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The Agronomic and Quality Descriptions of Ethiopian Bread wheat (*Triticum aestivum* L.) Variety "Boru"

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ABSTRACT

A multiplications evaluation was conducted with twenty-eight advanced bread wheat genotypes and two standard checks for two consecutive years 2017 and 2018 at Kulumsa, Asasa, Robe Arsi, Bekoji, Areka, Shambu, Holeta, Adet, Enawari, Awalgera, and Debra Zeit, Ethiopia. The objective of the paper was to describe the agronomic and quality related traits of newly developed bread wheat varieties "Boru" for optimum moisture areas of Ethiopia. Boru is a commercial name given for a newly released variety with the pedigree name SAUAL/MUTUS/6/CNO79//PF70354/MUS/3/PASTOR/4/BAV92*2/5/FH6-1-7/7/CNO79//PF. 70354/MUS/3/PASTOR/4/BAV92*2/5/FH6-1-7 which originated from CIMMYT germplasms. Boru is adapted within the range of altitude 2050 to 2780 masl with annual rainfall amount receiving from 620 to 1290 mm. Boru showed superior overall agronomic performances over the standard check Wane and Hidasse and it had a 9% and 14% yield advantage respectively. The new variety had a bold seed size than the two checks. Boru 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. Boru offers new hope for resource-poor farmers in rust-prone areas of Ethiopia. It's expected to replace the variety 'Ogolcho' in medium areas, and 'Hidasse' in high land areas of Ethiopia. In addition, the Boru variety is known for its higher protein content (14.37%) than standard check Wane (12.14%) and local check Hidasse (12.3%).

KEYWORDS: Boru, commercial, diseases resistance, high yielding, local check, standard check, superior

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1. INTRODUCTION

Wheat (*Triticum* spp.) is one of the globally produced and marketed cereal crops which covers 15% of the total sowing areas of cereal crops within the world. It has covered the most cultivation area and its product is the most generally used in the world and of primary importance for human nutrition (Abdelaal et al., 2018, Hossain et al., 2018). It is a crucial industrial grain that ranks second among the foremost important cereal crops in the world after rice and is traded internationally (Najafi, 2014, Falola et al., 2017).

Wheat is also a strategic commodity that generates farmer income and improves food security status in sub-Saharan African countries (Negassa et al., 2013, Minot et al., 2015, Amentae et al., 2017). In developing countries, wheat demand will increase dramatically by 2050 (Rosegrant and Agcaoili, 2010, Nelson et al., 2010, Shiferaw et al., 2013). In Ethiopia, wheat is among the major important cereal crop occupying 1.79 mha of land with a total production of 5.32 mt and productivity of 2.97 t ha^{-1} (Anonymous, 2020). Ethiopia is the largest wheat producer in sub-Saharan Africa and remains a net importer of wheat, meeting just over 70% of demand from domestic production (Shiferaw et al., 2011, Hodson et al., 2020, Mottaleb et al., 2021).

In Ethiopia, wheat production and productivity are affected by complex and interactive effects of biotic and abiotic factors and socio-economic challenges. Wheat rust (fungal) diseases, notably stem and stripe rust, are the most important biotic constraints to wheat production in Ethiopia (Ayele et al., 2008, Singh et al., 2016), a lack of backward agronomic practices, use of marginal agricultural land, and terminal drought stress, among others (Yami et al., 2012, Belay and Araya 2015, Anonymous, 2016, Hei et al., 2017, Semahegn et al., 2021) and erratic rainfall pattern, low soil fertility, high temperature are some of the abiotic yield-limiting factors in wheat (Husnu et al., 2010, Kılıc et al., 2010). The occurrence and relative importance of these constraints vary in different agro-ecologies, and farmers may perceive them differently, which affects the wheat breeding goals and hence varietal choices and adoption.

In addition, Ethiopia is characterized by diverse climatic factors; lowland, midland, and highland wheat growing areas. Developing bread wheat varieties suitably adapted to each of the main growing agro-ecologies is the priority area of breeding in the country (Alemu et al., 2019). A fruitfully developed new variety should be stable and broadly adaptable over wide ranges of environments on top of high yielding potential. Therefore, breeding for high grain yield, stability/ adaptability, and resistance to diseases has become the first areas of interest for breeders within the country. To develop and release improved varieties for commercial cultivations, screening, and testing in different environments to identify specific and broad adaptations of potential genotypes is important (Husnu, 2016, Sajjid and Fida, 2018). Improving the adaptability of crop varieties to a changing environment supported by appropriate crop management strategies is the working principle worldwide in ensuring crop productivity (Blum, 2011, Farooq et al., 2015, Stroosnijder et al., 2012, Wasson et al., 2012).

So far, several varieties of bread wheat have been released for large-scale production in Ethiopia (Anonymous, 2016, Hodson et al., 2020). However, their high yielding potential and rusts resistance ability will not last long mainly due to the stem and yellow rusts epidemic (Olivera et al., 2015, Tolemariam et al., 2018). Therefore, the objective of the present paper was to describe the agronomic and quality performance of the recently developed and released bread wheat variety 'Boru'.

2. MATERIALS AND METHODS

Twenty-eight advanced bread wheat genotypes and two standard checks were tested under national variety trials for two consecutive years 2017 to 2018 at Kulumsa, Asasa, Robe Arsi, Bekoji, Areka, Shambu, Holeta, Adet, Enawari, Awalgera, and Debra Zeit. Sowing and harvesting of evaluated materials were carried out from mid-June to mid-July and from November to December, respectively. 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 0.2 m 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, 121 kg/ha NPS and 100 kg/ha urea's. Finally, data were collected for days to heading (days), days to maturity (days), plant height (cm), thousand seed weight (g), hector-liter weight (hl/kg), and grain yield (t/ha); and diseases data (stem rust, leaf rust, yellow rust, and septoria). In addition, some quality parameters (% protein and gluten index) were analyzed in the laboratory. For agronomic traits for multi environments were combined and analyses were carried out; while for quality parameters samples were analyzed from each genotype. Finally, based on the results for agronomic performance; disease resistance, and quality parameters two candidate genotypes viz. ETBW953 and ETBW9554 were selected and verified on farmer's fields along with two st. checks Wane and Hidasse in 2019. At maturity time, the National Variety Release Committee was evaluated with the farmers and proposed to release a candidate variety ETBW9554 (Boru) for official registration in the country as a commercial variety (Table 1).

Table 1: List of test locations and their description

Location	Geographic position		Altitude	Temperature (°C)		Rainfall (mm)
	Latitude	Longitude		Min.	Max.	
Adet	11°16' N	37° 29' E	2216	9.2	25.5	1250
Asasa	07°07'228''N	39°11'932''E	2360	5.8	23.6	620
Arsi Robe	7°53'02''	39°37'40''	2420	6	22.1	796
Areka	7°3'25'' N	37°40'52''E	2230	-	-	1290
Awalgera	12°31" N	39°33'E	2490	-	-	-
Bekoji	07°32'629''N	39°15'360''E	2780	7.9	18.6	1010
Debre Zeit	08°38'08''N	38°30'15''E	2050	NA	NA	900
Enawari	9°53'0.0''N	39°09'00.0''E	2650	NA	NA	878
Holeta	09°03'414''N	38°30'436''E	2400	6.1	22.4	976
Kulumsa	08°01'10''N	39°09'11''E	2200	10.5	22.8	820
Shambu	9°34' 0''N	37° 6' 0''E	2503	-	-	-

3. RESULTS AND DISCUSSION

3.1. Varietal evaluations

Boru variety is high-yielding and resistant to diseases which allow 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 Boru is a commercial name given for a newly released bread wheat variety with the pedigree name SAUAL/MUTUS/6/CNO79//PF70354/MUS/3/PASTOR/4/BAV92*2/5/FH6-1-7/7/CNO79//PF70354/MUS/3/PASTOR/4/BAV92*2/5/FH6-1-7 which was introduced from CIMMTY. It's targeted for optimum moisture areas to high land areas it's good agronomic characteristics and late-maturing type as compared to the present varieties apart from Danda'a and Lemu. As Boru 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. The bread wheat national variety trial consisting of 28 advanced bread wheat genotypes including the standard check Wane, and Hidasse was conducted at major bread wheat-growing regions in Ethiopia. Boru 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 5.23 t ha^{-1} (Table 2). The candidate ETBW 9554 (Boru) produced an 11% and 15% yield advantage over the standard check (Wane) and local check (Hidasse), respectively. Thus, ETBW 9554 (Boru) was verified at 10 locations (at on-station and two on-farms at each location) in 2019 for official release. Consequently, ETBW 9554 (Boru) showed superior overall agronomic performances over the standard check Wane and therefore the local check Hidasse under verification trial too. 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. Boru offers new hope for resource-poor farmers in stem rust-prone and yellow rust-prone areas of Ethiopia. It's expected to replace the varieties Ogolcho in medium areas, and Hidasse in high land areas varieties.

3.2. Agronomic and morphological characteristics

The wheat germplasm distributed globally by CIMMYT 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. Boru was adapted mid to high land-agro-ecologies of Ethiopia, within the range of altitude 2050 to 2780 masl (Table 1). It gives a high yield under the range of 640–1290 mm annually. In an attempt to develop Boru, higher yield, and resistance to major bread wheat diseases were important traits of consideration. Boru was taken 70 days for heading and 128 days for maturing (Table 2). Concerning day to flowering, the number of days to flowering was later than the standard check wane and local check Hidasse by 4 days. The Boru is comparatively taller than the standard varieties of Wane and local check Hidasse. However, Boru has better thousand kernel weight (42.70 g) and grain yield than standard check Wane (38.3 g), and local check Hidasse (38.10 g) and 71.4 hl kg^{-1} (Table 3 and Fgure 1 and 2). Likewise, the Boru variety had bold seeds than checks. It possessed a 5.2% and 5.5% TKW advantage over Wane and Hidasse, respectively.

Table 2: Mean performance of some important agronomic traits of 28 genotypes and 2 checks tested in the 2017 and 2018 cropping seasons

Entry	Genotype	DTH (days)	DTM (days)	PHT (cm)	TKW (g)	HLW (hl kg^{-1})	GYLD (t ha^{-1})
1	Wane	66.00	123.00	89.00	38.30	71.20	4.61
2	ETBW 8751	65.00	123.00	89.00	39.60	73.20	5.12
3	ETBW 8858	67.00	124.00	91.00	39.30	73.10	4.77
4	ETBW 8870	67.00	126.00	94.00	37.90	72.80	4.87
5	ETBW 8802	68.00	129.00	90.00	33.00	71.80	4.36
6	ETBW 8991	65.00	123.00	85.00	37.40	72.70	5.04
7	ETBW 8862	69.00	127.00	100.00	40.20	73.80	4.88
8	ETBW 8804	65.00	123.00	80.00	34.00	72.10	3.67
9	ETBW 8996	64.00	124.00	93.00	39.80	73.40	4.99
10	ETBW 8583	68.00	127.00	89.00	38.70	73.40	4.77
11	ETBW 8668	65.00	125.00	95.00	43.30	74.80	5.00
12	ETBW 8595	65.00	126.00	95.00	42.80	74.30	4.88
13	ETBW 8684	64.00	125.00	90.00	40.50	74.10	4.60
14	ETBW 9486	66.00	123.00	87.00	41.10	73.80	4.37
15	ETBW 9547	72.00	128.00	87.00	43.40	73.40	4.91
16	ETBW 9548	72.00	128.00	87.00	40.00	73.40	4.49
17	ETBW 9549	70.00	129.00	88.00	39.20	73.10	4.31
18	ETBW 9550	68.00	126.00	85.00	36.50	73.90	4.17
19	ETBW 9551	67.00	127.00	87.00	38.70	71.50	4.24
20	ETBW 9552	69.00	128.00	89.00	42.70	72.70	3.91
21	ETBW 9553	74.00	131.00	92.00	40.40	72.30	4.90
22	ETBW 9554 (Boru)	70.00	128.00	94.00	42.70	71.40	5.10
23	ETBW 9555	67.00	127.00	88.00	36.90	71.60	4.14
24	ETBW 9556	68.00	125.00	91.00	39.80	73.50	4.63
25	ETBW 9557	68.00	126.00	90.00	37.30	69.70	4.87
26	ETBW 9558	67.00	126.00	91.00	40.50	73.90	4.79
27	ETBW 9559	69.00	126.00	92.00	40.20	72.60	4.49
28	ETBW 9560	66.00	125.00	89.00	37.80	72.00	4.75
29	ETBW 9561	72.00	130.00	90.00	39.80	74.40	4.59
30	Hidasse	66.00	124.00	92.00	38.10	70.80	4.42
Grand mean		68.00	126.00	90.00	39.30	72.80	4.62

DTH: days to heading, DTM: days to maturity, PHT: plant height, TKW: thousand kernel weight, HLW: hector liter weight and GYLD: grain yield

3.3. *Quality traits*

The priorities of the national wheat research breeding program are high grain yield, disease resistance, and tolerance to abiotic stresses like drought and warmth, and desirable quality. Wheat quality may be a very broad subject that may be defined differently by the various stakeholders of the wheat chain, which makes it a very complex and variable concept. The environment will influence most bread wheat grain traits. When variation in a trait is caused more by differences in the environment the plants are grown in than by genetic differences among those plants it can be difficult for the breeder to select

Table 3: Morphological characteristics of Boru

Growth habit	Erect
Auricle color	White
Leaf waxiness	Weak
Ear density	Medium
Ear color	White
Ear shape	Parallel Side
Hairiness of ear	Absent
Ear length	Long
Seed color	White

Figure 1: The spike of Boru variety

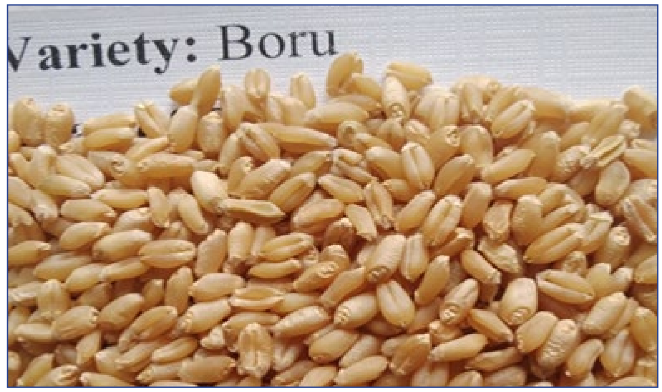

Figure 2: The seed of Boru variety

the desired genotype. Wheat genotype from *Triticum aestivum* L. grown at the same location was chosen and ranged from 12.14% to 14.83% protein contents (Table 4). The wheat protein content is a crucial consideration for all end products (uses of wheat) from bread baking to noodles, pasta, cakes, and biscuits. Wheat protein content varies widely counting on wheat class, growing region, type and quality of soil, and course fertilizers input (amount and timing), nitrogen particularly. All other factors being equal, flour from higher protein wheat has a greater water-absorbing capacity and thus greater bread volume potential, depending somewhat on the baking process used. While protein content is an intrinsic genetic trait and thus a

Table 4: Mean performance of some important quality traits of 28 genotypes and 2 checks tested in 2017 and 2018 cropping season

Genotype	PC (%)	GW (mg)	GH (%)	GD (mm)	DG (%)	WG (%)	GI (%)
Wane	12.14	36.49	62.63	2.74	17.65	38.25	73.13
ETBW 8751	12.68	36.74	74.60	2.88	16.65	36.60	80.28
ETBW 8858	14.06	36.47	72.89	2.70	21.00	40.95	74.57
ETBW 8870	14.03	34.78	74.25	2.66	17.50	38.35	70.31
ETBW 8802	14.12	28.99	84.93	2.55	13.60	31.20	83.27
ETBW 8991	13.19	35.45	76.33	2.82	17.65	38.95	73.63
ETBW 8862	14.14	38.94	70.85	2.78	20.55	41.20	73.04
ETBW 8804	13.68	33.59	78.95	2.69	14.55	34.45	82.65
ETBW 8996	13.83	37.11	67.45	2.81	17.30	39.90	69.47
ETBW 8583	14.02	35.16	80.13	2.69	17.30	36.80	83.84
ETBW 8668	13.22	34.70	67.46	2.68	16.80	38.45	68.00
ETBW 8595	13.26	41.55	70.40	2.87	15.35	36.55	71.76
ETBW 8684	13.01	36.75	78.40	2.85	20.05	41.35	68.84
ETBW 9486	14.32	39.06	73.12	2.90	16.23	39.48	64.34
ETBW 9547	14.62	38.36	82.94	2.80	17.70	38.55	71.34
ETBW 9548	14.17	39.12	79.03	2.85	20.35	41.70	75.01

Table 4: Continue...

Genotype	PC (%)	GW (mg)	GH (%)	GD (mm)	DG (%)	WG (%)	GI (%)
ETBW 9549	14.83	36.70	77.88	2.81	16.00	36.25	73.34
ETBW 9550	14.40	36.60	78.96	2.83	19.70	42.30	72.49
ETBW 9551	13.29	32.35	74.05	2.68	16.00	34.70	78.79
ETBW 9552	14.22	39.96	81.22	2.51	16.25	35.15	83.31
ETBW 9553	13.67	38.41	77.53	2.93	18.45	37.00	77.95
ETBW 9554	14.37	37.09	73.67	2.75	15.50	33.95	83.98
ETBW 9555	14.17	34.60	70.71	2.65	17.25	39.95	78.69
ETBW 9556	14.28	40.45	53.87	2.94	16.05	36.00	82.44
ETBW 9557	13.65	33.19	77.13	2.59	15.45	35.15	85.73
ETBW 9558	14.27	37.26	71.46	2.83	15.50	33.70	79.76
ETBW 9559	13.91	37.84	76.67	2.82	15.40	33.45	83.92
ETBW 9560	14.62	35.94	64.94	2.73	17.25	39.10	69.49
ETBW 9561	13.93	37.15	84.42	2.88	16.95	35.90	84.94
Hidasse	12.30	36.57	38.94	2.70	27.96	38.88	40.28
Mean	13.81	36.58	73.19	2.76	17.46	37.47	75.29
CV (%)	3.21	4.41	4.22	3.12	16.73	8.16	12.50
LSD (p=0.05)	0.77	4.84	10.50	0.21	8.40	6.01	15.34
R^2	0.80	0.87	0.95	0.81	0.79	0.66	0.62

PC: protein content; GW: grain weight; GH: grain hardness; GD: grain diameter; DG: dry gluten; WG: wet gluten; GI: gluten index

variety of criterion in breeding programs, environmental impact is considerably greater than that controlled by the breeders. The recently released variety contains higher protein content than stander check wane and local check Hidasse. Boru had 37.09, 73.67, 2.75, 15.5, 33.95, and 83.98 grain weight, grain hardness, grain diameter, dry gluten, wet gluten, and gluten index, respectively (Table 4).

3.4. Disease resistance

Rust diseases cause significant losses to wheat production worldwide. 28 newly evolved wheat genotypes along with two commercial wheat varieties were evaluated for resistance to rust diseases. The advanced genotypes and commercial varieties had different responses against rust (leaf, yellow, and stem rust) infections. Some genotypes showed a highly resistant (R or MR type) reaction, while others showed MS type reaction. Two of the advanced genotypes (ETBW 9554 (Boru) and ETBW 9553) were showed resistance against stem rust, yellow rust, and leaf rust with desirable infection levels (<5 MR). The standard check Wane varieties showed moderately susceptible to stem rust and yellow rust disease with 10 MS and 5 MS respectively. However, the local check Hidasse showed highly susceptible to stem rust and yellow rust with the 80 S and 60 S respectively. Genotypes with slow rusting resistance are highly important to achieve effective breeding for durable resistance to stripe rust (Nzuve et al., 2012). The newly released bread wheat varieties are moderately resistant to stem rust, resistant to yellow rust and comparable for leaf rust disease and Septoria with the standard checks Wane and local check Hidasse (Table 5). Current commercial bread wheat varieties cultivated in the highland are susceptible to yellow rust and a long maturity period. There was intense stripe rust disease pressure, and the newly released bread wheat variety which was designated

Table 5: Reaction to the major wheat diseases

Diseases	ETBW 9554 (Boru)	ETBW 9553	Wane (St. Check)	Hidasse (L. Check)
Stem rust (%+ reaction)	5MR	TR	10MS	80S
Yellow rust (%+reaction)	5R	TMR	5MS	60S
Leaf rust (%+ reaction)	0	0	0	0
Septoria (00–99)	21	32	12	56

Where, R: resistant, MR: moderately resistant, MS: moderately susceptible, S: susceptible; TMR: Trace moderately susceptible with the local name Boru exhibited a high level of yellow rust resistance with resistance and moderately resistant response to stem rust (Table 5). Therefore, the release of new rust-resistant varieties will be a good opportunity for resource-poor wheat-growing farmers.

3.5. Variety maintenance

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

4. CONCLUSION

Boru (ETBW9554) was tested in more environments in a variety of verification trials to determine its adaptability and potential recommendation for release to farmers for production and possible registration as the new variety for similar agro-ecologies in the study. Therefore, Boru (ETBW9554) was released as a variety by the national variety releasing committee of the country in 2020 because of its stability, resistant to wheat rust, high-yielder and other useful agronomic traits.

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5. REFERENCES

Abdelaal, K., Omara, R., Hafez, Y.M., Esmail, S., EL Sabagh, A., 2018. Anatomical, biochemical, and physiological changes in some Egyptian wheat cultivars inoculated with *Puccinia gramini* f. sp. Tritici. Fresenius Environmental Bulletin 27, 296–305.

Alemu, T., Zegeye, H., Kasa, D., Asnake, D., Solomon, T., Asefa, A., 2019. Wheat product concepts validation and assessment of dissemination and utilization constraints. Research Report No. 126. EIAR, Addis Ababa, Ethiopia, 37.

Amentae, T.K., Hamo, T.K., Gebresenbet, G., Ljungberg, D., 2017. Exploring wheat value chain focusing on market performance, post-harvest loss, and supply chain management in Ethiopia: The case of Arsi to Finfinnee market chain. Journal of Agricultural Science 9(8), 22. DOI https://doi.org/10.5539/jas.v9n8p22.

Anonymous, 2016. MoANR (Ministry of Agriculture and Natural Resource). Plant Variety Release, Protection and Quality Control Directorate. Crop Variety Register. Issue No. 19. Addis Ababa, Ethiopia.

Anonymous, 2016. Wheat Atlas. Commercial wheat varieties released in Ethiopia. Available at http://wheatatlas.org/country/varieties/ETH/. Accessed on September, 2021.

Anonymous, 2020. CSA (Central Statistical Agency). Report on area and production of major crops (private peasant holdings, meher season). Volume I. Statistical Bulletin 587. Available at https://instepp.umn.edu/sites/instepp.umn.edu/files/product/downloadable/Ethiopia_ 2019-0_vol_1. Accessed on May 12, 2021.

Ayele, B., Eshetu, B., Betelehem, B., Bekele, H., Melaku, D., Asnakech, T., Melkamu, A., Amare, A., Kiros, M., Fekede, A., 2008. Review of two decades of research on diseases of small cereal crops. Increasing Crop Production Through Improved Plant Protection 1, 375–416.

Belay, T., Araya, A., 2015. Grain and biomass yield reduction due to Russian wheat aphid on bread wheat in northern Ethiopia. African Crop Science Journal 23(2), 197–202.

Blum, A., 2011. Drought resistance–is it really a complex trait? Functional Plant Biology 38(10), 753–775.

Falola, A., Achem, B.A., Oloyede, W.O., Olawuyi, G.O., 2017. Determinants of commercial production of wheat in Nigeria: A case study of Bankura local government area, Zamfara state. Trakia Journal of Sciences 15(4), 397–404. DOI https://doi.org/10.15547/tjs.2017.04.024 .

Farooq, S., Shahid, M., Khan, M.B., Hussain, M., Farooq, M., 2015. Improving the productivity of bread wheat by good management practices under terminal drought. Journal of Agronomy and Crop Science 201(3), 173–188.

Hei, N., Shimelis, H.A., Laing, M., 2017. Appraisal of farmer's wheat production constraints and breeding priorities in rust prone agro-ecologies of Ethiopia. African Journal of Agricultural Research 12(12), 944–952.

Hodson, D.P., Jaleta, M., Tesfaye, K., 2020. Ethiopia's transforming wheat landscape: tracking variety use through DNA fingerprinting. Scientific Reports 10, 18532.

Hossain, M.M., Hossain, A., Alam, M.A., EL Sabagh, A., Ibn Murad, K.F. Haque, M.M., Muriruzzaman, M., Islam, M.Z., Das, S., Barutcular, C., Kizilgeci, F., 2018. Evaluation of fifty spring wheat genotypes grown under heat stress conditions in multiple environments of Bangladesh. Fresenius Environmental Bulletin 27, 5993–6004. DOI 10.1155/2008/896451.

Husnu, A., 2016. Tracing highly adapted stable yielding bread wheat (*Triticum aestivum* L.) genotypes for greatly variable South-Eastern Turkey. Applied

Ecology and Environmental Research 14(4), 159–176.
Husnu, A., Kılıç, H., Kendal, E., Altıkat, A., 2010. Evaluation of yield and yield components of some bread wheat genotypes in Diyarbakir conditions. In: Collaboration of University and Public and Industry Symposium, 357–363.
Kilic, H., Akçura, M., Aktas, H., 2010. Assessment of parametric and non-parametric methods for selecting stable and adapted durum wheat genotypes in multi-environments. Notulae Botanicae Horti Agrobotanici Cluj-Napoca 38(3), 271–279.
Minot, N., Sawye, B., 2012. Agricultural production in Ethiopia: Results of the 2012 ATA Baseline Survey. International Food Policy Research Institute, Washington, D.C.
Mottaleb, K.A., Sonder, K., Lopez-Ridaura, S., Frija, A., 2021. Wheat consumption dynamics in selected countries in Asia and Africa: implications for Wheat Supply by 2030 and 2050. CIMMYT, El Batan, Mexico.
Najafi, A., 2014. Wheat production price performance prediction in the Iranian north province. African Journal of Agricultural Research 9(1), 74–79.
Negassa, A., Shiferaw, B., Koo, J., Sonder, K., Smale, M., Braun, H.J., Gbegbelegbe, S., Zhe Guo, D.H., Wood, S., Payne, T., Abeyo, B., 2013. The potential for wheat production in Africa: analysis of biophysical suitability and economic profitability. International maize and wheat improvement center, CIMMYT. ISBN 978-607-8263-28-8.
Nelson, G.C., Rosegrant, M.W., Palazzo, A., Gray, I., Ingersoll, C., Robertson, R., Tokgoz, S., 2010. Food security, farming, and climate change to 2050: Scenarios, results, policy options. International Food Policy Research Institute, Washington, D.C.
Nzuve, F.M., Bhavani, S., Tusiime, G., Njau, P., Wanyera, R., 2012. Evaluation of bread wheat for both seedling and adult plant resistance to stem rust. African Journal of Plant Science 6, 426–432.
Olivera, P., Newcomb, M., Szabo, L.J., Rouse, M., 2015. Phenotypic and genotypic characterization of race TKTTF of *Puccinia graminis* f. sp. tritici that caused a wheat stem rust epidemic in southern Ethiopia in 2013–14. Phytopathology 105(7), 917–928.
Rosegrant, M.W., Agcaoili, M., 2010. Global food demand, supply, and price prospects. International Food Policy Research Institute, Washington, D.C.
Sajjid, M., Fida, M., 2018. Identifying stable bread wheat-derived lines across environments through GGE biplot analysis. Sarhad Journal of Agriculture 34(1), 63–69.
Semahegn, Y., Shimelis, H., Laing, M., Mathew, I., 2021. Farmers' preferred traits and perceived production constraints of bread wheat under drought-prone agro-ecologies of Ethiopia. Agriculture and Food Security 10(1), 1–13.
Shiferaw, B., Negassa, A., Koo, J., Wood, J., Sonder, K., Braun, J.A., Payne, T., 2011. Future of wheat production in Sub-Saharan Africa: Analyses of the expanding gap between supply and demand and economic profitability of domestic production. In: Increasing Agricultural Productivity & Enhancing Food Security in Africa: New Challenges and Opportunities. Africa Hall, UNECA, Addis Ababa, Ethiopia, 1–3 November, 2011.
Shiferaw, B., Smale, M., Braun, H.J., Duveiller, E., Reynolds, M., Muricho, G., 2013. Crops that feed the world 10. Past successes and future challenges to the role played by wheat in global food security. Food Security 5, 291–317.
Singh, R.P., Singh, P.K., Rutkoski, J., Hodson, D.P., He, X., Jorgensen, L.N., Hovmoller, M.S., Huerta-Espino, J., 2016. Disease impact on wheat yield potential and prospects of genetic control. Annual Review of Phytopathology 54, 303–322.
Stroosnijder, L., Moore, D., Alharbi, A., Argaman, E., Biazin, B., van den Elsen, E., 2012. Improving water use efficiency in drylands. Current Opinion in Environmental Sustainability 4(5), 497–506.
Tolemariam, A., Jaleta, M., Hodson, D., Alemayehu, Y., Yirga, C., Abeyo, B., 2018. Wheat varietal change and adoption of rust resistant wheat varieties in Ethiopia from 2009–10 to 2013–14. Socioeconomics Program Working Paper 12. Mexico, CDMX, CIMMYT.
Wasson, A.P., Richards, R.A., Chatrath, R., Misra, S.C., Prasad, S.S., Rebetzke, G.J., Kirkegaard, J.A., Christopher, J., Watt, M., 2012. Traits and selection strategies to improve root systems and water uptake in water-limited wheat crops. Journal of Experimental Botany 63(9), 3485–3498.