	5.13	2.90	4.07	2.06	5.70	4.52	7.59	4.55	4.69
10	ETBW 9304	3.24	5.08	7.42	5.51	2.80	7.23	2.42	7.87	5.85	7.80	4.72	5.45
11	ETBW 9313	1.65	3.12	7.09	4.58	2.92	7.72	2.87	6.63	0.52	7.14	3.26	4.32

12	ETBW 9094	2.90	4.59	7.52	4.87	2.11	5.59	3.33	7.87	4.94	8.02	5.01	5.16
13	ETBW 9066	2.89	5.11	6.13	5.09	2.81	4.92	3.42	6.86	2.64	6.99	4.20	4.64
14	ETBW 9102	3.88	5.26	7.41	5.82	2.63	5.69	4.18	7.80	6.05	7.91	4.13	5.52
15	ETBW 9315	3.85	4.41	6.60	5.79	2.27	7.41	2.73	7.47	4.57	7.16	5.52	5.25
16	BW174459	3.98	3.82	8.03	4.81	2.84	6.76	3.20	6.81	2.57	7.79	5.51	5.10
17	BW174460	3.80	4.36	7.88	5.10	2.64	6.67	2.64	7.17	5.31	7.92	5.08	5.32
18	BW174461	3.49	4.95	8.13	5.13	2.10	4.91	2.56	7.50	5.97	7.46	4.43	5.15
19	BW174462	3.11	4.91	7.89	4.96	2.18	5.42	2.11	7.76	4.78	7.42	5.24	5.07
20	BW174463	3.93	4.53	7.58	5.43	2.81	5.61	3.50	7.31	4.17	8.41	4.45	5.25
21	BW174464	3.10	4.59	7.94	5.95	1.85	4.31	3.35	8.83	5.79	7.82	5.67	5.38
22	BW174465	3.31	3.32	6.28	4.03	2.69	4.11	2.64	5.01	3.52	7.41	3.81	4.19
23	BW174466	2.76	3.75	7.28	5.32	2.17	7.03	2.89	7.94	4.34	7.44	4.29	5.02
24	BW174467	1.85	3.36	7.27	5.42	1.51	5.10	2.80	8.27	5.22	6.85	3.57	4.66
25	LEMU	3.27	4.09	6.44	5.08	3.13	7.54	3.67	6.05	3.20	7.85	4.36	4.97
Ent. Mean		3.24	4.53	7.42	5.21	2.60	5.97	2.88	7.21	4.13	7.61	4.56	5.03
CV (%)		20.30	18.82	7.85	12.85	19.32	12.68	21.15	13.32	17.50	15.16	15.97	14.73
LSD (5%)		1.08	1.40	0.96	1.10	0.82	1.24	1.00	1.58	1.19	1.52	1.20	-
R2		0.64	0.52	0.58	0.47	0.65	0.77	0.55	0.62	0.87	0.39	0.61	0.91

Table 1: Mean grain yield (t ha-1) of 25 genotypes tested across eleven locations in 2018 and 2019.

S/No	Genotype	DTH (days)	DTM (days)	PHT (cm)	TKW (g)	HLW (hl/kg)
1	WANE	65	127	91	38	65
2	ETBW 9185	70	128	90	37	67
3	ETBW 9193	69	128	95	35	66
4	ETBW 9086	71	130	93	39	68
5	ETBW 9087	70	129	97	38	68
6	ETBW 9089	67	127	95	48	69
7	ETBW 9109	72	132	89	38	69
8	ETBW 9284	67	129	96	40	65
9	ETBW 9299	71	128	94	38	66
10	ETBW 9304	67	127	95	40	68
11	ETBW 9313	72	132	92	37	66
12	ETBW 9094	64	125	90	41	67
13	ETBW 9066	75	130	91	37	66
14	ETBW 9102	66	128	93	38	67
15	ETBW 9315	68	128	93	41	68
16	BW174459	72	132	90	40	67
17	BW174460	69	128	96	42	67
18	BW174461	70	128	96	41	67
19	BW174462	68	128	93	40	67
20	BW174463	69	128	85	34	66

21	BW174464	65	127	84	37	68
22	BW174465	72	132	78	29	68
23	BW174466	67	130	90	39	67
24	BW174467	67	127	86	39	67
25	LEMU	75	132	93	36	67
	Mean	69.1	128.87	91.39	38.47	67.15
	LSD (5%)	2.35	2.31	3.46	3.12	1.78
	CV (%)	4.93	2.03	4.42	7.7	2.04

Note: DH=Days to 50 heading; DM=Days to 95 % maturity; PHT=Plant height(cm); TKW=Thousand kernel weight(g); HLW=Hectoliter weight; YLD=Grain Yield(t/ha)

Table 2: Mean performance of some important agronomic traits of 23 genotypes and 2 checks tested across 10 locations in the 2018/19 and 2019/20 cropping season.

Variety Maintenance

The variety is maintained under the responsibility of the wheat breeder at the Kulumsa agriculture research center.

Summary and Conclusion

Increasing the production of foodstuffs in developing countries against the background of rapid population growth, widespread food shortage, malnutrition and the destruction of the natural resource base remains important for the future. Therefore, there is a need to intensify crop production through the application of relevant innovations including better crop varieties adapted to varying agro-ecological conditions and socioeconomic set-ups. A successful variety must produce a high yield in favorable environments and still should produce an acceptable yield under less favorable ones. In general, both yield and stability of performance should be considered simultaneously to take advantage of the useful effect of GE interaction and to make a selection of the variety more precise and refined. Shaki was the best yielding bread wheat variety. It is stable ingrain yield performance over locations and years. It was resistant to major wheat rust diseases that prevailed in the growing areas. Farmers also preferred the variety for its superior performance over the existing local variety, which is manifested by better grain yield, and disease resistance. Likewise, the variety has white grain color and it has good general acceptance for bread with high quality. Hence, Shaki was verified and officially released for midland and Highland wheat-growing areas of Ethiopia in 2021.

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