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Evaluation of bread wheat (*Triticum aestivum* L.) genotypes for resistance against stem rust (*Puccinia graminis* f. sp. *tritici*) diseases at seedling and adult stages

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Bread wheat is the most important food crops among cereals cultivated in the world and consume in various diets. However, the production of bread wheat majorly affected by fungal diseases especially rust diseases. Of the rust diseases, stem rust is the most destructive due to the frequent emerging of new races of the pathogen. The field experiment was conducted at Kulumsa Agricultural Research Debre Zeyit sub-center using 36 genotypes during 2015 cropping season, and the greenhouse experiment was carried out at Ambo Plant Protection Research Center to evaluate bread wheat genotypes for resistance/tolerance to wheat stem rust disease adult and seedling stages, respectively. For field experiment, the treatments were arranged in the randomized complete block design with three replications. Stem rust evaluations for Pgt races TTKSK, TKTTF, TRTTF and JRCQC were replicated so that a total of at least 20 seedlings from each cultivar were evaluated. At seedling stage, most of the genotypes confirm low IT ≤2 on four of the stem rust races indicating that they are resistance to the four stem rust races used. Out of these, nine of the gentypes namly genotype ETBW7178, ETBW7198, ETBW7236, ETBW7220, ETBW7161, ETBW7191 and one standard chick Dand'a has potential (IT≤1) to overcome stem rust races at sedling stage. On the experiment for adult stage, the only genotype showing strong resictance was genotype ETBW7178 (5R). The rest genotypes show moderately resistance, moderately susceptible and totally susceptible to stem rust inoculums used. These results can assist wheat breeders in Ethiopia for choosing parents for crossing in programs aimed at developing cultivars with desirable levels of stem rust resistance in collabration with International Maize and Wheat Improvement Center (CIMMYT) and will also facilitate stacking of resistance genes into advanced breeding lines.

Key words: Genotypes, inoculums, resistance, suscepitable.

INTRODUCTION

Ethiopia, with its range of altitudes, soils and climatic conditions provide ecological settings suitable for the cultivation of diverse species of wheat (Harlan, 1971). Durum wheat (*Triticum turgidum* Desf.) and bread wheat (*Triticum aestivum* L.) are, however, the two most important wheat species grown in the country although

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other species are also cultivated to a lesser extent (Amsal, 2001). Though bread wheat is believed to be a relatively recent introduction to Ethiopia (Hailu, 1991); it exhibits wider adaptation and higher yield potential than durum wheat (Amsal, 2001).

Approximately 630 million tons of wheat (*T. aestivum*) is produced in over 200 million ha of cultivation area globally (Rosegrant, 1995). Wheat contributes 21% of the food calories and 20% of the protein consumed by more than 4.5 billion people in 94 developing countries (Braun et al., 2010). However, wheat productivity is adversely affected by many biotic and abiotic stresses and rust diseases are of prime importance worldwide. Severe wheat yield losses due to stem rust, caused by *Puccinia graminis* f. sp. *tritici*, have been reported in Europe, Asia, Australia, and the United States before the middle of the 20th century (Roelfs, 1978; Saari and Prescott, 1985), making stem rust the most feared wheat disease (Singh et al., 2011). Since 1970, yield losses caused by stem rust have been minimal due to the successful deployment of stem rust resistance (*Sr*) genes (e.g., *Sr31*) in commercial wheat cultivars (Leonard and Szabo, 2005). A new virulent race of *P. graminis* f. sp. *tritici* was identified in Uganda wheat nurseries and was observed to be able to infect wheat lines carrying *Sr31*. This new race became popularly known as Ug99 after the country and year of discovery, and was reported to disperse over large distances due to windborne spores. Similarly, Ug99 was observed in 2001 in Kenya, in 2003 in Ethiopia, and in 2007 in Yemen and Iran. Therefore, stem rust is again becoming a threat to wheat production worldwide (Nazari et al., 2009).

Wheat stem rust, a devastating disease of wheat and barley caused by the fungal pathogen *Puccinia graminis* f. sp. tritici, was largely eradicated in Western world during the mid-to-late twentieth century. However, isolated outbreaks have occurred in recent years. Different scholars investigate whether a lack of resistance in modern varieties, increased presence of its alternate host barberry and changes in climatic conditions could be facilitating its resurgence. Climate changes over the past 25 years in Europe for example, suggest increasingly conducive conditions for infection. Furthermore, it was documented that the first occurrence in decades of *P. graminis* on barberry in the UK. The result from Clare et al. (2018) illustrated that wheat stem rust does occur in the UK and, when climatic conditions are conducive, could severely harm wheat and barley production. Stem rust is favored by humid conditions and warm temperatures of 15 to 35°C. The fear of black rust through history and today is understandable. Apparently, healthy crop three or four weeks before harvest can be reduced to a black tangle of broken stems and shriveled grain. Harvest losses of 100% can occur in susceptible crop varieties.

In the mid-twentieth century, devastation caused by stem rust spurred efforts to breed wheat strains that could resist the fungi. That research led by agronomist Norman Borlaug, famously led to the Green Revolution in agriculture, increasing crop yields around the world. But stem rust returned in the late 1990s and 2000s, with a variety called Ug99 that spread through Africa and parts of the Middle East. It ruined harvests and caused international concern because, Dusunceli says, more than 90% of wheat crops were susceptible to it. So far, however, it has not hit large wheat-producing regions such as Europe, China and North America. Researchers are developing resistant crops (Bhattacharya, 2017).

In Ethiopian highlands, bread wheat has been produced by small scale farmers since the introduction of the crop approximately about 5000 years ago but in recent years becuase of the emerging new races of stem rust and yellow rust, the production and productivity is highly reduced and in some case there is 100% yield losses. The highlands of western Ethiopia suitable for wheat production are in great problems due to lack of resistant varities with good yield and quality, since most of the adapated varieties became susceptible to the new emering races and reduction in productivity (Singh et al., 2015).

Strong messages emerge from the Ethiopian TKTTF experience. The presence of a race in one region and incursion into a new region can have a devastating impact. The speed with which a stem rust epidemic can develop and spread is incredibly fast. Effective control of stem rust, especially under small-holder farming systems, is virtually impossible in the absence of resistant varieties. The current stem rust situation in Ethiopia reinforces the need for effective global rust surveillance and monitoring, the critical need for the continued development and promotion of durable rust resistant varieties, and the diversification of varietal and cropping systems (Singh et al., 2015). Hence, there is a need for screening of genotypes aginst major disease and yield peroformance in order to come up with promising varieties which coud resist/tolerate the new races of stem rust pathogens with high grain yield. Therefore, the objectives of the project was to evaluate bread wheat genotypes for resistance/tolerance to wheat stem rust dieases.

MATERIALS AND METHODS

Site description

The experiments were conducted at Kulumsa Agricultural Research Debrezeyit sub-center and Ambo Plant Protection Resaerch Center during 2015 croping season for evaluation of bread wheat genotypes against stem rust races at adult and seedling stages, respectively. The sites ranged from mid to high altitude areas which favor the opportunity for different pests and diseases to occur and interact with genotypes. The annual rain fall distribution is 1800 to 2000 mm and the annual minimum and maximum temperature is 17 to 21°C. And have clay loam to loam soil types. The population of the area is engaged with mixed farming for both location (Tesfaya, 2001).

Experimental materials

Thirty six bread wheat genotypes including two standard checks selected from 121 first trial, preliminary yield trials at Shambu starting from 2012. The first 36 materials were originally obtained from Kulumsa Agricultural Research Centre National Wheat Research Coordination Centre and were promoted based on the yield and other agronomic performances in the season (Table 1).

Design and data management

At Debre-Zeyit, treatments were arranged in randomized complete block design with three replication on plot size of 5 rows × 1.2 m length × 20 cm between row spacing = 1 m^2 or on a 1.2×0.8 m area of land. The seed rate was 150 kg/ha. Treatments were subjected to grow on open field as the environment and the time of sowing used favours the infestation of stem rust in the area. At least six seedlings of each genotypes were grown in 10 × 10 cm^2 pots in Metro-Mix 200 vermiculite peat-perlite medium in a greenhouse with supplementary lighting to provide a 16 h photoperiod under controlled environment at Ambo Agricultural Research Center for seedling test against the reaction of the inoculated stem rust race.

Inoculums and inoculation

Inoculums' source and infection

Aeciospores from *Berberis vulgaris* are currently rare, but historically it was an important source of inoculums in Northern North America and Europe. Mycelium or uredinia on volunteer wheat are the most important source of inoculums in tropical and subtropical climates. Windblown urediniospores are usually from earlier maturing wheat from the south in the northern hemisphere, or from the north in the southern hemisphere. Urediniospores and aeciospore germinate when in contact with free water and infection by penetration through the stomata. Penetration requires at least a low light intensity. Germination optimum is 18°C, latent period varies from 10 to 15 days in the field with temperatures of 15 to 30°C (Berlin, 2017).

All isolates were derived from single pustule, increase in isolation, and stored at -80°C. Inoculation of *P. graminis* isolates was performed in an inoculation booth at Ambo Agricultural Research Center. Inoculum of four different races was used for stem rust inoculation. Isolates of Pgt races are described in Rouse et al. (2011). In addition, isolate 06YEM34-1 was used for race TRTTF. Inoculation and incubation were performed as described previously (Jin et al., 2007). *P. graminis* and *Puccinia triticina* urediniospores were retrieved from storage at -80°C and heat shocked at 45°C for 15 min. Spores were rehydrated by placing the capsules in an air-tight container at 80% humidity maintained by a KOH solution for 2 to 4 h. Urediniospores were then suspended in a light-weight mineral oil (Soltrol 70) and sprayed onto seedlings. Seedlings were inoculated when the first leaf was fully expanded with a suspension of urediniospores of single *P. triticina* and *P. graminis* races. The inoculation booth was washed with water between inoculations of plants with different *P. graminis* and *P. triticina* isolates in order to prevent contamination. For approximately 30 min, plants were under a fume hood for oil evaporating. Plants were kept in a 100% humidity chamber overnight and maintained in the greenhouse at 15 to 25°C with supplemental lighting after inoculation (Jin et al., 2007).

Disease assessment and data analysis

After dew chamber incubation, plants were kept in a greenhouse at the Ambo Agricultural Research Center, Cereal Disease Laboratory maintained at 18 ± 2°C for 14 days. Infection types (ITs) were classified on a 0-4 scale 12 to 14 days after inoculation on seedlings as described by Stakman et al. (1962): IT 0 = immune response, with no uredinia or necrosis; IT fleck (;) = necrotic flecks; IT1 = small uredinia surrounded by necrosis; IT2 = small uredinia surrounded by chlorosis; IT3 = moderate uredinia; IT 4 = large uredinia. Designations of + and - were added to indicate larger and smaller size of uredinia; X = a mesothetic response of flecks, small and large uredinia. Stem rust evaluations for Pgt races TTKSK, TKTTF, TRTTF and JRCQC were replicated so that a total of at least 20 seedlings from each cultivar were evaluated (Mohammadi et al., 2013).

Treatments use and experimental design for adult plant test

The experiment was arranged in RCBD with three replications. Plots having the size of 2 × 1 m was prepared. There are 10 rows per plot and the space between rows, plots and replications was 0.2, 0.5 and 1 m, respectively. To initiate sufficient disease development, known very susceptible bread wheat varieties (604) to rust was sown on the bordered of all plots. Seed of each variety was planted in each plot by hand drilling at the rate of 150 kg/ha, which was recommended for the area was used. Fertilizers at a rate of 46 kg/ha N and 46 kg/ha P_2O_5 was applied during planting. Weeds were controlled by hand weeding was carried out according the farmers' practices of the areas. Natural infection was used to initiate the epidemics of the disease.

Data collection

Diseases data

Disease incidence: Rust incidence was recorded on each experimental plot by counting number of diseased plants from 16 randomly taken and tagged plant/plot from eight central rows and calculated as the proportion of the diseased plants over the total stand count (16 plants) at 10 days interval.

Disease severity: Proportion of the stem and leaf of the plant affected by the disease, recorded using the modified Cobb's scale (Peterson et al., 1948). Starting from the appearance of the sign or symptoms, each plant within each plot was visually evaluated for percent foliar infection (severity) at 10 days interval.

RESULTS

The result of experimental analysis for seedling stage and adult stage was conducted separately and the result is shown in Tables 2 and 3, respectively.

The reaction of 36 wheat genotypes was determined, including cultivars currently and widely grown in Ethiopia, to four collected isolates of *P. graminis* f. sp. *tritici.* To combat the threat posed by Ug99, breeders require knowledge about existing sources of resistance to this race. Such information would enable wheat breeders to carefully design crosses to combine individual resistance sources into one breeding line and enhance germplasm for Ug99 resistance.

Infection types (ITs), described by Stakman et al. (1962), were assessed 14 days post-inoculation. From a practical point of view, seedling resistance genes can be

Table 1. List of bread wheat genotypes used in the study, and their pedigree and origion.

Entry	Genotype	Pedigree	Seed source
1	ETBW 7178	DVERD-2/AE.SQUARROSA(214)//2*ESDA/	IESRRL# 53
2	ETBW 7252	SAMAR-8/KAUZ'S'//CHAM-4/SHUHA'S'	IESRRL # 214
3	ETBW 7238	CROW 'S'/BOW'S' 3-1994/95//TEVEE'S'/T	IESRRL # 177
4	ETBW 7198	VAN'S/3/CNDR'S'/ANA//CNDR'S'/MUS'S'/	IESRRL# 84
5	Kubsa	Check	Breeder seed,2011
6	ETBW 7237	CROW 'S'/BOW'S' 3-1994/95//TEVEE'S'/T	IESRRL # 176
7	ETBW 7171	FOW'S'//NS732/HER/3/CHAM-6//GHURA	IESRRL# 43
8	ETBW 7208	CHAM-4/SHUHA'S'/6/2*SAKER/5/RBS/AN	IESRRL# 110
9	ETBW 7236	CROW 'S'/BOW'S' 3-1994/95//KATILA-11	IESRRL # 174
10	ETBW 7248	SAKER/5/RBS/ANZA/3/KVZ/HYS//YMH/TUL/	IESRRL # 209
11	ETBW 7173	FOW'S'//NS732/HER/3/CHAM-6//GHURA	IESRRL# 45
12	ETBW 7235	CROW 'S'/BOW'S'-1994/95//ASFOOR-5	IESRRL # 173
13	ETBW 7268	SOMAMA-9//SERI 82/SHUHA'S'	IESRRL # 272
14	ETBW 7174	CHAM-6/GHURAB'S'//JADIDA-2	IESRRL# 46
15	ETBW 7220	CHAM-4/SHUHA'S'/6/2*SAKER/5/RBS/AN	IESRRL# 135
16	ETBW 7221	DUCULA/KAUZ/3/KAUZ'S'//GLEN/PRL'S'/4	IESRRL# 142
17	ETBW 7227	IZAZ-2//TEVEE'S'/SHUHA'S'	IESRRL# 164
18	ETBW 7239	WEEBILL – 1/BOCRO-3	IESRRL # 178
19	ETBW 7160	CHAM-6/WW 1402	IESRRL# 29
20	ETBW 7161	CHAM-6/WW 1403	IESRRL# 30
21	ETBW 7191	BOCRO-4/3/MAYO'S'//CROW'S'/VEE'S'	IESRRL# 72
22	ETBW 7199	VAN'S/3/CNDR'S'/ANA//CNDR'S'/MUS'S'/	IESRRL# 85
23	ETBW 7182	CHIL-1//VEE'S'/SAKER'S'	IESRRL# 58
24	ETBW 7194	VAN'S/3/CNDR'S'/ANA//CNDR'S'/MUS'S'/	IESRRL# 76
25	ETBW 7204	SHA3/SERI//YANG87-142/3/2*TOWPE	IESRRL# 103
26	ETBW 7234	IRQIPAW 35 S5B-98/ABUZIG-4	IESRRL# 172
27	ETBW 7164	SHUHA-4//NS732/HER	IESRRL# 33
28	ETBW 7195	VAN'S/3/CNDR'S'/ANA//CNDR'S'/MUS'S'/	IESRRL# 78
29	ETBW 7244	ANDALIEB-5// TEVEE-1/SHUHA-6	IESRRL # 198
30	ETBW 7258	SABA/FLAG-1	IESRRL # 234
31	ETBW 7264	SERI 82/SHUHA'S'// SOMAMA-9	IESRRL # 268
32	ETBW 7215	CHAM-4/SHUHA'S'/6/2*SAKER/5/RBS/AN	IESRRL# 117
33	ETBW 7156	TAM200/TUI//MILAN/KAUZ/3/CROC-AB	IESRRL# 17
34	ETBW 7247	HD2206/HORK'S'/3/2*NS732/HER//KAUZ	IESRRL # 208
35	Danda'a	Check	Breeder seed,2011
36	ETBW 7175	CBME4SA#4/FOW-2	IESRRL# 47

useful in future selection processes. The information presented can be useful for wheat breeders contributing to a more efficient exchange of information and use of germ-plasm, but this research needs to be complemented with additional studies on adult plant resistance because some leaf rust resistance genes express resistance optimally in adult plants.

DISCUSSIONS

The emergence of virulence on *Sr31* in 1998 has increased the vulnerability of wheat to stem rust worldwide after decades of widespread use of this effective gene in global wheat-breeding programs. The occurrence of virulence to *Sr31* in Ethiopia has highlighted the need for germplasm enhancement to develop cultivars resistant to the Ug99 race of *P. graminis* f. sp. *tritici*. For seedling stage and most of the genotypes show low IT ≤2 on four of the stem rust races indicating that they are resistant to the four stem rust races used. Out of these, nine of the gentypes namly genotype ETBW7178, ETBW7198, ETBW7236, ETBW7220, ETBW7161, ETBW7191 and one standard chick Dand'a has potential (IT≤1) to overcome stem rust races at seedling stage. On the contrary, half of the

Table 2. Wheat germ plasm screened against four major stem rust races during seedling stage.

S/N	Code	TTKSK			TKTTF			TRTTF			JRCQC		
		1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
1	G-1	2	0	-	0	2	-	0	;	-	0	0	-
2	G-2	2	2+	-	;	0	-	;	;	-	;	0	-
3	G-3	3-	3-	-	2+	3-	-	2	;2-	-	;1	2+	-
4	G-4	;1	1	-	;1(c)	;1	-	;	;	-	;	;1	-
5	G-5	3-	3-	-	3-	2+,3-	-	;2-	;2-	-	0	3-	-
6	G-6(1)	2+	3-	-	2+	0	-	2	;1	-	;1	;1	-
7	G-6(2)	2+	2+,3-	-	2	3-	-	;2-	;2	-	0,2	2+	-
8	G-8	3-	3	-	2,2+	3-	-	2+	;2	-	;1	3-	-
9	G-9	;1	;1	-	;1(c)	;1	-	2-	;1+	-	;	;	-
10	G-10	2	1	-	;1	;1	-	2	;1	-	;1	1+	-
11	G-11	2+	;1	-	;1	3-	-	;1+	3-	-	;1	;1	-
12	G-12	3-	3-	-	2-	3-	-	2-	;1	-	;	3-	-
13	G-13	;1+	3-	-	;2+	;1	-	;1+	;2	-	;1	;1	-
14	G-14	2+,3-	3-	-	;1	;1	-	;1	;1	-	;1	;1	-
15	G-15	;1	;1	-	;1	0	-	;1	;	-	;1	1	-
16	G-16	2+,3-	2+	-	;2	2		2	3-	-	2-	2-	-
17	G-17	;1	2+	-	;	;1	-	;	;1+	-	;	;1	-
18	G-18	;	2	-	;	;1	-	;	;1+	-	;1	;1+	-
19	G-19	2-	2+	-	;1	;1	-	;	2-	-	;	;1+	-
20	G-20	;1	;1	-	;1	;1	-	;	;1+	-	;	;1	-
21	G-21	;1	;	-	;1	;1	-	;	;1	-	0	;	-
22	G-22	;1+	2	-	;1	2	-	;1	;1	-	;1	;1	-
23	G-23	;1,2+	3-	-	;1	1+	-	;1	;1+	-	;1	2-	-
24	G-24	2(c)	3-	-	;1	1+	-	;1	;1+	-	;	2	-
25	G-25	;1+	2-		0	1	-	;1	;1+	-	;1	;1	-
26	G26	3-	3-	-	;2	2	-	3-	3-	-	;	3-	-
27	G-27	2+	2+,3-	-	;1	;1	-	;1	;1+	-	;	;1	-
28	G-28	3-	3-	-	;2	3	-	2-	3-	-	;1	2+	-
29	G-29	2+	3-	-	;1	1+	-	;1	;2-	-	;1	;1	-
30	G-30	2+(c)	1	-	;1	1+	-	;1+	3-	-	0,1	0	-
31	G-31	;1+	;1	-	;1	;1	-	;1	;1	-	;1	;1	-
32	G-32	2-	2-	-	;1+	2	-	;1	;1	-	;1	;1	-
33	G-33	2-	2	-	;1+	2+	-	;1+	;1	-	;1	;1+	-
34	G-34	2,2+	3-	-	;1+	2-	-	;1	2,3-	-	;	;1+	-
35	G-35	;1	;1	-	0	0	-	0	0	-	0	;	-
36	G-36	;1	;1	-	;1	;1	-	;	0	-	0	;	-

[a]Infection types according to a 0 to 4 scale. Within line variation is indicated by '/'. [b]Races were represented by the following isolates: TTTTF 01MN84A-1-2, TTKSK 04KEN156/04, TTKST 06KEN19V3, TTKSF UVPgt55, TTKSP UVPgt59, PTKST UVPgt60.

materials used as ETBW7238, kubsa, ETBW7237, ETBW7171, ETBW7208, ETBW7182 and ETBW7804 show high infection type (IT) or are suscptability to stem rust races at seedling stage (Table 2).

On the experiment for addult stage, the only genotype showing strong resistance was genotype ETBW7178 (5R). The rest genotypes show moderatly resistance, moderately susceptable and totally susceptible to stem rust disease (Table 3). Genotypes ETBW7161, ETBW7227, ETBW7221, ETBW7174, ETBW7171, ETBW7198, ETBW7164 and ETBW7156 show MRMS. In countrast, genotypes ETBW7235, ETBW7204, 7234, ETBW7256 and ETBW7247 showed MSS and ETBW7182 showed SMS indicating highly susceptibility to stem rust at adult stage which can be used as border variety for infesting stem rust at field condition. The result was inline with that of Yu et al. (2010) which characterized resistance genotypes of a diverse and widely distributed collection of germplasm originating from the International Maize and Wheat Improvement Center (CIMMYT) and

Table 3. Severity of the tested wheat genotypes aginest stem rust at DebreZeit at adult stage at field condition.

S/N	Cultivar/Accession number	Terminal severity
1	ETBW 7178	5R
2	ETBW 7252	30MSMR
3	ETBW 7238	40MSS
4	ETBW 7198	30MRMS
5	Kubsa	40MRMS
6	ETBW 7237	40MSS
7	ETBW 7171	30MRMS
8	ETBW 7208	40MS
9	ETBW 7236	40MS
10	ETBW 7248	40SMS
11	ETBW 7173	40MRMS
12	ETBW 7235	50MSS
13	ETBW 7268	40MSS
14	ETBW 7174	30MRMS
15	ETBW 7220	30MS
16	ETBW 7221	30MRMS
17	ETBW 7227	30MRMS
18	ETBW 7239	40MSS
19	ETBW 7160	40MS
20	ETBW 7161	30MRMS
21	ETBW 7191	40MRMS
22	ETBW 7199	40MSS
23	ETBW 7182	50SMS
24	ETBW 7194	40MSS
25	ETBW 7204	50MSS
26	ETBW 7234	50MSS
27	ETBW 7164	30MRMS
28	ETBW 7195	40MSS
29	ETBW 7244	30MSMR
30	ETBW 7258	50MSS
31	ETBW 7264	30MSMR
32	ETBW 7215	40MSS
33	ETBW 7156	30MRMS
34	ETBW 7247	50MSS
35	Danda'a	40MSS
36	ETBW 7175	30MSS

IRs at the adult plant stage following the descriptions of Roelfs et al. (1992), where R = resistant, MR = moderately resistant, MS = moderately susceptible, and S = susceptible.

obtained that most wheat cultivars lacks Sr. genes at adult stage.

Conclusion

Stem rust is caused by *P. graminis f.sp. tritici*. It is devastating fungal disease can cause 100% yield lose. Based on field and laboratory studies in Debrezyit and Ambo Plant Protection, Ethiopia, this report confirmed the broad virulence that race TTKS possesses, across most of the bread wheat genotypes used.

At seedling stage, most of the genotypes revealed that low infection type (IT ≤2) on four of the stem rust races indicating that they are resistant to the four stem rust inoculum used. Out of these, nine of the gentypes namey genotypes ETBW7178, ETBW7198, ETBW7236, ETBW7220, ETBW7161, ETBW7191 and one standard

chick Dand'a has potential resistance (IT≤1) to overcome stem rust races at seedling stage. On the experiment for adult stage, the only genotype showing strong resictance was genotype ETBW7178 (5R). The rest genotypes show moderately resistance, moderately susceptible and totally susceptible to stem rust disease. Genotypes ETBW7161, ETBW7227, ETBW7221, ETBW7174, ETBW7171, ETBW7198, ETBW7164 and ETBW7156 show MRMS. In countrast, genotypes ETBW7235, ETBW7204, 7234, ETBW7256 and ETBW7247 showed MSS and ETBW7182 was the one showing SMS indicating highly susceptibility to stem rust at adult stage which can be used as border variety for infesting stem rust at field condition. These results can assist wheat breeders in Ethiopia for choosing parents for crossing in programs aimed at developing cultivars with desirable levels of stem rust resistance in collabration with International Maize and Wheat Improvement Center (CIMMYT) and will also facilitate stacking of resistance genes into advanced breeding lines. This requires extensive crossing of adapted germplasm with international cultivars and breeding materials that possess the effective resistance genes. Once crossed, procedures such as marker-assisted selection or marker-assisted backcross selection would be the methods of choice.

CONFLICT OF INTERESTS

The author has not declared any conflict of interests.

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