Evaluation of Ethiopian Durum Wheat landraces and CIMMYT Germplasm for Resistance to Three *Puccinia graminis* f. sp. *tritici* Races Under Single Race Nurseries at Debre Zeit, Ethiopia

Ashenafi Gemechu[1], Gizachew Hirpa[1], Shitaye Homa[1], Habtamu Tesfaye[1], Karim Ammar[3], Ayele Badebo[4], Bekele Abeyo[4], Netsanet Bacha[2], Mattew N Rouse[5], Sridhar Bhavani[3]

[1]Debre Zeit Agricultural Research Center, Ethiopian Institute of Agricultural Research (EIAR), Debre Zeit, Ethiopia
[2]Ethiopian Institute of Agricultural Research, Addis Ababa, Ethiopia
[3]International Maize and Wheat Improvement Center (CIMMYT), Mexico, DF, Mexico
[4]International Maize and Wheat Improvement Center (CIMMYT), Addis Ababa, Ethiopia
[5]Department of Plant Pathology, University of Minnesota, St. Paul, MN 55108, USA

Abstract

Most of the major stem rust resistance genes deployed in commercial durum wheat cultivars and breeding lines were succumbed to emerging races. During 2019 and 2020, a total of 156 durum wheat germplasm consisting of released varieties, landraces and advanced lines were evaluated against three Pgt races at the seedling stage in greenhouse and adult plant growth stage in field in single race nurseries. Most of the entries were susceptible to the three stem rust races at the adult plant stage. Seven entries (two cultivars, two landraces and three CIMMYT advanced lines) showed high infection type (3-4) at seedling stage exhibited resistance at adult plant growth stage to the three races. The responses of the durum wheat entries across races were positively correlated. Durum wheat entries which exhibited resistance to TTRTF and JRCQC were susceptible to TTTTF race both at seedling and adult plant growth stages. Therefore, identification of sources of resistance to race TTTTF is of paramount as this race is more virulent than TTRTF and JRCQC races. This study also confirmed the importance of testing durum wheat germplasm to multiple races of Pgt both at seedling and adult plant growth stages.

Introduction

Breeding wheat for stem rust resistance is a priority work worldwide including Ethiopia. Due to race diversity of stem rust races in Ethiopia. The appearance of *Puccinia graminis* f.sp. *tritici* (*Pgt*) races such as JRCQC and TRTTF) with broad virulence spectra including *Sr13b* and *Sr9e* has increased the vulnerability of durum wheat to stem rust (Olivera *et al*., 2012). The TTRTF race that caused a severe epidemic on durum wheat in Sicily, Italy was also reported in Ethiopia (Yehizbalem *et al*.(,2020). Searching of sources of stem rust resistance from commercial cultivars, breeding lines, and landraces would be the most environmentally safe and economically feasible approach for properly managing the pathogen. This study was initiated to determine the effectiveness of durum wheat entries to multiple *Pgt* races at the seedling and adult plant growth stages in Ethiopia.

Material and Methods

A total of 156 durum wheat entries (accessions) consisting of 38 released cultivars, 28 landraces and 90 advanced durum wheat breeding lines from CIMMYT were evaluated against three stem rust races at seedling and adult plant growth stages at Debre Zeit research center. These races were selected based on their broad virulence on commercially deployed resistance genes mainly on durum wheat. Six seeds of each line were planted in trays filled with soil: compost: sand combination in 2:1:1by volume (v/v/v) ratio. Seven-day-old seedlings were inoculated with urediniospores of each race following the procedure by Rouse *et al.* (2012). Seedlings were scored 14 d post inoculation using the 0-4 scale described by Stakman *et al*. (1962). The scored data were converted to 0-9 scale for analysis. After converting the 0-6 response at seedling was considered as resistance whereas 7-9 response considered as susceptible at seedling stages. The same entries were used for field evaluation. Three checks (Mangudo, Arendato and Local red) as moderately resistance, moderately susceptible and susceptible checks were included in the field nurseries every twenty entries, respectively. While three wheat cultivars (local red, Arendato and Leeds) were used as spreader rows in the field nurseries. The nurseries were evaluated in 2019 and 2020 main seasons at Debre Zeit Agricultural Research Center. Each single race nursery was surrounded by oat and linseed and planted 500m apart to minimize contaminations. The nurseries were inoculated with stem rust races of TTTTF, TTRTF and JRCQC three times starting from stem elongation growth stage using a syringe late in the afternoon. Three notes were taken and area under disease progress curve, coefficient of infection and final rust severity were used for data analyses.

Results and Discussion

Of the 156 durum wheat entries, 28.2%, 71.2% and 64.7% were resistant to TTTTF, TTRTF and JRCQ, respectively(Table 1). However, 30 (19.2%) entries exhibited resistance to the three races (Table 1). These entries consisted of eight cultivars, ten landraces and 12 durum wheat entries from CIMMYT breeding program. At field condition of the evaluated germplasms about 16 and 84% of the entries were resistant and susceptible to TTTTF, respectively (Table 2). More entries were resistant to race JRCQC as compared to the two other races from the field data (Table 2). From the combined result of seeding and field reaction of the entries; 97 entries were susceptitble both at seedling and field conditions(Fig 1). A total of seven entries were susceptible(7-9) at seedling and resistance at field conditions. At adult plant growth stage a total of 17 wheat entries were resistance against the three races (Table 2). These entries showed the final rust severity, AUDPC and COI of ≤25, ≤157.5 and ≤ 22.5 at field conditions, respectively. The seedling correlation coefficient between TTRTF and TTTTTF was very weak (r=0.16) and weak correlation between JRCQC and TTRTF(r=0.22), JRCQC and TTTTF(r= 0.24) (Fig.2.). The phenotypic correlation coefficient was from moderate to very strong (r=0.44-0.99)(Fig. 3).

In general, seven entries (two cultivars, two landraces and three CIMMYT advanced lines) showed adult plant resistance to the three races and showed high infection (3- -4) at seedling stage and lower severity with (5MR-25MS) at field condition.

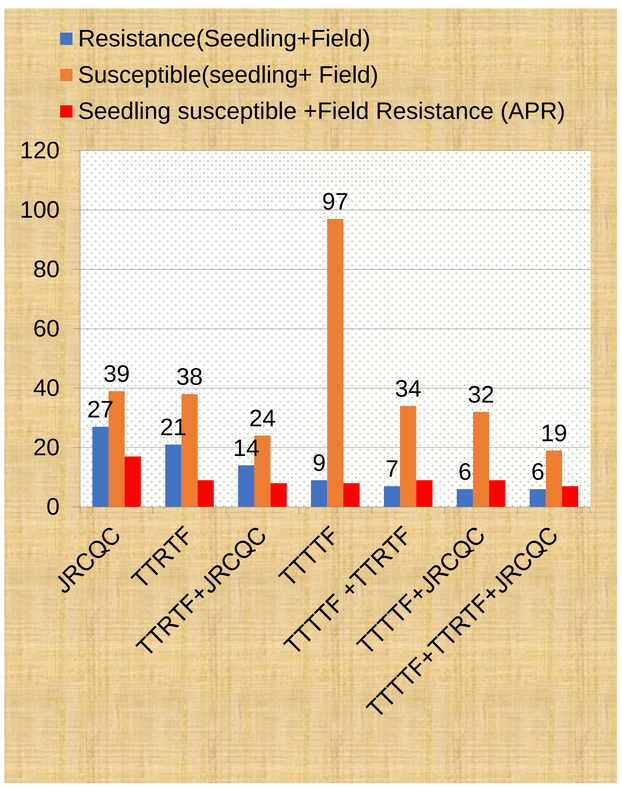

Fig 1.. Frequency of resistant and susceptible durum wheat entries to different races at seedling and adult plant growth stages

Table 1. Frequency of resistant durum wheat germplasm after being exposed to three stem rust races at seedling stage

Races	Number of resistant entries	Percent (%) of resistant
TTTTF	44	28.2
TTRTF	111	71.2
JRCQC	101	64.7
TTTTF+TTRTF	37	23.7
TTTTF+JRCQC	34	21.8
TTRTF+JRCQC	84	53.8
TTTTF+TTRTF+JRCQC	30	19.2

Table 2. Frequency of resistant durum wheat germplasm after being exposed to three stem rust races at adult plant growth stage

Races	Number of resistant entries	Percent (%) of resistant
TTTTF	25	16
TTRTF	31	19.9
JRCQC	42	26.9
TTTTF+TTRTF	19	12.2
TTTTF+JRCQC	22	14.1
TTRTF+JRCQC	18	11.5
TTTTF+TTRTF+JRCQC	17	10.9

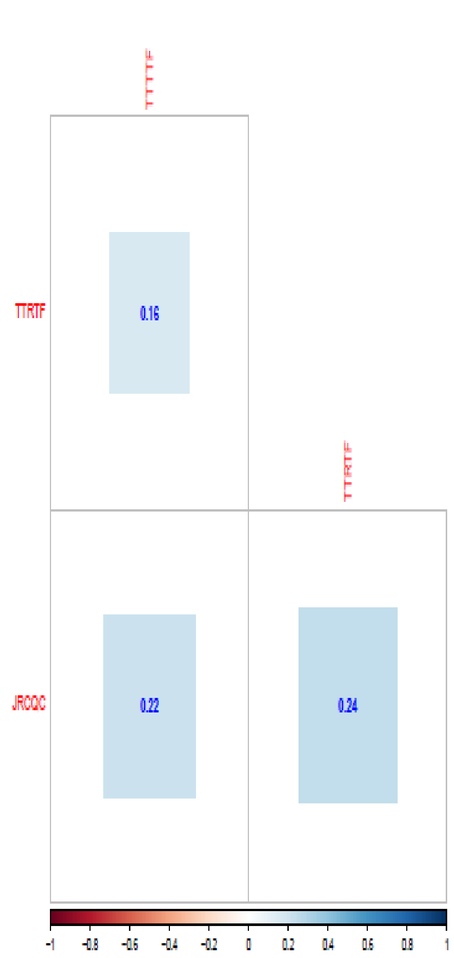

Fig.2. Correlation among durum wheat germplasms against the three races at seedling stage

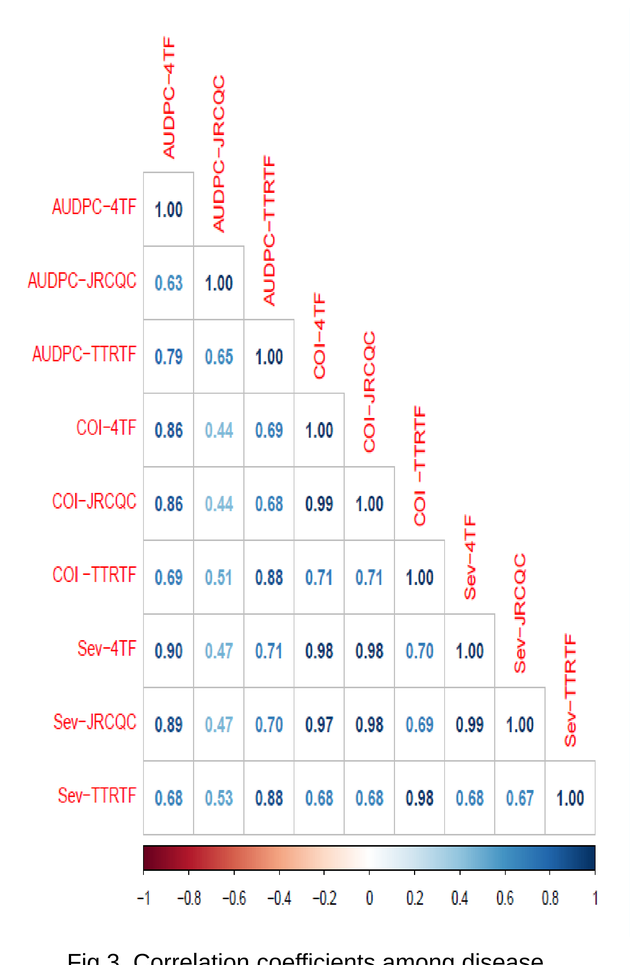

Fig.3. Correlation coefficients among disease parameter and the three races from field data

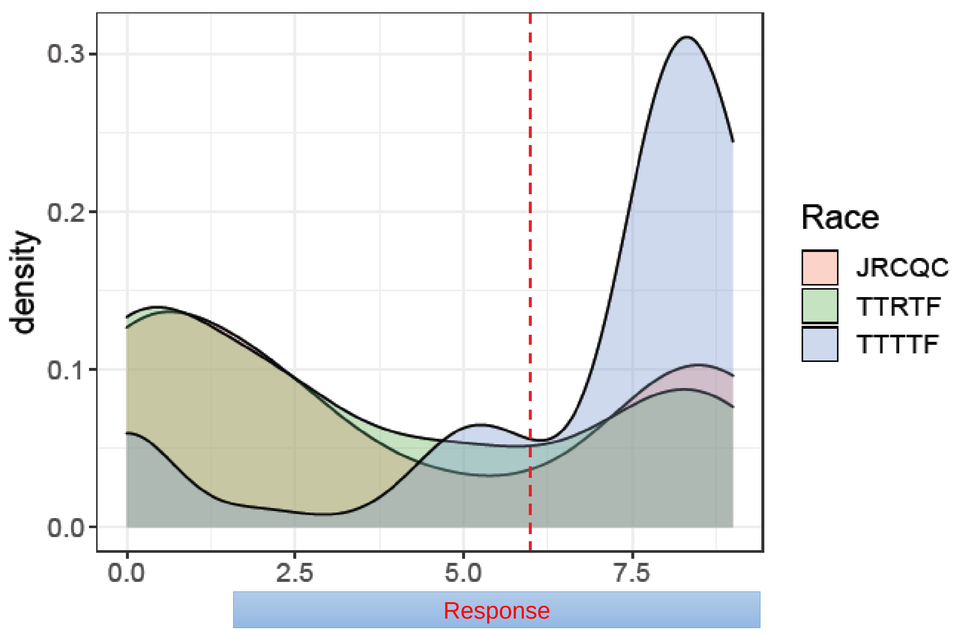

Fig.4. Distribution of seedling responses of lines against three *Pgt* races after linearized to 0-9 scale.

Conclusion

The result of the current study indicated that the Ethiopian landraces, cultivars and CIMMYT durum wheat breeding lines confer race-specific and multiple-race resistance to virulent *Pgt* races at the seedling stage and field condition. Lines consistently resistance at field condition and susceptible at the seedling assay can be used as sources of resistance in the durum wheat breeding program.

Reference

Olivera, P. D., Jin, Y., Rouse, M., Badebo, A., Fetch, T., Singh, R. P., & Yahyaoui, A. (2012b). Races of *Puccinia graminis* f. sp. *tritici* with combined virulence to Sr13 and Sr9e in a field stem rust screening nursery in Ethiopia. *Plant Disease*, 96, 623–628. https://doi.org/10. 1094/PDIS-09-11-0793

Rouse, M. N., Wanyera, R., Njau, P., & Jin, Y. (2011). Sources of resistance to stem rust race Ug99 in spring wheat germplasm. *Plant Disease*, *95*, 762–766. https://doi.org/10.1094/PDIS-12-10- 0940.

Stakman, E. C, Steward, D. M, & Loegering, W. Q. (1962). Identification of physiologic races of Puccinia graminis var. tritici. Doc. E-617. USDA, Agricultural Research Service.

Yehizbalem Azmeraw, Belayneh Admassu2, Bekele Abeyo, and Netsanet Bacha. Virulence Spectrum of Puccinia graminis f. sp. tritici in Northwest Ethiopia. Ethiop. J. Agric. Sci. 30(1) 87-97 (2020)

Acknowledgment

EIAR, CIMMYT, Cornell University, USDA