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The release and registration of bread wheat variety (Kulito) for low moisture stress areas of South Ethiopia

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A B S T R A C T

Bread wheat (*Triticum aestivum* L.) is the most valuable crop in Ethiopia. The low yield of existing varieties has been partly attributed to high wheat rust pressure and recurrent drought in the country. Field experiments were carried out in Halaba, Inseno, and Lanfero, South Ethiopia, during 2019, 2020, and 2022 cropping seasons, with the objective to obtain rust-resistant and high-yielding genotypes for low moisture stress areas. Under regional variety trials of 2019 and 2020, fifteen advanced lines and a local check variety, Ogolcho (released in 2011), were grown using four replications in a randomized complete block design. Plant height was 83.25, 87.73 and 78, 68 cm; yield was 3.18, 3.72 and 4.43 tons ha^{-1}; and 1000-seed weight was 38.10, 33.07 and 39.54 g, respectively, for Halaba, Inseno and Lanfero. Plant height was 80.86, 81.61, 80.07, and 85.84 cm; yield was 4.09,4.23, 4.16, and 3.56 tons ha^{-1}; and 1000-seed weight was 38.41, 35.46, 39,58, and 37.57 g, for the high yielding genotypes ETBW9131, ETBW9152, ETBW9077, and the check variety Ogolcho, respectively. Under variety verification trials of 2022, genotype ETBW9131, a local check variety, Ogolcho and a standard check variety, Biftu (released in 2022), were grown. The yield was 4.58, 3.35, and 2.96 tons ha^{-1} for ETBW9131, Biftu, and Ogolcho, respectively. For its high yield, moderate susceptibility to stem rust and moderate resistance to yellow rust, ETBW9131 has been released and registered by the variety name 'Kulito' for cultivation in low moisture stress areas of Halaba, Inseno, Lanfero, and other areas with similar agro-ecologies.

Keywords: Bread wheat, Variety Kulito, Yield, Low moisture stress

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Introduction

Since its introduction to Ethiopia in the early 1940s, bread wheat (*Triticum aestivum* L.) has dominated wheat production, recently occupying over 90% of wheat production area in the country (Hodson *et al.*, 2020). Wheat is grown across a wide range of agro-ecologies, between 6 and 16°N, 35 and 42°E, and from 1500 m to 3000 m above sea level (Anteneh and Asrat, 2020; Alemu *et al.*, 2022) under various soil and climatic conditions. In Ethiopia, bread wheat ranks third in terms of cereal crops production area, after tef (*Eragrostis tef*) and maize. It occupies over 1.8 million hectares of land (18.00% of annual cereal crops production area) and produces more than 5.7 million tons of grain (19.14% of annual cereal grains production), with an average yield of 3.05 tons ha^{-1} (CSA, 2021). In Ethiopia, bread wheat is used for making bread, porridge, soup, biscuits, noodles, and roasted grain. In addition, the straw is a valuable source of animal feed (Tadesse *et al.*, 2022).

In Ethiopia, one hundred eleven bread wheat varieties have been released and/or registered since 1974 for cultivation in the country (EAA, 2023). However, many of these varieties are out of production mainly due to stem rust (caused by *Puccinia graminis* f.sp. *tritici*) and yellow rust (caused by *Puccinia striiformis* f.sp. *tritici)* diseases (Olivera *et al.*, 2015; Tadesse *et al.*, 2022). Moreover, it is mainly cultivated under rain-fed conditions and is subjected to recurrent drought which is common in Ethiopia (Farshadfar *et al.*, 2012; Adhikari *et al.*, 2015). Even though lack of adequate soil moisture affects growth and development of wheat crop at all crop stages, post-anthesis drought can reduce yields up to 58-92% (Pradhan *et al.*, 2012; Farooq *et al.*, 2014). Therefore, the present study was conducted to release rust-resistant and high-yielding bread wheat varieties for cultivation in low moisture stress areas of South Ethiopia and other areas with similar agro-ecologies.

Materials and Methods

Regional variety trials

In South Ethiopia, regional variety trials were carried out in three locations, namely Halaba, Inseno, and Lanfero, during the 2019 and 2020 cropping seasons. Halaba is situated 1765 meters above sea level at 07˚18'45''N, 37˚06'49''E. The annual mean rainfall and temperature are 865 mm and 21.30˚C, respectively. In 2019 and 2020, the rainfall during the cropping period (August to November) was 330 mm and 272 mm, respectively. Inseno is located at 08˚01'53 ''N, 37˚27'23''E and 1885 m above sea level, and Lanfero is located at 07º49'22''N, 38º27'55''E and 1892 m above sea level. According to the information from the nearby meteorology station for both Inseno and Lanfero, they have annual mean rainfall of 730 mm and a temperature of 23˚C. Moreover, the cropping period (July to October) rainfall was 353 mm in 2019 and 388 mm in 2020.

Fifteen lines of bread wheat advanced through a series of screenings of materials obtained from the International Center for Agricultural Research in the Dry Areas (ICARDA), and the check variety Ogolcho, released in 2012 and widely cultivated in low moisture stress areas, were grown in four replications using a randomized complete block design. Each plot consisted of six rows, with 2.5 m row length, 20 cm between rows, and 1 m between replications. A seeding rate of 120 kg ha^{-1} was used to drill the seeds. Each plot received 38 kg ha^{-1} P_2O_5 in the form of NPS, and 65 kg ha^{-1} N in the form of NPS and urea at planting. For the duration of the experiment, weeds were manually removed. In addition to days to heading and maturity, the four middle rows of each plot were used to record the grain yield (tons ha^{-1}), which was then estimated after adjusting plot yield to a seed moisture content of 12.5%. Plant height (cm) was recorded using the average of five random plants at maturity in each plot, and 1000-seed weight (g) was estimated after harvesting. The severity and reaction to stem and yellow rusts were recorded using modified Cobb's scale (Peterson *et al.*, 1948). Moreover, SAS software version 9.0 (SAS Institute, 2002) was used for data analysis.

Results and Discussion

Table 1 showed that the effects of location, year, genotype, and location x year were significant ($p<0.01$) for yield, plant height, and 1000-seed weight, whereas the effect of genotype x location x year was not significant for these traits. The significant location x year interaction indicated that location means were inconsistent across years. The significant effect of genotype x location interaction for plant height, 1000-seed weight, and days to heading would indicate that particular genotypes tended to rank differently in these traits at different locations, whereas the non-significant effect of genotype x location interaction for yield would indicate that the relative ranking of genotypes remain the same across locations. Domitruk *et al.* (2001) also suggested that varieties for specific adaptation would be developed in the presence of genotype x location interaction.

The lack of a significant genotype x location x year interaction for yield showed that the genotypes' performance varied less over years across locations, which could be because of the lack of varying effects of stress factors faced by genotypes across locations (Fan *et al.*, 2007). However, more testing years may be required for each location because thorough characterization of differential factors of environments (locations and years) is required for better understanding of the genotype x year, genotype x location, and genotype x location x year interactions (Domitruk *et al.*, 2001; Fan *et al.*, 2007). This could be because environmental conditions during the two years of the present study might not adequately represent the long-term variations in agro-climatic conditions expected at any of the test locations.

Table 1. Significance of mean squares for days to heading and maturity, plant height, yield and 1000-seed weight for 16 bread wheat genotypes grown in three locations during 2019 and 2020 cropping seasons.

Sources of variation	DF	Yield (tons ha^{-1})	PHT (cm)	TSW (g)	DF	DTH	DTM
Replication (LxY)	18	3.35**	48.02**	54.67**	Rep(L)=6	2.77ns	2.87ns
Location (L)	2	50.26**	2621.77**	1479.29**	1	86.13**	2565.07**
Year (Y)	1	32.86**	2225.40**	6390.42**	-	-	-
Genotype(G)	15	2.84**	92.36**	101.95**	15	41.60**	11.78**
Lx Y	2	15.35**	740.37**	771.99**	-	-	-
G x L	30	0.57ns	33.25**	36.44*	15	20.32*	7.70ns
G x Y	15	0.73ns	19.39ns	22.88ns	-	-	-
G x L x Y	30	0.46ns	25.24ns	21.20ns	-	-	-
Error	270	0.63	18.219	22.34	90	10.72	4.88
CV%		21.05	5.13	12.81		5.17	2.02

**, ** significant at 5%, and at 0.1%, respectively; ns = non-significant; PHT = plant height, TSW= 1000-seed weight, DTH = days to heading, DTM = days to maturity; DTH and DTM were based on data from Halaba and Lanfero for 2020 cropping season.*

There was considerable variation among locations and between years for plant height, yield and 1000-seed weight (Table 2). Compared to Halaba and Inseno, Lanfero had short plant height, and high 1000-seed weight (39.54 g) and yield (4.43 tons ha^{-1}). Similarly, year 2020 gave higher plant height (85.63 vs. 81.82 cm), and yield (4.07 vs. 3.48 tons ha^{-1}), whereas lower 1000-seed weight (32.82 vs. 40.98 g) than year 2019. Days to maturity was earlier in Halaba (105 days) than in Lanfero (114 days).

Table 2. Days to heading and maturity, plant height, yield and 1000-seed weight for two years and three locations across 16 bread wheat genotypes.

Items	DTH	DTM	PHT (cm)	Yield (tons ha^{-1})	TSW(g)
Year					
2019	-	-	81.82	3.48	40.98
2020	-	-	85.63	4.07	32.82
Mean	-	-	83.22	3.78	36.90
$LSD_{0.05}$	-	-	0.86	0.16	0.95
Location					
Halaba	64	105	83.25	3.18	38.10
Inseno	na	na	87.73	3.72	33.07
Lanfero	63	114	78.68	4.43	39.54
Mean	63	109	83.22	3.78	36.90
$LSD_{0.05}$	1.15	0.78	1.01	0.2	1.16

na = not available; DTH = days to heading, DTM = days to maturity, PHT = plant height, TSW= 1000-seed weight; DTH and DTM were based on data from Halaba and Lanfero for 2020 cropping season.

Considerable variations in average days to heading and maturity, plant height, 1000-seed weight, yield, and stem and yellow rust severity and reactions were observed for genotypes (Table 3). Days to heading was 61, 61, 67 and 64; plant height was 80.86, 81.61, 80.07 and 85.84 cm; 1000-seed weight was 38.41, 35.46, 39.58, and 37.57 g; and yield was 4.09, 4.23, 4.16 and 3.56 tons/ha for the high yielding genotypes ETBW9131, ETBW9152, ETBW9077, and Ogolcho, respectively. These genotypes were moderately susceptible to stem rust except ETBW9152, whereas genotypes ETBW9131 and ETBW9152 were moderately resistant, and genotypes ETBW9077 and Ogolcho were moderately susceptible to yellow rust. The variation in reaction to stem and yellow rusts has also been reported for wheat in Ethiopia (Solomon, 2022).

The yield and its related traits have been used as key criteria for screening genotypes for drought resistance (Passioura, 2012). The lower plant height of ETBW9131 relative to the check variety is an important criterion because reduced plant height is associated with increased harvest index in water-limited environments (Blum, 2010). The earlier heading of ETBW9131 is also important because by reducing the number of days to heading, terminal drought stress can be escaped (Lopes *et al.*, 2012; Sime *et al.*, 2023).

Table 3. Days to heading and maturity, plant height, 1000-seed weight, yield, and percent stem rust and yellow rust severity, and reactions for 16 bread wheat genotypes grown across three locations during 2019 and 2020 cropping seasons.

Genotypes	DTH	DTM	PHT (cm)	TSW(g)	Yield (tons ha^{-1})	Rank (yield)	% yield of Ogolcho	SR	YR
ETBW9063	63	109	83.40	36.81	4.02	4	12.92	30S	34MS
ETBW9124	65	110	81.30	36.59	3.64	11	2.25	19MS	20MR
ETBW9131	61	109	80.86	38.41	4.09	3	14.89	27MS	13MR
ETBW9134	63	108	81.04	38.39	4.02	5	12.92	23S	11MS
ETBW9135	62	108	83.45	34.54	3.71	10	4.21	25MS	13MR
ETBW9143	64	111	82.76	36.04	2.95	16	-17.13	32MS	18MR
ETBW9146	69	111	82.90	34.21	3.24	15	-8.99	41S	20MS
ETBW9152	61	108	81.61	35.46	4.23	1	18.82	24S	14MR
ETBW9157	62	109	85.25	40.82	3.93	7	10.39	27MS	25MS
ETBW9158	64	109	84.61	39.34	3.60	12	1.12	21S	14MS
ETBW9160	63	110	82.51	34.06	3.89	9	9.27	19MS	14MS
ETBW9059	63	109	85.73	34.76	3.94	6	10.67	19MS	18MS
ETBW9075	61	109	83.73	35.96	3.90	8	9.55	38S	13MS
ETBW9077	67	110	80.07	39.58	4.16	2	16.85	35MS	23MS
ETBW9082	66	112	86.52	37.91	3.55	14	-0.28	19MS	14MS
Ogolcho (check)	64	110	85.84	37.57	3.56	13	0	31MS	23MS
Mean	63	109	83.22	36.90	3.78				
$LSD_{0.05}$	3.25	2.19	2.43	2.69	0.45				

DTH = days to heading, DTM =days to maturity, PHT = plant height, TSW = 1000-seed weight, SR = stem rust, YR = yellow rust, MS = moderately susceptible, MR = moderately resistant; DTH and DTM were based on data from Halaba and Lanfero for 2020 cropping season.

Variety verification trials

The genotype ETBW9131 from regional variety trials was selected for variety verification trials, for its stem and yellow rust resistance, and high yield. ETBW9131 was tested along with local check variety Ogolcho, and standard check variety Biftu, released in 2022 for lowland and moisture stress areas, during 2022 cropping season, in Halaba, Inseno and Lanfero. Each genotype was grown in a single plot in each location, having one on-station and two on-farm trials with the plot size of 10 m x 10 m, and 20 cm between rows. During variety verification trials, the annual and cropping period (August to November) rainfall was 644 mm and 323 mm, respectively, for Halaba, whereas it was 567 mm and 340 mm, respectively, for Inseno and Lanfero.

The variety verification trials showed that the mean yield of ETBW9131 (4.58 tons ha^{-1}) was 36.72% of variety Biftu (3.35 tons/ha) and 54.73% of variety Ogolcho (2.96 tons ha^{-1}) (Table 4). The National Variety Releasing Committee of Ethiopian Agricultural Authority, a legal authority responsible for variety release and registration, evaluated the variety verification trials and approved the release and registration of the genotype ETBW9131 by the variety name 'Kulito' for cultivation in low moisture stress areas of Halaba, Inseno, Lanfero, and other areas with similar agro-ecologies, for its stem and yellow rust resistance, and high yield relative to check varieties (EAA, 2023).

Table 4. Yield (tons ha^{-1}) of variety Kulito (ETBW9131) and check varieties on variety verification trials, during 2022 cropping season.

Genotypes	Halaba	Inseno	Lanfero	Mean	% of Biftu	% of Ogolcho
Kulito (ETBW9131)	4.25	5.89	3.59	4.58	36.72	54.73
Biftu (standard check)	2.70	4.34	3.00	3.35		
Ogolcho (local check)	2.36	4.12	2.39	2.96		

Note: Halaba = 2 sites; Inseno = 1 site; and Lanfero = 3 sites harvested.

Conclusion and Recommendation

Regional variety trials were carried out in Halaba, Inseno and Lanfero, South Ethiopia, during 2019 and 2020 cropping seasons, using fifteen advanced bread wheat lines, and one local check variety, Ogolcho, using four replications in a randomized complete block design. The effects of location, year, genotype, and location x year interaction were significant for plant height, yield and 1000-seed weight, whereas the effect of genotype x location for yield and genotype x location x year interaction for plant height, yield and 1000-seed weight was not significant. Short plant height and high yield were obtained for Lanfero compared to Inseno and Halaba. The yield of genotype ETBW9131 (4.09 tons ha^{-1}) was 14.89% of the check variety Ogolcho (3.56 tons/ha) in regional variety trials of 2019 and 2020. In variety verification trials of 2022, the yield of genotype ETBW9131 (4.58 tons ha^{-1}) was 36.72% of standard check variety Biftu (3.35 tons/ha) and 54.73% of local check variety Ogocho (2.96 tons ha^{-1}). Therefore, for its stem and yellow rust resistance, and high yield relative to check varieties, genotype ETBW9131 by the pedigree: BERKUT//PBW343*2/TUKURU/3/KINGBIRD #1/4/KACHU, and by the variety name, 'Kulito' has been released and registered for cultivation in moisture stress areas of Halaba, Inseno, Lanfero, and other areas with similar agro-ecologies.

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