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Research Article

Identification of Resistance to *Puccinia striiformisf*. sp. *tritici* (*Pst*) in Some Commercial and Elite Bread Wheat Lines

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Abstract

Stripe rust is caused by *Puccinia striiformisf.* sp. *tritici* (*Pst*) threatening wheat production in Ethiopia. The emerged virulent stripe rust races at one point of the world spread to the rest of wheat-producing countries by the wind as well as human travels and damaged popular resistant wheat cultivars thereby posing food insecurity. However, wheat cultivars succumb to new Pst race (s) soon after their release from research centers. This study aimed to determine stripe rust resistance in some Ethiopian commercial and elite bread wheat lines. In 2017, a total of 37 commercial and elite bread wheat lines were exposed to stripe rust in under the disease hot spot areas (Kulumsa and Meraro) Arsi zone Oromia regional state. In the second year (2018), 22 promising lines consisting of 16 commercial bread wheat and 6 elite's lines were evaluated both at seedling and adult plant growth stages. The seedling test was conducted in the greenhouse at Kulumsa research center using three Pst races. In field evaluations, terminal severity (TRS), coefficient of infection (CI), area under disease progress curve (AUDPC), disease progress rate (DPR), and spike infection (SI) were considered. Of the 37 commercial and elite bread wheat lines, 19 (51.4%) exhibited lower or equal disease reaction compared to the resistant check (Enjoy) across locations and seasons. Eleven bread wheat lines showed both adult plant and seedling resistance. The 37 commercial wheat lines that showed field resistance was further exposed to three Pst races at the seedling stage and 11 exhibited seedling resistance to all races. This study has identified seedling and adult plant resistance in some commercial and elite bread wheat lines to the prevailing Pst races.

Keywords

Bread Wheat Lines, *Race,* Resistance, Stripe Rust, *Puccinia striiformisf.* sp. *tritici* (*Pst*)

1. Introduction

Bread wheat (*Triticum aestivum* L. is hexaploid (2n = 6x = 42, a self-pollinating annual plant of the grass family Poaceae [10]. It is the third most important staple food crop providing 15% of caloric intake required for human after corn (19.5%) and rice (16.5%) [20]. Wheat is one of the most important cereal crops cultivated at altitudes ranging from 1500 to 3000 m. a. s. l, between 6-160 N latitude and 35-420 E longitude in Ethiopia, of which agro-ecological zones located between 1900 and 2700 m. a. s. l are the most suitable [6].

Wheat ranks fourth after Teff, Maize, and Sorghum with an area coverage of 2.1 million ha and third in total production with 6.7 million tons of grain yield and yielding 3.0 and 4.0

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t/ha under rain-fed and irrigation, respectively [12]. The share of cultivated wheat area reached about 0.269% of world and 40.54% of East Africa wheat production area coverage in 2021/22 [4].

Wheat production is constrained by several biotic, abiotic, and socio-economic factors worldwide, including in Ethiopia. Of the various wheat diseases including fungal, bacterial, nematode, and viral diseases, rust diseases are the most important diseases constraining wheat production and a major concern for plant breeders, farmers, and commercial seed companies at worldwide [15] and in Ethiopia. Pathogens causing rust diseases in wheat are carried by the wind for thousands of kilometers from initial infection sites or foci and even across continents in the form of dikaryotic uredospore's [7].

Stripe rust is a common wheat disease in temperate regions as well as in the cool highlands of the tropics and subtropics [16] including Ethiopia [3]. Major stripe rust epidemics occurred in the 1970s, 1980, and 1988 [6] and 2010 in Ethiopia damaged popular commercial wheat varieties including *Kubsa* and *Galama* due to the breakdown of resistance gene *Yr27* [18]. Stripe rust used to incurr grain yield losses on susceptible wheat variety ranging from 47 to 97% in Ethiopia [2]. The 2010 stripe rust outbreak was the most spread and devastating and apread to wheat produced almost in all wheat-growing regions except in Tigray [12] and affecting more than 600,000 ha of wheat and led to an expenditure of more than US$ 3.2 million on fungicides, while significant, widespread losses were still realized [1]. Similarly, the stripe rust epidemics occurred in the Central and West Asia and North Africa (CWANA) region in 2010 also resulted in the breakdown of the *Yr27* in "Attila" crosses, such as *PBW343* (India), Inquilab-91 (Pakistan) *Kubsa* (Ethiopia) [18].

Stripe rust is managed mainly by host resistance, fungicides and integrated disease management in Ethiopia of which developing and growing resistant cultivars based on host resistance including race-specific and race non-specific resistances, is the most economic, effective and environment-friendly method. About 106 bread wheat varieties from (1949–2016) have been released with their respective agronomic recommendations and resistance to diseases including stripe rust in Ethiopia [9]. However, all stage rust resistance is ephemeral and most of varieties with the resistance gene of major effect become susceptible soon after their release due to virulent race evolution in the pathogen population. Epidemics of occurred in the 1970s, 1980, and 1988 [6, 18]. Were the outcomes of collapsed stripe rust resistance genes. Therefore, characterizations of wheat germplasm for stripe rust resistance at regular basis for sustaining effective stripe rust management is required. The objective of this study was to evaluate some commercial and elite bread wheat lines and identify effective seedling and adult plant resistances for sustaining effective stripe rust management in wheat.

2. Materials and Methods

2.1. Description of the Study Areas

The field study was conducted at two wheat stripe rust hot spot areas, Kulumsa Agricultural research center and Meraro research site in Arsi Zone of Oromia Region, Ethiopia. Kulumsa represents mid-highlands (2200 m. a. s. l.) and is located at 39° 09'11"E l and 08° 01'10"N. It has an average maximum temperature of 22.8°C and a minimum temperature of 10.5°C temperatures and it receives 832 mm of rainfall annually. Meraro represents extreme highlands being located at 2960 m. a. s. l. with 39° 14'56"E and 07° 24' 27"N. Meraro receives 1196 mm annual rainfall with maximum and minimum temperatures of 18.1°C and 5.7°C, respectively. The greenhouse experiment was conducted at Kulumsa Agricultural Research Center.

2.2. Planting Materials

Thirty seven test materials including, commercial and elite bread wheat lines and three checks were used in this study. The lines and checks were obtained from the national wheat breeding program at the Kulumsa research center. In 2017, all of the bread wheat lines were tested under field conditions whereas only selected lines were exposed to the prevailing races of *Pst* in the field and greenhouse during 2018.

2.3. Field Experimental Design and Testing Procedures

The experiment was laid out in augmented design where the three check varieties; Digalu (susceptible), Pavon-76 (moderately resistant), and Enkoy (resistant) were replicated in each block. Each plot consisted of 2 rows of 1 m in length with 20 cm spacing between rows. To ensure the uniform spread of inoculum and sufficient disease development, infector plants consisted of mixtures of susceptible bread wheat varieties (Morocco, Digalu, and Kubsa) were planted bordering the plots from all sides. Fertilizer application and other agronomic practices were applied according to the recommendations for each location.

2.4. Field Disease Assessments

Different epidemiological parameters including terminal rust severity (TRS), coefficient of infection (CI), area under disease progress curve (AUDPC), and disease progress rate (DPR) were used for determining stripe rust resistance level of the test genotypes.

2.4.1. Disease Severity and Coefficient of Infection

Disease severity was noted five times at 10 days intervals on plot bases starting from the onset of rust using the modified Cobb's scale [14] and the host plant response (infection type) was noted according to [13]. The CI was calculated by multiplying the level of disease severity and the constant value of infection type and ACI was determined. The constant values for infection types were used based on; R = 0.2, MR = 0.4, M= 0.6, MS = 0.8, S = 1 [17]. Head infection was noted using 0-5 scale: 0 = no infection, 1 = 20%, 3 = 60%, 4 = 80% and 5 = 100% severity.

2.4.2. Area Under Disease Progress Curve (AUDPC)

AUDPC is an indicator of disease expression over time [19] and it was calculated for each experimental unit according to Wilcoxson *et al*. (1975): AUDPC = $\sum_{i=1}^{n}[0.5\,(xi + x_{i+1})$, Where, xi = the average coefficient of infection of i^{th} record, x_{i+1} = the average coefficient of infection of $i+1^{th}$ record and $t_{i+1} - t_i$ = Number of days between the i^{th} record and $i+1^{th}$ record, and n = number of observations.

2.4.3. Disease Progress Rate (DPR)

Disease progress rate was estimated from the logistic model [19]: ln (Y/(1-Y)) and Gompertz model [20]: ln [-ln(Y)]; where y = the percent of severity divided by 100; t = time measured in days. In this study, the Gompertz model was used for all assessment dates because of the higher values of the coefficient of determination (R^2) compared to the logistic model.

2.5. Seedling Test

Twenty-two bread wheat lines were selected for seedling resistance tests based on their field performances in 2017. The experiment was conducted according to standard procedures [15] in the greenhouse at Kulumsa research center in 2018. Five to six seeds of each entry plus three checks were grown in 7×7×6 cm plastic pots filled with compost, soil, and sand at a ratio of 1: 2: 1 (v/v/v) in a spore-free greenhouse compartment under supplemental light. The first leaves of seven to eight days old seedlings were inoculated with spores of three *Pst* (*PstS2* (v32), *PstS11*, and *PstS11 (v25)*) isolates suspended in lightweight mineral oil (Soltrol 170) using an atomizer. Inoculation was carried in an enclosed cage that was rinsed with water subsequently to avoid spore contamination. Inoculated seedlings were allowed to dry for 20 minutes and then incubated in a dew chamber for about 24 hrs. at 9-10°C with 100% relative humidity. Seedlings were kept in semi-open plastic cubicles in a greenhouse compartment at 18-22°C and 70 to 80% relative humidity. The seedlings were supplemented with 12 hrs light using fluorescent lamps. The experiment was replicated twice and repeated based on the infection type (IT) on susceptible variety (*Morocco*). Seedlings were evaluated 16-20 days post-inoculation using a 0-9 scale [5]. Entries with ITs 0-6 were considered resistant and 7-9 susceptible.

2.6. Data Analysis

All data: Mean disease severity, coefficient of infection (CI), area under disease progress curve (AUDPC), disease progress rate (DPR) and spike infection (SI) were determined using descriptive statistics on excel sheet.

3. Results and Discussion

3.1. Terminal Rust Severity on Wheat Leaves (TRS)

Stripe rust disease pressure was high in the study areas during 2017 and 2018. The commercial and elite bread wheat lines exhibited various reactions to stripe rust as measured by severity noted on wheat leaves and spikes. The disease pressure was more severe at Meraro (2900 masl) than at Kulumsa (2200 masl).

Field reaction of 37 test genotypes to stripe rust in 2017 cropping season

Resistant (Enkoy), moderately resistant (Pavon-76), and susceptible (Digalu), check varieties had terminal stripe rust severity of 9.6%, 40%, and 78% at Kulumsa and 20%, 59%, and 94% at Meraro in the given order. The mean severity recorded on spikes for the respective checks were 18%, 82% and 62% at Meraro (Table 2). Among 37 test genotypes, 29 (72.5%) and 23 (57.5 %) commercial varieties and elite bread wheat lines sustained CI not exceeding 20% (Figure 1) which is representing lower terminal severity. Of these genotypes, 29 genotypes at Kulumsa and 23 genotypes at Mararo showed stripe rust CI < than CI recorded resistant variety (Enkoy).

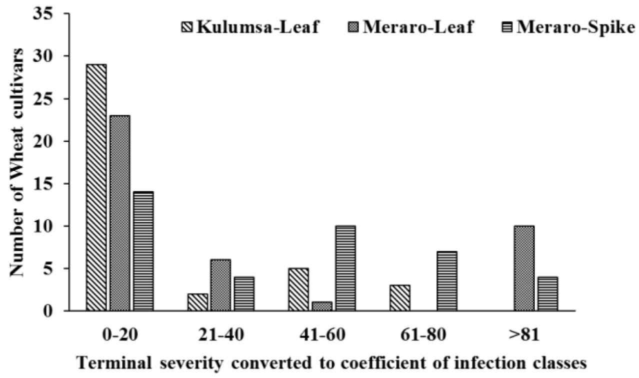

Figure 1. *Frequency distribution of commercial and elite bread wheat lines under different terminal severity converted to coefficient of infection classes at Kulumsa and Meraro in 2017.*

Field reaction of 22 test genotypes to stripe rust in 2018 cropping season

Resistant (Enkoy), moderately resistant (Pavon-76), and susceptible (Digalu), check varieties had terminal stripe rust severity of 1.5%, 28%, and 52% at Kulumsa and 14.2%, 35%, and 60% at Meraro in the given order (Table 2). The frequency of commercial and elite bread wheat lines under different stripe rust severity classes at Kulumsa and Meraro during 2018 is shown in Figure 2. Of the total 24 (60%) commercial and elite bread wheat lines, at Kulumsa and 22 (55 %) and 13 (32.5%) at Meraro exhibited low (0-20) TRS on leaves and spikes, respectively.

On highly infected wheat lines, the grains were shriveled and resulted in losses in yield, quality, and thousand kernel weights (TKW). This result is indicated the negative effect of spike infection on yield and yield components. Trace to low levels of spike infection on the moderately resistant and resistant varieties did not affect thousand kernel weights (TKW), yield, and yield components. Spike infection of wheat by stripe rust at higher altitudes results in 100% losses (Alemu and Getnet 2019).

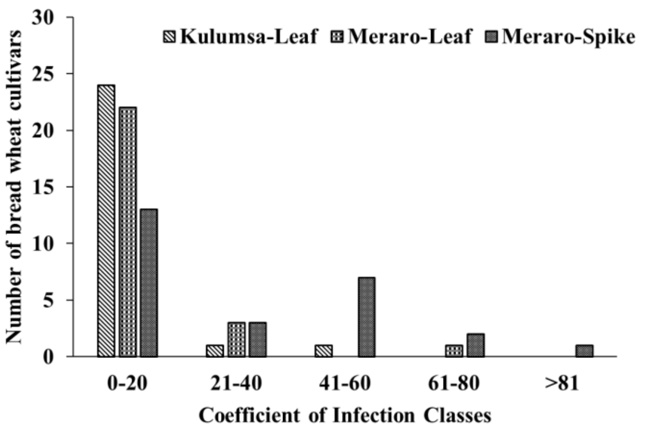

Figure 2. *Frequency distribution of commercial and elite bread wheat lines under different coefficient of infection classes at Kulumsa and Meraro in 2018.*

The study identified considerable variations among the commercial and elite bread wheat lines in the coefficient of infection (CI) at both locations and seasons. A higher disease severity level was observed at Meraro compared to Kulumsa. This may be attributed mainly due to more favorable environmental conditions. In this study, 24 (96%) and 22 (88%) commercial and elite bread wheat lines exhibited a high level of stripe rust resistance at Kulumsa and Meraro, respectively. Resistance in these commercial and elite bread wheat lines might be controlled by several minor genes which give long-lasting resistance.

3.2. Area Under Disease Progress Curve

In 2017 cropping season, high values of AUDPC recorded at Meraro (Figure 3). Twenty three of the genotypes (92%) and five genotypes (20%) showed lower AUDPC values lower than AUDPC values noted on the resistant (*Enkoy*) and moderately resistant (*Pavon-76*) checks at Kulumsa, whereas only 19 genotypes (79%) and nine genotypes (36%) showed AUDPC values lower than AUDPC values noted on *Enkoy* and *Paven-76* at Meraro, respectively These genotypes with lower AUDPC values than the AUDPC noted on the resistant check (*Enkoy*) are categorized to the genotypes possessing high rust resistance. According to [19], AUDPC is a good indicator of adult plant resistance under field conditions. This disease parameter is also directly related to grain yield loss [17] and provides critical information for designing effective disease management practices for lines with different types and levels of resistance.

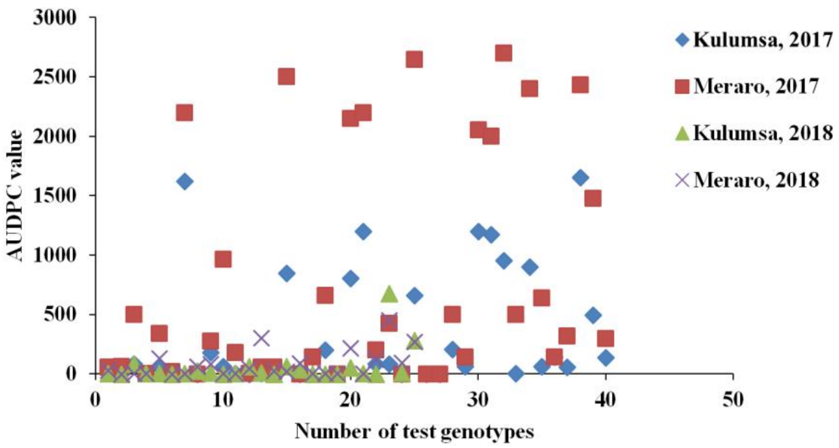

Figure 3. *The distribution of test genotypes (commercial varieties/ elite bread wheat lines) by AUDPC values and locations in 2017 and 2018.*

3.3. Disease Progress Rate (DPR)

Test genotypes consisting of commercial varieties and elite bread wheat lines were compared in 2017 cropping season using disease progress rate per a unit of time. Test genotypes were clearly varied by disease progress rate ranging from 0 to 0.136 per unit of time at Kulumsa and 0 to 0.111 at Mararo (Figure 4). Of the tested entries, 14 (35%) and 9 (22.5%) genotypes exhibited no disease progress (infection) at Kulumsa and Meraro, respectively. However, 17 (42.5%) and 14 (35%) commercial and elite bread wheat lines had lower DPR value per unit time than the resistant check and moderately resistant checks at Kulumsa and 10 (25%) and 10 (25%) at Meraro, respectively.

Of the total 22 test genotypes (commercial + elite bread wheat lines), 13 (59%) and 9 (40.9%) showed no progress in disease severity in 2018. However, 8 (36.4%) and 14 (63.6%) had lower DPR values per unit time than the resistant and moderately resistant checks at Kulumsa and 15 (68.2%), 3 (13.6%) at Meraro, respectively. The disease progress rate in terms of disease spread was lower in resistant varieties compared to the susceptible ones. In general, a low AUDPC value in wheat lines might not ensure a low DPR. Once the pathogen reaches its maximum infection level, the DPR value may decrease or remain constant as the disease progresses [3].

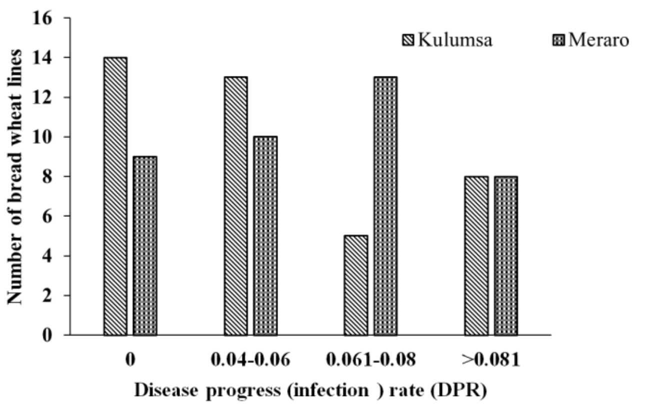

Figure 4. *The frequency of commercial and elite bread wheat lines under different disease progress rate classes at Kulumsa and Meraro, 2017.*

3.4. Seedling Resistance

A total of 22 commercial and elite bread wheat lines (Table 1&2) selected from 2017 were exposed to the three most virulent stripe rust isolates (*YR28WAB16, YR80NWA17,* and *YR39AD17)* which were designated to yellow rust races *PstS2 (v32),* (*PstS11*) and *PstS11 (v25*), respectively. Of these commercial and elite bread wheat varieties/ lines, 16 (72.7%), 17 (77%) and 16 (72.7%) showed resistance reaction to *PstS2* (v32), (*PstS11*) and (*PstS11 v25*), respectively (Figure 5). Commercial bread wheat varieties (Shorima, Mandoyu, Sofumer, Tusie, Tay, Liben and Tsehay) and four Elite bread wheat lines (TRAP#1/BOW/3/VEE/PJN//2*TUI/4/BAV92/RAYON/5/KACHU #1*2/6/KINGBIRD #1, SOKOLL/3/PASTOR//HXL7573/2*BAU*2/4/PAURAQ, CHIBIA//PRLII/CM65531/3/MISR 2*2/4/HUW234+LR34/PRINIA//PBW343*2/KUKUNA/3/ROLF07, and CHWINK/GRACKLE #1//FRNCLN) showed resistance to all three isolates whereas two genotypes (KACHU*2/MUNAL #1 and Lemu) and the rest genotypes showed susceptibility and differential reaction to the aforementioned isolates, respectively (Table 1 & 2).

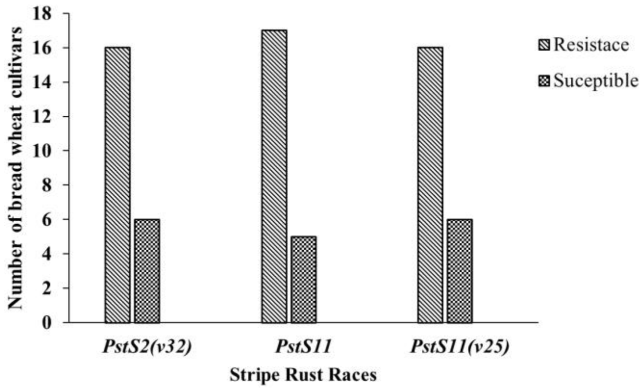

Figure 5. *Frequency distribution of resistant and susceptible 22 bread wheat genotypes evaluated for stripe rust seedling resistance to three stripe rust races in Kulumsa research center greenhouse, 2018.*

A total of 37 commercial and elite bread wheat lines were evaluated at adult plant growth stages and of these, 22 (59.5%) exhibited lower values for all disease parameters under field conditions. Eleven (50%) commercial and elite bread wheat lines exhibited resistance at seedling (to all isolates) and adult plant growth stages whereas 8 (36.4%) showed susceptible/intermediate reaction at the seedling stage but had low disease levels for all parameters under field conditions.

Wheat lines could be susceptible at seedling tests but exhibit moderate resistance to moderate susceptible reaction at the adult plant stage and these lines with show slow rusting resistance parameters at the adult plant stage could have durable resistance [15]. This kind of resistance can be kept for a long time even if the pathogen changes its genotype, it is controlled by more than one gene [5]. Generally, the seedling resistance genes are also active during the adult plant stage and they are classified into race-specific resistance types [9].

Table 1. *The reaction of selected commercial and elite bread wheat line's to stripe rust at seedling and adult plant growth stages tested at two hot spot test sites Meraro and Kulumsa, main season 2017 and 2018.*

No	variety/Lines	Pedigree	Seedling ITs (0-9)			Severity %				AUDPC % days				ACI		DPR		SI %
			Isolate			K		M		K		M						
			PstS2 (v32)	*PstS11*	*PstS11 (v25)*	2017	2018	2017	2018	2017	2018	2017	2018	K	M	K	M	M
1	Dashen	VEE #17, KVZ/BUHO"S"//KAL/BB	7	1	2_3	2	0.2	3	2	16	5	59	30	2.1	4	0.04	0.06	10
2	TRAP#1/BOW/3/VEE/PJN//2*TUI/4/BAV92/RAYON/5/KACHU #1*2/6/KINGBIRD #1	CMSS10Y00842T-099TOPM-099Y-099M-1WGY-0B	5_6	2_3	3_4	0	0	6	0	0	0	64	0	0	6	0	0.08	40
3	Shorima	UTQUE96/3/PYN/BAU//MILAN	5_6	5_6	6	8	8	24	0.2	84	82	500	3	12	24	0.06	0.05	60
4	Mandoyu	PASTOR//HXL7573/2*BAU/3/WBLL1	5_6	3_4	5_6	0.2	0.2	0.2	0.2	5	3	5	3	0.3	0.3	0	0	60
5	Kenya plume	Mida/McMurachy//Exc hange/3/Kenya 184p	2_3	7	3_4	4	0.2	12	16	54	4	342	130	4.1	20	0.06	0.11	60
6	Sofumer	LIRA 'S'/TAN"S"	2_3	1	2	0	0	4	0	0	0	20	0	0	4	0	0	10
7	SOKOLL/3/PASTOR//HXL7573/2*BAU*2/4/PAURAQ	CMSA10Y00236T-099B-050Y-050ZTM-7WGY-0B	5_6	3_4	2_3	0	0.2	0	0.2	0	1	0	3	0.1	0.1	0	0	30
8	Alidoro	HK-14-R251	5_6	3	7_8	12	4	6	8	184	24	272	60	14	10	0.07	0.09	10
9	Meraro	M/4/HAR 1709/3/M//24/E	2_3	1_2	8	0.4	0.2	12	8	2	7	184	80	0.5	16	0	0.09	10
10	SOKOLL/WBLL1/4/D67.2/PARANA 66.270//AE. SQUARROSA (320)/3/CUNNINGHAM	CMSA09M00466S-050ZTM-050Y-3WGY-0B	8	7_9	6	0	0	0.4	0.4	0	0	2	4	0	0.6	0	0	60
11	CHIBIA//PRLII/CM65531/3/MISR2*2/4/HUW234+LR34/PRINIA//PBW343*2/KUKUNA/3/ROLF07	CMSS09Y00853T-099TOPM-099Y-099ZTM-099NJ-099NJ-24WGY-0B	3_4	5	5_6	0.2	0.1	2	0.4	5	3.5	54	4	0.3	2.2	0	0.06	60
12	CHWINK/GRACKLE #1//FRNCLN	CMSS09Y00753T-099TOPM-099Y-099ZTM-099NJ-099NJ-13WGY-0B	2	2_3	2_3	0	4	0	8	0	62	0	42	2	4	0	0	0
13	KACHU*2/MUNAL	CMSS09Y00816T-099TOPM-099Y-0	7_8	8	7_8	4	0.2	4	30	144	7	144	300	4.1	19	0.0	0.0	50

No	variety/Lines	Pedigree	Seedling ITs (0-9)			Severity %				AUDPC % days				ACI		DPR		SI %
			Isolate			K		M		K		M						
			PstS2 (v32)	*PstS1 1*	*PstS11 (v25)*	2017	2018	2017	2018	2017	2018	2017	2018	K	M	K	M	M
	#1	99ZTM-099NJ-099 NJ-5WGY-0B														6	8	

Table 2. The reaction of selected commercial and elite bread wheat line's to stripe rust at seedling and adult plant growth stages tested at two hot spot test sites Meraro and Kulumsa, main season 2017 and 2018.

No	variety/Lines	Pedigree	Seedling ITs (0-9)			Severity %				AUDPC % days				ACI		DPR		SI %
			Isolate			K		M		K		M						
			PstS2 (v32)	*PstS1 1*	*PstS11 (v25)*	2017	2018	2017	2018	2017	2018	2017	2018	K	M	K	M	M
14	Tusie	COOK/VEE"S"//DOVE "S"/SERI	3_4	1	0	0	0	0	4	0	0	0	22	0	2	0	0	20
15	Africa Mayo		7_8	2_3	4_5	8	4	16	2	84	62	204	20	10	17	0.06	0.1	80
16	Lemu	WAXWING*2/HEILO	7	8	7	8	2	18	6	84	34	430	90	9	21	0.06	0.05	10
17	Sanate	Worrakata/pastor	3_4	6	7	0	0	0	0.2	0	0	0	3	9	0.1	0	0	20
18	Tay	ET-12D4/HAR604 (1)	2_3	1	2	0	0	0	0.2	0	0	0	3	0	0.1	0	0	0
19	Liben	UCU-LA/KAUZ/6/PSN/BOW/4/MAYA/NAC/3/RPB14.68//PVN/PHO/5/MUNIA	2_3	1	0	0	0	0	0.4	0	0	0	4	0	0.2	0	0	0
20	Kenya Leopard		6_7	5_6	6	14	2	24	30	207	50	500	218	15	39	0.07	0.05	0
21	Tsehay	VEE#5/SARA//DUCULA	3_4	6	3_4	0.2	0.2	24	0.4	5	5	500	4	0.3	24	0	0.05	40
22	Danda'a	KIRITA-TI//2*PBW65/2*SERI.1B	5_6	8	6_7	4	0	4	8	144	0	144	120	4	8	0.06	0.08	60
23	Digalu	SHANGHAI-7/KAUZ, MEX	8	9	5_6	78	52	94	60	###	680	###	454	104	124	0.13	0.07	62
24	Enkoy	(HEBRARD Sel/WIS 245 X SUP51) X FR-FN/Y) 2. A	7	7	7	6.1	1.5	14	14.2	138	12	292	99	6.4	19	0.1	0.06	18
25	Pavon 76	VCM//CNO"S"/7C/3/KAL/BB	5_6	6_7	5_6	32	28	94	35	491	282	###	271	45	111	0.06	0.08	82

AUDPC= Area under disease progress curve, ACI= Average coefficient of infection, DPR =Disease progress rate, SI= Spike infection, K=Kulumsa, M=Meraro

4. Conclusion

Most of the commercial bread wheat cultivars in Ethiopia break down to new races of stripe rust in hot spot areas. The information of this finding revealed that the majority of the evaluated commercial and elite bread wheat lines showed susceptible reactions to the prevalent stripe rust races. However, few commercial and elite bread wheat lines exhibited lower stripe rust disease severities. Among the commercial bread wheat cultivars Shorima, Mandoyu, Sofumer, Tusie, Tay, Liben, andTsehay and from elite bread wheat lines such as; TRAP#1/BOW/3/VEE/PJN//2*TUI/4/BAV92/RAYON/5/KACHU #1*2/6/KINGBIRD #1, SOKOLL/3/PASTOR//HXL7573/2*BAU*2/4/PAURAQ, CHIBIA//PRLII/CM65531/3/MISR 2*2/4/HUW234+LR34/PRINIA//PBW343*2/KUKUNA/3/ROLF07, and CHWINK/GRACKLE #1//FRNCLN have good stripe rust resistant under adult plant resistance and seedling stages across the test season and locations. So, they are still effective in the prevalent stripe rust races. Thus, those bread wheat lines tested in this experiment and showed lower stripe rust disease severities will contribute a significant role to a wheat breeding program and wheat growers in the diversification of cultivars.

Abbreviations

AUDPC	Area Under Disease Progress Curve
ACI	Average Coefficient of Infection
CI	Coefficient of Infection
DPR	Disease Progress Rate
TRS	Terminal Rust Severity on Wheat Leaves
R	Resistant
MR	Moderately Resistant
MS	Moderately Susceptible
S	Susceptible
SI	Spike Infection
TKW	Thousand Kernel Weights

Author Contributions

Fikrte Yirga is the sole author. The author read and approved the final manuscript.

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Conflicts of Interest

The author declares no conflicts of interest.

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