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*Full Length Research Paper*

# Analysis of pathogen virulence of wheat stem rust and cultivar reaction to virulent races in Tigray, Ethiopia

**Teklay Abebe[1], Getaneh Woldeab[2] and Woubit Dawit[3]***

[1]Tigray Agricultural Research Institute (TARI), Alamata Agricultural Research Center P.O. Box 56, Alamata, Ethiopia.
[2]Ethiopian Institute of Agricultural Research (EIAR), Ambo Plant Protection Research Center P.O. Box 37, Ambo, Ethiopia.
[3]Ambo University P.O. Box 19, Ambo, Ethiopia.

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**Wheat stem rust caused by *Puccinia graminis* f. sp. *tritici* is amongst the biotic factors which can cause up to 100% yield loss during epidemic years. The highland of Ethiopia is considered as a hot spot for the development of stem rust diversity. This study was carried out to analyze the virulence diversity of *P. graminis* f. sp. *tritici* and evaluate the seedling reaction of commonly grown wheat cultivars to selected virulent stem rust races. Race analysis was carried out by inoculating isolates on to the 20 differential hosts. A total of 20 races were identified from 32 isolates, which included the most prevalent races TTSNK, RRJJC, and HRJJC. Most of the the genes possessed by the differentials were ineffective against one or more of the tested isolates except *Sr24*. Three races (RRTTF, TTKSK and TTSNK) were used to determine the resistance of eleven wheat cultivars at seedling stage in greenhouse. Three varieties (Tura, Shina and Kubsa) were susceptible to them, while all the three durum wheat cultivars were resistant. Thus, the use of *Sr24* and *SrTmp* singlely or incombination with other genes through gene pyramiding has paramount importance as the additive effects of several genes offer the cultivar a wider base stem rust resistance.**

**Key words:** Physiologic race, *Puccinia graminis* f. sp. *tritici*, *Sr* genes.

## INTRODUCTION

Wheat (*Triticum aesvivum* L.) is one of the major crops cultivated in Ethiopia. It is among the cereal crops that contribute significantly to food security in the country. It is the main staple food for about 36% of the Ethiopian population (CIMMYT, 2005). Wheat ranks second both in terms of volume of production and productivity after maize (*Zea mays* L.) with the total volume of production of 2.54 million tones at the national level and it ranks third in terms of area coverage with the total area of 1.5 million ha after maize and tef (*Eragrostis tef* ) (CSA, 2009). In Tigray region, wheat is a priority cereal crop for securing food security.

However, productivity of wheat in Ethiopia in general and Tigray in particular is very low. The low productivity is attributed to a number of factors including biotic (diseases, insects, and weeds), abiotic, and low adoption of new agricultural technologies. Among these factors, wheat stem rust, also known as black rust, caused by the fungus *Puccinia graminis* f. sp. *tritici* Eriks. & Henn. has been the most devastating disease of all wheat rusts in Ethiopia causing up to complete annihilation of wheat crops over wide areas during epidemic years. The high virulence diversity and evolution rate of the pathogen makes a considerable proportion wheat germplasm at risk (Belayneh et al., 2009). According to Leppik (1970), the highland of Ethiopia is considered as a hot spot for the development of stem rust diversity. Furthermore, studies that were carried out in Ethiopia showed that most previously identified races were virulent on most of varieties grown in the country (Belayenh and Embet, 2005; Belayneh et al., 2009) and are among the most virulent in the world (van Ginkel et al., 1989).

Wheat stem rust can be effectively controlled by

*Corresponding author. E-mail: woubit123@yahoo.com. Fax: 0251-112-362037.

growing resistant varieties. The development of resistant varieties, however, requires a knowledge of the virulence diversity, race distribution in particular region, and which resistance genes are effective against these races. In addition, virulence surveys are important for studying the evolution of new races and forecasting the virulence shifts in a population. Hence, this study was initiated to determine the virulence diversity of wheat stem rust and cultivar reaction to virulence races.

## MATERIALS AND METHODS

### Identification of physiological races of *P. graminis* f. sp. *tritici*

#### *Collection of wheat stem rust samples*

Samples of infected stems (one sample per field) were collected at 5-10 km interval from wheat fields and trial plots in South Tigray. Stems and/or leaf sheath of wheat plants infected with stem rust were cut into small pieces of 5 to 10 cm in length using scissors and placed in paper bags after the leaf sheath was separated from the stem in order to keep stem and/or leaf sheath dry. This technique helps the samples easily air dry (reduce moisture) so as the spores can not germinate before processing in the greenhouse. The samples collected in the paper bags were labeled and transported to Ambo Plant Protection Research Center's (APPRC) Laboratory for analysis.

#### *Isolation and multiplication of single-pustules*

Seedlings of the universally rust susceptible variety "Morocco" which does not carry known stem rust resistance genes were raised in suitable 8 cm diameter pots. Leaves of seven-day-old seedlings or seedlings with fully expanded primary leaves and second leaves begining to grow, were rubbed gently with clean moistened fingers. By this way the waxy layer that hinders the penetration of the spores were removed from the surface of the leaves. Greenhouse inoculations were done using the methods and procedures developed by Stakman et al. (1962). Spores from the stem rust infected sample were scraped off with scalpels on to a watch glass and suspended in distilled water to make rust spore suspension, which was rubbed on the seedlings of Morocco. The plants were then moistened with fine droplets of distilled water produced with an atomizer and placed in an incubation chamber for 18 h dark at 18 to 22°C followed by exposure to light for 3 to 4 h to provide condition for infection and seedlings were allowed to dry thier dew for about 1 to 2 h.

Then, the seedlings were transferred from the dew chamber to glass compartments in the greenhouse where conditions was regulated at 12 h photoperiod, at temperature of 18 to 25°C and relative humidity (RH) of 60 to 70%. The remaining rust spore samples were kept in the refrigerator at 4°C and were used to substitute for samples which failed to produce infection on the universally susceptible variety in greenhouse. After seven to ten days of inoculation (when the flecks/symptoms was clearly visible) leaves containing a single fleck that produce single pustule was selected from the base of the leaves and the remaining seedlings within the pots were removed using scissors. Only 2 to 3 leaves with single a pustule were separately covered with cellophane bags (145 × 235 mm) and tied up at the base with a rubber band to avoid cross contamination (Fetch and Dunsmore, 2004).

After two weeks of inoculation (when the pustule was well developed) spores from each pustule were collected using power operated vacuum aspirator and stored separately in gelatine capsules. A suspension, prepared by mixing urediospores with lightweight mineral oil (Soltrol 130), was inoculated on seven-day-old seedlings of the susceptible variety 'Morocco' for multiplication purpose for each of the single pustules on separate pots. Immediately after inoculation, the seedlings were placed in a humid chamber in dark condition at 18 to 22°C for 18 h and light for 3 to 4 h, after which they were transferred to a greenhouse where the temperature varied between 18 and 25°C and RH of 60 to 70% following the procedures mentioned earlier.

About 14 to 15 days after inoculation, the spores of each single pustule were collected in separate test tubes and stored at 4°C until they were inoculated on the standard differential sets. This spore multiplication procedure was repeated until sufficient spores were produced to inoculate the set of stem rust differential hosts. In this way total of 32 single pustule isolates were developed from 16 wheat stem rust samples.

#### *Inoculation of wheat stem rust differential hosts*

Five seeds of the twenty wheat stem rust differentials with known resistance genes (*Sr5*, *Sr6*, *Sr7b*, *Sr8a*, *Sr9a*, *Sr9b*, *Sr9d*, *Sr9e*, *Sr9g*, *Sr10*, *Sr11*, *Sr31*, *Sr17*, *Sr21*, *Sr30*, *Sr36*, *Sr38*, *Sr24*, *SrTmp*, and *SrMcN*) and one susceptible variety Morocco were grown in 3 cm diameter pots separately in greenhouse. The susceptible variety Morocco (without *Sr* gene) was used to ascertain the viability of spores inoculated to the differential hosts.

The single pustule derived spores (approximately 3 to 5 mg of spores per ml of liquid suspension) was suspended in distilled water and sprayed/inoculated onto seven-day-old seedlings using atomizers and/or an air pump. After inoculation, plants were moistened with fine droplets of distilled water produced with an atomizer and placed in an incubation chamber for 18 h dark period at 18 to 22°C and 3 to 4 h of light and seedlings were allowed to remove their dew for about 1 to 2 h. Upon removal from the dew chamber, plants were placed in separate glass compartments in a greenhouse to avoid contamination and produce infection. Greenhouse temperature was maintained between 18 and 25°C. Natural day light was supplemented for additional 4 h/day with 120 $\mu E.M^{-2} S^{-1}$ photo synthetically active radiations emitted by cool white fluorescent tubes arranged directly above plants.

#### *Phenotyping differential sets*

Determination of races were based on the reaction of the inoculated differntial hosts. Stem rust infection types (ITs) were scored 14 days after inoculation using the 0 to 4 scale of Stakman et al. (1962). Infection types were grouped in to two, where, low (resistance) = (0, 0; (fleck), 1, 1+, 2 and 2+) and high (susceptible) = ( 3-, 3+ and 4).

#### *Designation of races*

Race designation was done by grouping the differential hosts into five subsets in the following order: (i) *Sr5*, *Sr21*, *Sr9e*, and *Sr7b*; (ii) *Sr11*, *Sr6*, *Sr8a*, and *Sr9g*; (iii) *Sr36*, *Sr9b*, *Sr30*, and *Sr17*; (iv) *Sr9a*, *Sr9d*, *Sr10*, *SrTmp*; and (v) *Sr24*, *Sr31*, *Sr38*, and *SrMcN* (Table 1).

Each isolate was assigned a five letter race code based on its reaction on the differential hosts (Roelfs and Martens, 1988; Jin et al., 2008). For instance, low IT on the four hosts in a set is assigned with the letter 'B', while high IT on the four hosts is assigned with a letter 'T'. Hence, if an isolate produces low infection type (resistant reaction) on the 20 differential hosts, the race will be assigned with a five letter race code 'BBBBB'. In the same way, an isolate which produces a high IT (susceptible reaction) on the 20 wheat differential hosts have a race code 'TTTTT'. If an isolate produces a

**Table 1.** Nomenclature of *Puccinia graminis* f. sp. *tritici* based on 20 differential wheat hosts.

| *Pgt*-code | Infection phenotype of pathogen and wheat *Pgt* gene | | | | |
|---|---|---|---|---|---|
| | Set 1 | 5 | 21 | 9e | 7b |
| | Set 2 | 11 | 6 | 8a | 9g |
| | Set 3 | 36 | 9b | 30 | 17 |
| | Set 4 | 9a | 9d | 10 | Tmp |
| | Set 5 | 24 | 31 | 38 | McN |
| B | | Low | Low | Low | Low |
| C | | Low | Low | Low | High |
| D | | Low | Low | High | Low |
| F | | Low | Low | High | High |
| G | | Low | High | Low | Low |
| H | | Low | High | Low | High |
| J | | Low | High | High | Low |
| K | | Low | High | High | High |
| L | | High | Low | Low | Low |
| M | | High | Low | Low | High |
| N | | High | Low | High | Low |
| P | | High | Low | High | High |
| Q | | High | High | Low | Low |
| R | | High | High | Low | High |
| S | | High | High | High | Low |
| T | | High | High | High | High |

Source: Roelfs and Martens (1988); Jin et al. (2008); L = low ITs (0 to 2+), H = high ITs (3- to 4).

**Table 2.** List of wheat cultivars used for evaluation of stem rust races at seedling stage.

| Cultivar | Wheat type | Code | Pedigree |
|---|---|---|---|
| Dashen | Bread | HAR 408 | VEE 17/KVZ/BUHO"S" //KAL/BB |
| Tura | Bread | HAR-1775 | ARO YR SEL. 60/89 |
| Hawi | Bread | HAR-2501 | CHIL/PRL |
| Shina | Bread | HAR-1868 | GOV9/AZ//MUS"S"/3/R37GHL/21//KAL/BB/4/ANI"S" |
| KBG-01 | Bread | FH-1-7-A | 300 /SM+501M/HAR 1709 |
| Sirbo | Bread | HAR-2192 | VS73.600/MRL/3/BOW//YR/TRF (MILLAN) |
| Digalu | Bread | HAR 3116 | SHA7/KAUZ |
| Kubsa | Bread | HAR1685 | NDG9144//KAL/BB/3/YACO"S"/4VEE#5"S" |
| Gerardo | Durum | - | VZ466/61-130XLD SX GII"S" CM9605 |
| Asasa | Durum | Dz 2085 | CHO"S"/TARUS//YAV"S"3/FG"S"/4/ FGS/CR"S"/5/DZ2085 |
| Local | Durum | - | - |

Source: Alamata Agricultural Research Center and Ambo Plant Protection Research Center, 2010.

low IT on *Sr36*, *SrTmp*, and *Sr24*, but a high infection type on the remaining 17 differential hosts, the race will be designated as TTKSK (Ug99) (Table 1).

***Response of wheat cultivars to virulent stem rust races at seedling stage***

The spores of prevalent and virulent stem rust race(s) identified from Southern zone of Tigray were multiplied on Morocco and collected in separate test tubes to inoculate wheat cultivars. The seedlings of eleven wheat cultivars (Table 2) mainly cultivated in the Tigray region were evaluated against the selected highly virulent stem rust races (TTKSK, TTSNK, and RRTTF). Seven-day-old seedlings were inoculated with the spores (approximately 3-5 mg of spores per 1 ml of liquid suspension) of virulent races and incubated. A complete randomized design (CRD) with three replicates was used. Data on infection types were recorded 14

**Table 3.** Prevalence of races of *P. graminis* f. sp. *tritici* across district.

| District | Race | Isolate |
|---|---|---|
| Raya-Alamata | BBBBC, HHSTF, and JRGSC | 4 |
| Raya-Azebo | BBBLC, BHJBC, CCGBC, GMHJC, HRJJC, JTGDB, RRTTF, SKQNH, SPSSF, TCQJH , TTKSK, TTSNK, and TTSSK | 22 |
| Ofla | DBHQC and DBHSC | 2 |
| Enda-Mekoni | GKJSF and RRJJC | 4 |

**Table 4.** Virulence spectrum and frequency of races of *P. graminis* f. sp. *tritici* collected from Southern zone of Tigray in 2010.

| Race | Virulence spectrum (ineffective *Sr* genes) | No. of isolates | Frequency (%) |
|---|---|---|---|
| BBBBC | *McN* | 1 | 3.1 |
| BBBLC | *9a*, *McN* | 1 | 3.1 |
| BHJBC | *6*, *9g*, *9b*, *30*, *McN* | 2 | 6.3 |
| CCGBC | *7b*, *9g*, *9b*, *McN* | 1 | 3.1 |
| DBHQC | *9e*, *9b*, *17*, *9a*, *9d*, *McN* | 1 | 3.1 |
| DBHSC | *9e*, *9b*, *17*, *9a*, *10*, *9d*, *McN* | 1 | 3.1 |
| GKJSF | *21*, *6*, *8a*, *9g*, *9b*, *30*, *9a*, *9d*, *10*, *38*, *McN* | 1 | 3.1 |
| GMHJC | *21*, *11*, *6*, *9g*, *9b*, *17*, *9d*, *10*, *McN* | 2 | 6.3 |
| HHSTF | *21*, *7b*, *6*, *9g*, *36*, *9b*, *30*, *9a*, *9d*, *10*, *Tmp*, *38*, *McN* | 2 | 6.3 |
| HRJJC | *21*, *7b*, *11*, *6*, *9g*, *9b*, *30*, *9d*, *10*, *McN* | 3 | 9.4 |
| JRGSC | *21*, *9e*, *11*, *6*, *9g*, *9b*, *9a*, *9d*, *10*, *McN* | 1 | 3.1 |
| JTGDB | *21*, *9e*, *11*, *6*, *8a*, *9g*, *9b*, *10* | 1 | 3.1 |
| RRJJC | *5*, *21*, *7b*, *11*, *6*, *9g*, *9b*, *30*, *9d*, *10*, *McN* | 3 | 9.4 |
| RRTTF | *5*, *21*, *7b*, *11*, *6*, *9g*, *36*, *9b*, *30*, *17*, *9a*, *9d*, *10*, *Tmp*, *38*, *McN* | 2 | 6.3 |
| SKQNH | *5*, *21*, *9e*, *6*, *8a*, *9g*, *36*, *9b*, *9a*, *10*, *31*, *McN* | 2 | 6.3 |
| SPSSF | *5*, *21*, *9e*, *11*, *8a*, *9g*, *36*, *9b*, *30*, *9a*, *9d*, *10*, *38*, *McN* | 2 | 6.3 |
| TCQJH | *5*, *21*, *9e*, *7b*, *9g*, *36*, *9b*, *9d*, *10*, *31*, *McN* | 1 | 3.1 |
| TTKSK | *5*, *21*, *9e*, *7b*, *11*, *6*, *8a*, *9g*, *9b*, *30*, *17*, *9a*, *9d*, *10*, *31*, *38*, *McN* | 1 | 3.1 |
| TTSNK | *5*, *21*, *9e*, *7b*, *11*, *6*, *8a*, *9g*, *9b*, *36*, *30*, *9a*, *10*, *31*, *38*, *McN* | 3 | 9.4 |
| TTSSK | *5*, *21*, *9e*, *7b*, *11*, *6*, *8a*, *9g*, *9b*, *36*, *30*, *9a*, *9d*, *10*, *31*, *38*, *McN* | 1 | 3.1 |

days after inoculation according to the host response.

## RESULTS

### Physiological races and virulence diversity of wheat stem rust in south Tigray

Determination of the physiologic race of *P. graminis* f. sp. *tritici* resulted in identification of 20 races, which have a wider range of virulence spectrum on the wheat stem rust differential hosts.

### Virulence and physiologic race composition of *P. graminis* f. sp. *tritici*

From 16 field samples from the Southern zone of Tigray, 32 single pustule-derived isolates ( two isolates per sample) were developed. Hence, 32 isolates were used for race analysis. Using the international system of nomenclature for *P. graminis* f. sp. *tritici*, 20 races were identified based on their reaction on 20 differential hosts. This indicated a high level of variation. The highest level of race variation was detected from Raya-Azebo district accounting for 65% of the races identified. Out of the total 20 races, 13 were identified from 22 isolates in this particular district. The remaining 35% of the races were detected from Raya-Alamata, Ofla and Enda-Mekoni districts (Table 3).

The frequency of each race was calculated as a percentage from the total number of isolates analyzed. Of the 20 races, the most frequent and predominant races identified were TTSNK, RRJJC, and HRJJC with a frequency of 9.4% each. The second most frequent and dominant races were BHJBC, GMHSC, HHSTF, RRTTF, SPSSF, and SKGNH, with a frequency of 6.3% each.

Conversely, the remaining 11 races were detected only once each with a frequency of 3.1% (Table 4).

**Table 5.** Virulence frequency of *P. graminis* f. sp. *tritici* isolates (32 isolates) on 20 *Sr* genes.

| *Sr* gene | Virulence frequency (%) | *Sr* gene | Virulence frequency (%) |
|---|---|---|---|
| *5* | 46.9 | *30* | 62.5 |
| *21* | 78.1 | *17* | 21.9 |
| *9e* | 43.8 | *9a* | 56.25 |
| *7b* | 53.1 | *9d* | 75.0 |
| *11* | 59.4 | *10* | 81.5 |
| *6* | 75.0 | *Tmp* | 12.5 |
| *8a* | 31.3 | *24* | 0.0 |
| *9g* | 87.5 | *31* | 25 |
| *36* | 40.6 | *38* | 37.5 |
| *9b* | 93.8 | *McN* | 96.9 |

The 20 races identified from wheat grown areas in Southern Tigray zone had wide virulence spectra (Table 3). The broadest virulence spectra were recorded for races TTKSK and TTSSK making 17 stem rust resistance genes ineffective. TTKSK (Ug99) was virulent to 17 *Sr* genes except *Sr36*, *Sr24*, and *SrTmp*. Similarly, race TTSSK was virulent to all the resistance genes except *Sr17*, *SrTmp*, and *Sr24.* In the same way, TTSNK and RRTTF were equally virulent to 80% of the stem rust resistance genes. On the other hand, eight races or 40% of the races identified were virulent on less than 50% of the 20 *Sr* genes included in this study. Race BBBBC was the least virulent, producing susceptible reaction on only monogenic gene, *SrMcN*. Races such as BBBLC, CCGBC, BHJBC, and DBHQC were also the least virulent, producing susceptible reactions on two, four, five, and six wheat differential hosts, respectively (Table 4).

### Virulence frequency of *P. graminis* f. sp. *tritici* isolates to *Sr* resistant genes

About 55% of the *Sr* genes were ineffective to more than 60% of the isolates. The differential host carrying the resistance gene McNair 701 (*SrMcN*) was ineffective to 96.9% of the isolates tested. Similarly, six differential hosts carrying resistance genes *Sr9d*, *Sr21*, *Sr6*, *Sr10*, *Sr9g*, and *Sr9b* were ineffective, with virulence frequencies of 65.6, 78.1, 75, 81.2, 87.5, and 93.8% to the isolates tested, respectively (Table 5).

On the other hand, the stem rust resistance gene *Sr24* was effective to all stem rust isolates collected from Southern Tigray region. Five resistance genes, *SrTmp*, *Sr17*, *Sr31*, *Sr36*, and *Sr38* were found to be effective against most of the stem rust races detected. Of these *Sr* genes, the differential hosts carrying *SrTmp*, *Sr31*, and *Sr17* were was resistant to 87.5, 75.0, and 78.1% of the isolates tested, respectively. Correspondingly, gene *Sr38* was effective against 62.5% of the isolates analyzed followed by *Sr36* which was effective against 59.4% (Table 5).

### Reaction of wheat cultivars to stem rust races at seedling stage in greenhouse

Three (Tura, Shina and Kubsa), five (Dashen, Tura, Shina, Sirbo and Kubsa) and seven (Dashen, Tura, Shina, Sirbo, Hawi, KBG01 and Kubsa) of the tested wheat cultivars produced suscptible reaction to RRTTF, TTKSK and TTSNK races, respectively. Whereas, bread wheat variety Digalu was resistant to all the tested races. Unlike bread wheat cultivars, all the three durum wheat cultivars (Gerardo, Asasa, and local) were resistant to the three stem rust races tested (Table 6).

## DISCUSSION

Wheat stem rust declined for several decades because of the widespread use of the 1BL.1RS translocation carrying *Sr31*, effective against all known *P. graminis* f. sp. *tritici* races. However, the most devastating stem rust race TTKSK (commonly known as Ug99) virulence on gene *Sr31* was first detected in Uganda in 1999 (Pretorius et al., 2000), and had spread to most of the wheat growing areas of Kenya in 2002 and Ethiopia in 2003. In 2005, Ethiopian reports confirmed its presence in six dispersed locations (Singh et al., 2008), and was spread to most wheat growing regions of the country and is becoming the main threat of wheat production (Belayneh et al., 2009).

The present study also detected the race at additional one location, indicating the race is getting spreads in the region. Furthermore, the new Ug99 variant TTSSK, which is identified in this study, was also detected in Kenya in 2006 and 2007 with virulence to gene *Sr36* indicates that Ug99 is evolving (Singh et al., 2008). In general, the virulence spectrum of the pathogen in this study confirmed the presence of wider range of virulence in the study area and is in line with previous studies conducted in Ethiopia (Belayneh and Emebet, 2005; Belayneh et al., 2009). A comparison of the races identified in the present study with these earlier reports revealed differences. This could be due to variation over location and time, as the

**Table 6.** Reaction of wheat cultivars to three virulent stem rust races identified in 2010.

| Cultivar | Race | | |
|---|---|---|---|
| | TTKSK | TTSNK | RRTTF |
| Dashen | 3 | 3 | 1+ |
| Tura | 3- | 3- | 3- |
| Hawi | 2 | 3- | 1+ |
| Shina | 3- | 3- | 3- |
| KBG01 | 2+ | 3- | 0; |
| Sirbo | 3 | 3 | 2 |
| Digalu | 1+ | 1+ | 2 |
| Kubsa | 3- | 3- | 3- |
| Gerardo | 1+ | 1 | 1 |
| Asasa | 1+ | 1 | 2 |
| Local | 1+ | 1 | 1 |
| Morocco (Suscp.check) | 3 | 3 | 3- |

Resistant IT (0 to 2+), susceptible IT (3- to 4); (-) uredia smaller, (+) uredia larger than normal.

prevalence of races in a specific season and region depends on the type of wheat cultivars grown and to some extent on the predominant environmental conditions, especially temperature (Roelfs et al., 1992).

It was evident that the majority of the resistance genes were ineffective against most of the isolates. Resistance genes *SrMcN*, *Sr9d*, *Sr21*, *Sr6*, *Sr10*, *Sr9g*, and *Sr9b* were ineffective, accounting for more than 65% of the isolates tested. Belayneh et al. (2009); reported similar findings. These *Sr* genes were ineffective for more than 85% of the isolates collected during 2006-2007 cropping season from Shewa, Arsi, Bale, and northwest regions of Ethiopia. Earlier studies indicated that virulence to *Sr6*, *Sr8b*, *Sr9a*, *Sr9d*, and *Sr11* is common worldwide (Roelfs et al., 1992). In contrast, *Sr24* and *SrTmp* were effective against all and most of the isolates tested, respectively. This confirms the report of Roelfs et al. (1992) stated that these genes are amongst the effective genes, which have an adequate and some immediate values to almost all races in the world, except occasional high infection types in some countries including Ethiopia. For instance, virulence to *Sr24* was reported in Kenya in 2006. A variant of Ug99 that added virulence on stem rust gene *Sr24* (Ug99+*Sr24* virulence, called TTKST) has further increased the vulnerability of wheat to stem rust worldwide (Jin et al., 2008). Furthermore, the most important gene *Sr24* was also defeated by another race PTKST, which is detected in Ethiopia in 2007 and Kenya and South Africa in 2009. This represents the first confirmed occurrence of Ug99 variant with virulence to *Sr24* in Ethiopia (FAO, 2011).

Genetic resistance to wheat stem rust has largely been based on two types of resistance: seedling and adult plant resistance. Seedling resistance genes, which also work at the adult plant stage, usually confer strong resistance response (Singh et al., 2008). The reaction of wheat cultivars to stem rust races in the greenhouse revealed that none of these varieties were immune (complete disease freedom). A variation in resistance spectrum was observed between durum and bread wheat cultivars. According to this study, durum wheat showed a broader resistance spectrum than bread wheat. This might be associated with the fact that most of the durum wheat cultivars were developed from local landraces, which have co-evolved with indigenous pathogen populations. The results of this study also supports this fact and show that durum wheat cultivars and the local landrace could be valuable sources of resistance to the stem rust races in the area. This finding was also in agreement with the previous report, which stated that the Ethiopian cultivated tetraploid wheat accessions are resistant or moderately resistant to stem rust, and the landraces are found to be a potential source of resistance to stem rust (Beteselassie et al., 2007). In contrast, bread wheat cultivars were introduced into the country via different ways including genotypes developed by international breeding programs elsewhere. In addition, the wheat based mono-cropping system and the continuous release and extensive cultivation of CIMMYT originated bread wheat genotypes with similar genetic background (commonality in parentage) could serve as the breeding ground/reemergence for new physiological races of stem rust that can attack previously resistant cultivars. Hence, their susceptibility to a wide pathogen isolates was not surprising.

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