Evaluation of Bread Wheat Genotypes for Adult Plant Resistance to Stem Rust

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Abstract
Wheat stem rust (*Puccinia graminis* f. sp *tritici*) also known as 'polio of agriculture' is a ravaging disease of wheat (*Triticum aestivum* L.) making it a foremost confront to wheat production in Ethiopia and other wheat producing countries of the world due to the frequently evolving of virulent pathogen races. Because of this, searching novel genes in wheat genotypes is a critical issue. Twenty eight advanced bread wheat genotypes were evaluated for their response against stem rust caused by *Puccinia graminise* under field conditions at Kulumsa and Asassa during 2018 main growing season. Evaluation was carried out through disease assessment including terminal stem rust severity (TRS) and coefficient of infection (ACI) under natural infection. Twenty two wheat genotypes viz; ETBW-8858, ETBW-8870, ETBW-8583, ETBW-8684, ETBW-9548, ETBW-9549, ETBW-9554, ETBW-9558, ETBW-9559, ETBW-9560, ETBW-8751, ETBW-8862, ETBW-8804, ETBW-8896, ETBW-8991, ETBW-9560, ETBW-9556, ETBW-9486, ETBW-9561, ETBW-9550, ETBW-9553 and ETBW-9555 out of twenty-eight evaluated genotypes were discovered to be adult plant resistant (TRS $\leq$ 30 and ACI $\leq$ 20) to stem rust disease at both screening sites. Therefore, these genotypes with high stem rust resistance could be backcrossed to widely acclimatized and high yielding but susceptible Ethiopian wheat varieties to prevent further wheat yield declines. However, may need to evaluate for seedling response to confirm whether the genotypes are true adult plant resistant.
Keywords: Adult plant, Puccinia graminis, Stem rust, TRS, Wheat genotypes.
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1. Introduction

Wheat ranks first as a cultivated cereal in the world (>200 mha annually) and is the most important crop with respect to sustaining food security (Shiferaw *et al* 2013). Ethiopia is the most important wheat-growing country in sub-Saharan Africa, with 1.6 million hectares and annual grain production of 4.5 million tons at 2.67 t grain yield per hectare (Central Statistical Agency 2017). Wheat and wheat products represent 14 percent of the total caloric intake in Ethiopia, making wheat the second-most important food, behind maize (19 percent) and ahead of teff, sorghum, and enset (10-12 percent each) (FAO, 2014). However, enhancing the production in the face of changing climate *inter alia* requires protection against biotic stresses (Singh *et al* 2011; 2008) that cause huge yield loss. Among various biotic stresses, three rust diseases (stem rust, leaf rust and stripe rust) are the major threats to wheat production globally (Murray,2009).

All three rust pathogens belong to the genus *Puccinia* are host-specific viz., *P. graminis* f. sp. *tritici* Erik. & E. Henn. for stem rust, *P. triticina* Erik. for leaf rust and *P. striiformis* West. for the stripe rust. Of the three, stem and yellow rust are the most devastating in Ethiopia (Olivera *et al.*, 2015).

Under favorable environmental conditions, stem rust can cause yield losses of up to 100% in susceptible wheat varieties (Roelfs, 1985b). The yield loss due to this disease is usually greatest

if the disease becomes severe before the grain is completely formed, but yield losses are generally influenced by the resistance level of the cultivar grown, the weather conditions and the onset of the disease (Luig, 1985; Roelfs, 1985a).

The first devastating effects of stem rust epidemics was recorded in East Africa (in Kenya in the early 1990s and Ethiopia in 1972) because of a breakdown of the resistance gene Sr36 in cultivar Enkoy (Kebede *et al.* 1995). In Ethiopia, an epidemic of stem rust of wheat occurred in 1972, due to the loss of resistance in cultivar Lakech, which was grown on large area. Similarly, the cultivar Enkoy went out of production in the country after the epidemics in 1972. In Ethiopia, yield losses due to stem rust have been reported to be in the range of 61-100% depending on the susceptibility of the variety and environmental conditions (Eshetu, 1985; Shank, 1994).

In order to reduce losses associated with wheat stem rust, planting resistant varieties is eco-friend and cost effective option. However, breeding for wheat rust resistance always requires constant novel sources of resistance genes, due to the appearance of new virulent pathogen races (Singh *et al.*, 2011) In most cases of country breeding programs wheat cultivars were replaced by new resistant cultivars due to susceptibility to rusts (Admassu *et al.,* 2009).

However, the only effective way to eliminate crop yield losses due to leaf rust infection (other than the use of fungicides rarely a cost effective option) are through planting stem rust resistant wheat varieties. Therefore, the objective of this investigation was to evaluate 28 advanced bread wheat genotypes against stem rust under Ethiopian wheat belt zone rust screeing sites at field conditions to select the resistant genotype to be included in wheat breeding programs.

2. Materials and Methods

2.1. Descriptions of study area

Arsi, with diverse agro-ecological zones, main wheat belt of east Africa and prevalence of pathogens, affords a chance to screen wheat germplasm at various disease hotspots on a large scale.

Asassa, major wheat producer district in south East Ethiopia located at 39° 11' 43" E and 07° 05' 57"N altitude of 2371m above sea level. It has a mean annual temperature of 18^0C and 930mm rainfall. The economy of the districts is dominated by agriculture. The farming system is mainly characterized by producing annual cereals mainly wheat in the absence of crop rotation in the main meher growing season. This screening site is a hotspot for leaf and stem rusts and is the natural epicenter of initial inoculum of these rusts. Therefore, infection occurs naturally in susceptible cultivars.

Kulumsa research center is located at 08° 01' 10" N, 39° 09' 11" E and at 2200 meters above sea level (m.a.s.l). It receives mean annual rainfall of 820 mm representing highland and high rainfall agro ecology. The monthly mean minimum and maximum temperature is 10.5 and 22.8°C respectively. The sites dominant soil type is loam type, which is fertile.

2.2. Planting materials and experimental procedure

Twenty-eight advanced bread wheat lines used in the present study obtained from Kulumsa Agricultural Research center, Ethiopian national wheat research excellence. Their pedigree sources were used in this study (Table 1).This experiments was carried out at two wheat rust screening sites i.e. Kulumsa agricultural research center and Asassa agricultural research site Ethiopia during 2018 growing season. These experiments were planted in randomized complete block design (RCBD) with 3 replicates. The tested wheat genotypes were planted in plots containing two rows of 1.2m × 1m width and length respectively. In order to engage uniform spread of inoculums and for adequate disease development during the trial period, a universal susceptible wheat cultivar 'Morocco' was planted a week earlier as infector row between blocks perpendicular to entries. The infector rows were sprayed and injected with active uredinospores collected and maintained at Kulumsa wheat rust laboratory, south east Ethiopia. To maintain crop stand/vigor normal agronomic practices including recommended fertilization dose and irrigation schedule were applied.

Table 1. The wheat genotypes with their pedigree used in the study

No	Genotype	Pedgree
1	ETBW 8751	SUP152//ND643/2*WBLL1
2	ETBW 8858	SWSR22T.B./2*BLOUK #1//WBLL1*2/KURUKU
3	ETBW 8870	WAXWING*2/TUKURU//KISKADEE #1/3/FRNCLN
4	ETBW 8802	CHAM-4/SHUHA'S'/6/2*SAKER/5/RBS/ANZA/3/KVZ/HYS//YMH/TOB/4/BOW'S"
5	ETBW 8991	SUP152//ND643/2*WBLL1
6	ETBW 8862	C80.1/3*BATAVIA//2*WBLL1/3/C80.1/3*QT4522//2*PASTOR/4/WHEAR/SOKOLL
7	ETBW 8804	TURACO/CHIL/6/SERI 82/5/ALD'S'/4/BB/GLL//CNO67/7C/3/KVZ/TI
8	ETBW 8996	FALCIN/AE.SQUARROSA (312)/3/THB/CEP7780//SHA4/LIRA/4/FRET2/5/DANPHE #1/11/CROC_1/AE.SQUARROSA (213)//PGO/10/ATTILA*2/9/KT/BAGE//FN/U/3/BZA/4/TRM/5/ALDAN/6/SERI/7/VEE#10/8/OPATA
9	ETBW 8583	MINO/898.97/4/PFAU/SERI.1B//AMAD/3/KRONSTAD F2004
10	ETBW 8668	BAVIS*2/3/ATTILA/BAV92//PASTOR
11	ETBW 8595	BAVIS*2/3/ATTILA/BAV92//PASTOR

No	Genotype	Pedgree
12	ETBW 8684	PASTOR//HXL7573/2*BAU/3/WBLL1/4/1447/PASTOR//KRICHAUFF
13	ETBW 9486	FRANCOLIN #1/3/PBW343*2/KUKUNA*2//YANAC/4/KINGBIRD #1//INQALAB 91*2/TUKURU
14	ETBW 9547	MUTUS*2/AKURI//MUTUS*2/TECUE #1
15	ETBW 9548	REEDLING #1//KFA/2*KACHU
16	ETBW 9549	KFA/2*KACHU/3/KINGBIRD #1//INQALAB 91*2/TUKURU/4/KFA/2*KACHU
17	ETBW 9550	KFA/2*KACHU*2//WAXBI
18	ETBW 9551	KFA/2*KACHU/4/KACHU #1//PI 610750/SASIA/3/KACHU/5/KFA/2*KACHU
19	ETBW 9552	KACHU #1/4/CROC_1/AE.SQUARROSA (205)//BORL95/3/2*MILAN/5/KACHU/6/KFA/2*KACHU
20	ETBW 9553	MURGA/KRONSTAD F2004/3/KINGBIRD #1//INQALAB 91*2/TUKURU
21	ETBW 9554	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
22	ETBW 9555	KFA/2*KACHU/5/WBLL1*2/4/BABAX/LR42//BABAX/3/BABAX/LR42//BABAX/6/KFA/2*KACHU
23	ETBW 9556	SOKOLL/3/PASTOR//HXL7573/2*BAU/4/PARUS/PASTOR
24	ETBW 9557	SOKOLL/WBLL1/4/D67.2/PARANA 66.270//AE.SQUARROSA (320)/3/CUNNINGHAM
25	ETBW 9558	BABAX/LR42//BABAX/3/ER2000/5/ATTILA/4/WEAVER/TSC//WEAVER/3/WEAVER/6/KA/NAC//TRCH
26	ETBW 9559	CHIBIA//PRLII/CM65531/3/MISR 2*2/4/HUW234+LR34/PRINIA//PBW343*2/KUKUNA/3/ROLF07
27	ETBW 9560	CHWINK/GRACKLE #1//FRNCLN
28	ETBW 9561	TRAP#1/BOW/3/VEE/PJN//2*TUI/4/BAV92/RAYON/5/KACHU #1*2/6/KINGBIRD #1
29	Morocco	Universal susceptible check

2.3. Disease assessment

Terminal stem rust severity data recording was started from the first appearance of yellow rust on the susceptible check and continued every 14 days from all plants until the early dough stage [25]. Final rust severity includes two components i.e. disease severity based on modified Cobb,s scale (Peterson *et al.*, 1948), where Tr = less than 5 % and 5 = 5 % up to 100 = 100 %, and host response (infection type) based on scale described by Stakman *et al*. (1962), which was expressed in five types as follows: immune (0), resistant (R), moderately resistant (MR), moderately susceptible (MS) and susceptible (S) moderately susceptible to moderately resistant (MSMR).

Coefficient of infection (CI) was calculated by multiplying rust severity with constant values of infection type (IT). The constant values for infection types were used based on; R = 0.2, MR = 0.4, X = 0.6, MS = 0.8 and S = 1 (Stubbs *et al.*, 1986). Average coefficient of infection (ACI) was derived from the sum of CI values of each line divided by number of scoring times.

3. Results and Discussion

A total of 28 advanced bread wheat genotypes were tested for adult plant resistance to stem rust disease at Asassa agricultural research experimental site and Kulumsa agricultural research center south East Ethiopia, results showed below in Table 2.

	Genotypes	Kulumsa		Asassa	
		Final	ACI	FRS	ACI
1	ETBW 8751	10ms	8	15ms	12
2	ETBW 8858	0	0	0	0
3	ETBW 8870	tms	1.6	Tms	1.6
4	ETBW 8802	50s	50	40s	40
5	ETBW 8991	20ms	16	15ms	12
6	ETBW 8862	0	0	0	0
7	ETBW 8804	0	0	0	0
8	ETBW 8996	0	0	0	0
9	ETBW 8583	10ms	8	15ms	12
10	ETBW 8668	60s	60	50s	50
11	ETBW 8595	50s	50	40s	40
12	ETBW 8684	0	0	0	0
13	ETBW 9486	10ms	8	15ms	12
14	ETBW 9547	20ms	16	20ms	16
15	ETBW 9548	15ms	12	25ms	20
16	ETBW 9549	tms	1.6	Tms	1.6
17	ETBW 9550	15ms	12	10ms	8
18	ETBW 9551	30s	30	25ms	20
19	ETBW 9552	40s	40	40s	40
20	ETBW 9553	0	0	0	0
21	ETBW 9554	tms	1.6	5ms	4
22	ETBW 9555	0	0	0	0
23	ETBW 9556	0	0	0	0
24	ETBW 9557	70s	70	60s	60
25	ETBW 9558	0	0	0	0
26	ETBW 9559	5ms	4	Tms	1.6
27	ETBW 9560	5ms	4	5ms	4
28	ETBW 9561	5ms	4	10ms	8
29	Morocco	80S	80	70S	70

Data in Table (2) showed that, final stem rust severity of the tested genotypes ranged from 0-70 to 0 to 60% at Kulumsa and Asassa screening sites respectively. Out of 28 tested genotypes, 23 genotypes showed admirable slow rusting resistance (0-30%) to terminal stem rust severity at both locations. These genotypes were ETBW-8858, ETBW-8870, ETBW-8583, ETBW-8684, ETBW-9548, ETBW-9549, ETBW-9554, ETBW-9558, ETBW-9559, ETBW-9560, ETBW-8751, ETBW-8862, ETBW-8804, ETBW-8896, ETBW-8991, ETBW-9560, ETBW-9556, ETBW-9486, ETBW-9561, ETBW-9550, ETBW-9551, ETBW-9553 and ETBW-9555.

According to Ali *et al*., (2008) genotypes with ACI values of 0-20, 21-40, 41-100 were regarded as high, moderate and low levels of adult plant resistance, respectively. In this study, 88% and 92.8% of the tested genotype namely, ETBW-8858, ETBW-8870, ETBW-8583, ETBW-8668, ETBW-8595, ETBW- 8684, ETBW-9548, ETBW-9549, ETBW-9552, ETBW-9554, ETBW-9558, ETBW-9559, ETBW-9560, ETBW-875, ETBW-8802, ETBW-8862, ETBW-8804, ETBW-8896, ETBW-9557, ETBW- 8991, ETBW-9486 and ETBW-9561 showed ACI values between 0 and 20 at Kulumsa and Asassa experimental locations and were designated as having a high level of slow rusting genes. On the other hand, the susceptible check Morocco and four ETBW-8802,ETBW 8668, ETBW-8595 and ETBW-9557, and two ETBW-8668 and ETBW-9557 tested genotypes displayed ACI above 41 Table 2 and Figure 1 and 2.

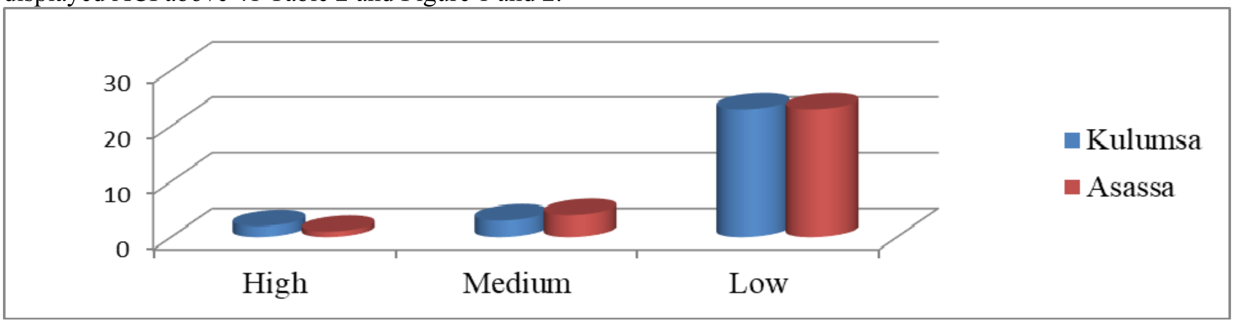

Figure 1: The percentage FRS values of advanced bread wheat test lines and susceptible check tested at Kulumsa and Asassa in 2018 growing season.

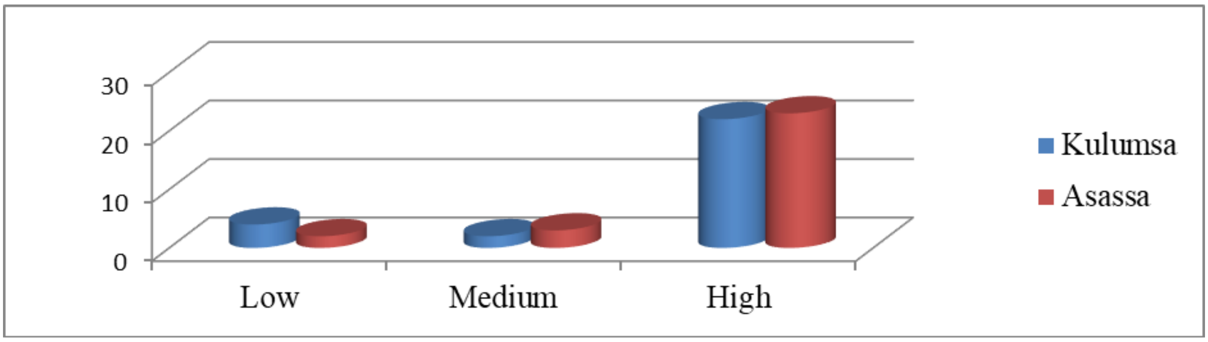

Figure 2: The percentage ACI values of advanced bread wheat lines and susceptible check tested at Kulumsa test sites in 2018.

Information's of this study disclosed that 22 wheat genotypes namely ETBW-8858, ETBW-8870, ETBW-8583, ETBW-8684, ETBW-9548, ETBW-9549, ETBW-9554, ETBW-9558, ETBW-9559, ETBW-9560, ETBW-8751, ETBW-8862, ETBW-8804, ETBW-8896, ETBW-8991, ETBW-9560, ETBW-9556, ETBW-9486, ETBW-9561, ETBW-9550, ETBW-9553 and ETBW-9555 showed acceptable level of stem rust slow rusting in both diseases assessment parameters, terminal rust severity and average coefficient of infections during 2018 growing season at both locations compared with Morocco (universal susceptible check).These wheat lines were found to be resistant to stem rust disease and can be used in breeding programs to release commercial cultivars as safely production under Ethiopian conditions. The result of this study is in agreement with Bekele Hundie *et al*. (2018), who reported advanced bread wheat lines extracted from wheat breeding trials against stem rust at adult plat stage under stem rust hot spot sites and at seedling stages in the greenhouse. In addition, the result of this study is in lined with the works of Nzuve F. (2012) who reported as evaluating wheat genotypes for both field and seedling resistance to stem rust and genotypes showed diverse seedling and adult plant resistance responses.

4. Conclusion

Disease tolerant wheat cultivars are believed the main issues in wheat breeding agriculture research programs to protect wheat plants from disease epidemics and thus from yield loss. In this study 28 wheat genotypes were grown at two wheat rust diseases screening hotspot sites, Kulumsa and Asassa, south East Ethiopia. The grown wheat genotypes were evaluated in two major diseases assessment features; terminal rust severity and average coffient of infection. Thus, among the 28 genotypes evaluated, 78.5% have showed high slow rusting therefore could be suggested either for release to production and/or also could be used for durable stripe rust resistance breeding in Ethiopia.

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