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Evaluation of Ethiopian Wheat Germplasm Against Yellow Rust *(Puccinia striiformis)* Disease Under Field Condition

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Abstract: Wheat rust outbreak especially yellow rust is the major production constraint in Ethiopia. Arsi Zone is the hot spot zone for yellow rust (*Puccinia striiformis* (*Pst*)) particularly Meraro and Bekoji sites are frequently yellow rust epidemic was occur due favorable environmental and higher pressure of inoculums in the areas. Therefore, the objective the study was to identify sources of resistance against yellow rust at adult plant stage under hot spot sites. In this study, Three hundred seventy five elite breeding and advanced lines were planted at Meraro, Arsi-Robe and Bekoji. The results show that 34, 10 and 54% of the lines at Meraro were found resistant to moderately resistant, intermediate and moderately susceptible to susceptible. At Arsi-Robe 61, 23.5 and 15.5% of lines were showed that resistant to moderately resistant, intermediate and moderately susceptible to susceptible. Finally, at Bekoji 35.5, 21.3 and 43.2% lines at were resistant to moderately resistant, intermediate and moderately susceptible to susceptible category of yellow rust. Average coefficient of infection (ACI) less than 20% showed at Meraro (34%), Bekoji (35.5%) and Arsi-Robe (61%) was good percent of resistance to the current yellow rust pressure respectively, indicating higher disease pressure at Meraro and Bekoji than that of Arsi-Robe. Among the lines, 43.7% showed a good level of resistance (<30% severity) in all locations. Generally, most of the lines, which showed better resistance at Arsi-Robe, were susceptible at Meraro and Bekoji.

Keywords: Wheat, *Puccinia striiformis*, Yellow Rust, Hot Spots

1. Introduction

In Ethiopia wheat (*Triticum aestivum*) is one of the staple food crops cultivated by 5million small scale farmers and it is covered 1.7 million hectares and it accounts for 13.49% of the cropland, with an annual production of 4.5 million metric tons in the country [6]. Wheat contributes about 15.63% of the grain production in the country. In terms of area, wheat ranks fourth after teff, maize and sorghum and the mean wheat yield in Ethiopia is estimated to be 2.67 t ha^{-1} [6], which is well below the world mean of 3.0 t ha^{-1} [9]. This is due to losses caused by biotic and a biotic constraints [1, 10]. Among biotic constraints wheat rusts are the main restrictive factors for wheat production in Ethiopia [1]. From rusts especially, yellow rust can cause yield losses of up to 100% on susceptible cultivars if infection was occurs at early stage and the disease continues to develop during all growing season [3, 11]. The impact of yellow rust varies depending upon the susceptibility of cultivar, earliness of the initial infection, rate of disease development and duration of the disease [5]. Yellow rust epidemics are becoming more frequent in Ethiopia. According to Mozgovoy [12], epidemics of yellow rust occurred in 1977, 1980-83 and 1986, resulting 30-40% yield losses In another report, grain yield losses up to 96% were impose on susceptible wheat cultivars [18]. The Epidemics occurred from in 1998-1990 have resulted in 58% of yield loss [4]. Therefore, the past two decades, frequent epidemics of yellow rust have been a major challenge to wheat production in the country. Releasing of genetically resistant cultivars and chemical option are the two major management of yellow rusts disease in Ethiopia as well as in worldwide. According to Chen [5] research report increasing resistant cultivars is preferred approach for control of yellow rust because it is an effective, easy-to-use, economic and environmentally friendly strategy. on the other hand, resistant cultivars become susceptible due to dynamics of pathogen within the population. Therefore, searching for resistance sources to the current yellow rusts

diseases is becoming crucial. The objective of this study was to identify yellow rust resistance genotype/elite lines at adult plant stage (APR) under hot spot sites.

2. Materials and Methods

A total of 375 elite bread wheat lines that were either selected from international nurseries including resistant and susceptible check were used for study. From resistant cultivars (Danda'a, Wane, and Kingbird Daka) and susceptible check varieties (Kekeba and Lemu) were repeatedly planted at certain intervals of test lines. Natural yellow rust epidemics were enhanced by planting a mixture of spreader rows of PBW343, Kubsa, Digalu and Morocco in perpendicular to the test entries in 2019 main cropping season. Plots were kept weed free by two times hand weeding. When the susceptible check started to show yellow rust development, scoring of severity was carried out using the modified Cobb scale [13]. Average Coefficients of Infection (ACI) were calculated by taking into account the severity of yellow rust of the lines and cultivars, and their field response [14] in addition, genotypes were compared for resistance using final rusts severity score, field reaction and average coefficient of infection. The scores were converted into average coefficients of infection, by multiplying severity by an assigned value for the field response, as suggested by Stubbs et al. [14] (Table 1). The constant value was further modified to include infection responses of resistant to moderately resistant (RMR=0.3) and moderately susceptible to susceptible (MSS=0.9).

Table 1. *Field response values according to Stubbset al. [14] with some modifications.*

Field response	Symbol	Constant value
Zero (Very resistant)	0	0
Resistant	R	0.2
Resistant to moderately resistant	RM	0.3
Moderately resistant	MR	0.4
Intermediate	M	0.6
Moderately susceptible	MS	0.8
Moderately susceptible to susceptible	MSS	0.9
Susceptible	S	1.0

R= resistant, RMR = resistant to moderately resistant, MR =moderately resistant, M = moderately resistant to moderately susceptible, MS = moderately susceptible, MSS = moderately susceptible to susceptible and S = susceptible

3. Results

3.1. Reactions of the Evaluated Genotype

From 375 elite breeding and advanced lines at Meraro, Arsi Robe and Bekoji 15, 1 and 31 were immune against all the races of yellow rust prevailing in nature respectively (Table 2). However, at all locations none of the test lines show Resistant (R) and Resistant to moderately resistant (RM). One hundred ten, four and one hundred eleven lines were exhibiting moderately resistant (MR) at the three locations (Tabel 2). Whereas 17, 6 and 4 genotype show intermediate (M) reactions at Meraro, Arsi Robe and Bekoji respectively, twenty lines and forty-two at Meraro and Arsi Robe showed moderately susceptible (MS) reactions and 60 lines at Bekoji. With respect to moderately susceptible to susceptible reactions (MSS) 9, 16 and 8, displayed this reaction at Meraro, Arsi Robe and Bekoji. Majority of the elite lines and cultivars was show completely susceptible (S) reaction at Meraro, Arsi Robe and Bekoji with 204,306 and 160 respectively. In general, considering the disease reactions at Meraro and Arsi Robe, more lines were in the susceptible categories at Meraro and Arsi Robe than at Bekoji (Figure 1). However, in reaction categories which is show moderately resistant, the number of lines at Meraro and Bekoji exceeded by far the number of lines at Arsi Robe (Figure 1)

Table 2. *Number of bread wheat genotype/lines included check in resistance and susceptibility categories for yellow rust.*

No	Reaction category	Number of genotype/lines		
		Meraro	Arsi Robe	Bekoji
1	0	15	1	31
2	R	0	0	0
3	RM	0	0	0
4	MR	110	4	111
5	M	17	6	4
6	MS	20	42	60
7	MSS	9	16	8
8	S	204	306	160

R= resistant, RMR= resistant to moderately resistant, MR=moderately resistant, M= moderately resistant to moderately susceptible, MS= moderately susceptible MSS= moderately susceptible to susceptible and S= susceptible

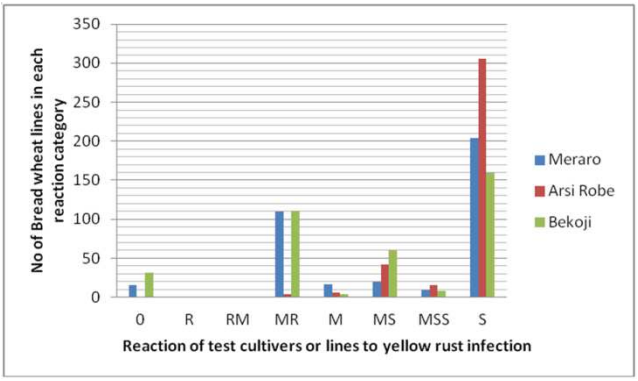

Figure 1. *Number of bread wheat genotyp/elite lines in different classes of yellow rust reactions at Meraro, Arsi Robe and Bekoji in 2019.*

3.2. Severity of Yellow Rust

Majority of the taste lines (131 and 133) tested at Meraro, and Bekoji (Figure 2) showed a severity $\leq$ 20%; whereas at Arsi Robe, almost two-third of the line (229) showed the same severity levels (Figure 2). 41, 88 and 80 display a severity range between 21-30% at Meraro, Arsi robe and Bekoji respectively. 203, 58 and 162 genotype/lines show severity range > 30%.

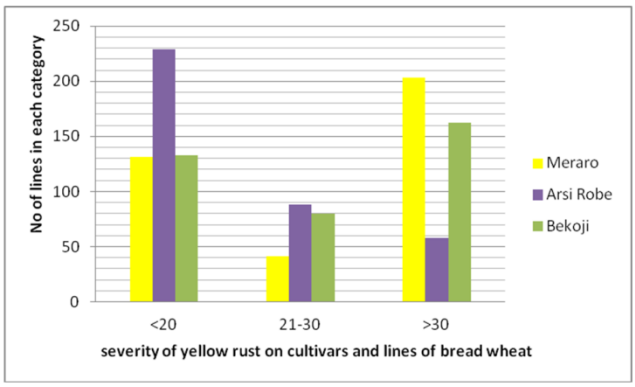

Figure 2. *Bread wheat genotype/Elite lines evaluated in Meraro, Arsi Robe and Bekoji and their severity levels.*

Terminal yellow rust severity less than or equal to ten percent and coefficient of infection

The selection of elite bread wheat lines was made based on the occurs of the highest yellow rust pressers site from the three yellow rust hot spot areas. In 2019 main cropping season the highs yellow rust pressers was occurrence at Meraro than the other hot spot location. Therefore, we are select the terminal severity of the yellow rust leas than or equal to ten percent by correcting of the other hot pot location. The selection was made by considering the three parameters, the highest score was recorded for elite line KU18BWOL_339_9 (Table 3). The least score was recorded for elite bread wheat line KU18BWPL1_29 (Table 3). Two elite lines show an average coefficient of infection (ACI) value of less than or equal two. These included lines KU18BWOE_134 and KU18BWOE_69. Generally 39 (79%) of the test genotypes displayed an ACI value of less than or equals to ten percent of the coefficient of infection. On the other hand 10 (20%) The test genotype show as greater than or equals to ten.

3.3. Response of the Check Cultivars Against Yellow Rust in Hot Spot Areas

When see the average disease severity in check cultivars and it is response almost all check cultivars was moderately susceptible to susceptible reactions except wane at Meraro, Arsi-Robe and Bekoji. The responses of check cultivars against yellow rust was score 24, 34, 46.8 and 46.5% on Wane, Lemu, King-bird and Kekeba in all location respectively (Figure 3). From the chekek cultivars the highest disease severity was recorded on King-bird and Kekeba.

Table 3. *Terminal yellow rust severity, coefficient of infection and average coefficient of infection of selected elite wheat lines in Meraro, Bekoji and Arsi- Robe testing sit.*

Plot	Genotype	Seed source	Terminal yellow rust severity			CI-value			ACI value
			Meraro	A/Robe	Bekoji	Meraro	A/Robe	Bekoji	
16	BW120101	KU18BWOE_14	10mr	5ms/mr	5mr	4	3	2	3
24	BW120109	KU18BWOE_228	10mr	30s	5mr	4	30	2	12
28	BW120115	KU18BWOE_323	0	10s	0	0	9	0	3
29	BW120116	KU18BWOE_134	10mr	Tmr	0	4	0.4	0	1.5
30	BW120118	KU18BWOE_69	10mr	5mr	0	4	2	0	2
47	BW120137	KU18BWOE_52	0	5s	5mr	0	5	2	2.3
104	BW172800	KU18BWOE_53	10mr	10ms/mr	tmr	4	6	0.4	3.5
111	BW172831	KU18BWOE_332	10mr	5ms	15ms	4	4	12	6.7
112	BW174116	BW18NE2_12	0	10s	0	0	10	0	3.3
113	BW174298	KU18BWOE_237	0	20s	tmr	0	20	0.4	6.8
115	BW174334	KU18BWOE_93	10mr	10s	0	4	10	0	4.7
118	BW174371	KU18BWOE_125	0	30s	0	0	30	0	10
120	BW174388	KU18BWOE_248	0	15s	0	0	15	0	5
124	BW174413	KU18BWOE_330	10mr	5ms	tmr	4	4	0.4	2.8
125	BW174414	KU18BWOE_301	10ms/s	20s	0	9	20	0	9.7
127	BW174425	KU18BWOE_31	10mr	30s	5mr	4	30	2	12
128	BW174427	KU18BWOE_147	0	10s	0	0	10	0	3.3
129	ETBW9080	BW18NE1_11	0	20s	0	0	20	0	6.7
134	ETBW9452	BW18NE1_14	10msmr	10s	0	6	10	0	5.3
153	BW120052	KU18BWOL_114_248	10s	20s	tmr	10	20	2	10.7
165	BW120069	KU18BWOL_66_265	10mr	15ms	20ms	4	12	16	10.7
172	BW172093	AA18BWNE2_24	10mr	10ms	10sms	4	8	9	7
176	BW172144	AA18BWNE2_17	10mr	20s	tmr	4	20	2	8.7
186	BW172440	KU18BWOL_339_91	10ms	30s	10mr	8	30	4	14
194	BW172550	KU18BWOL_199_115	10mr	20s	tmr	4	20	0.4	8.1

Table 3. *Continued.*

Plot	Genotype	Seed source	Terminal yellow rust severity			CI-value			ACI value
			Meraro	A/Robe	Bekoji	Meraro	A/Robe	Bekoji	
195	BW172558	KU18BWOL_61_118	10mr	20s	tmr	4	20	0.4	8.1
234	BW174187	KU18BWOL_137_171	10mr	15ms	tmr	4	12	0.4	5.5
236	BW174456	AA18BWNE2_8	10msmr	20s	5mr	6	20	2	9.3
263	ETBW 9080	AA18BWNE1_11	0	0	tmr	0	0	0.4	0.1
271	ETBW 9396	AA18BWNE1_13	0	30s	10mr	0	30	4	11.3
290	ETBW 9661	AA18BWNE2_7	10mr	20s	tmr	4	20	0.4	8.1
292	ETBW9547	KU17BWNL_15	10mr	30s	tmr	4	30	0.4	11.5
296	BW173457	KU18BWPE3_26	10mr	15s	10mr	4	15	4	7.7
298	BW173528	KU18BWPE2_29	10mr	25s	10mr	4	25	4	11
302	ETW17-271	KU18BWPE1_2	10msmr	20s	tmr	6	20	0.4	8.8
323	ETW17-476	KU18BWPE3_12	0	15s	0	0	15	0	5
329	BW164003	EYT_22	0	15s	0	0	15	0	5
330	BW164004	EYT_65	10mr	30s	0	4	30	0	11.3
333	BW164007	EYT_81	10mr/ms	10ms/s	10mr	6	9	4	6.3
334	BW164008	EYT_99	10mr	15ms/s	20ms	4	13.5	16	11.2
343	BW172020	KU18BWPL4_11	10mr	15s	0	4	15	0	6.3
353	BW174019	KU18BWPL3_19	10mr	30s	10mr	4	30	4	12.7
356	ETW17-133	KU18BWPL2_7	10mr	15s	tmr	4	15	0.4	6.5
358	ETW17-143	KU18BWPL2_24	10mr/ms	10s	30s	6	2	30	12.7
362	ETW17-193	KU18BWPL3_8	10mr	10s	5mr	4	10	2	5.3
366	ETW17-50	KU18BWPL1_10	0	10s	tmr	0	10	0.4	3.5
371	ETW17-88	KU18BWPL1_29	0	0	5mr	0	0	2	0.7

CI = coefficient of infection, ACI = average coefficient of infection

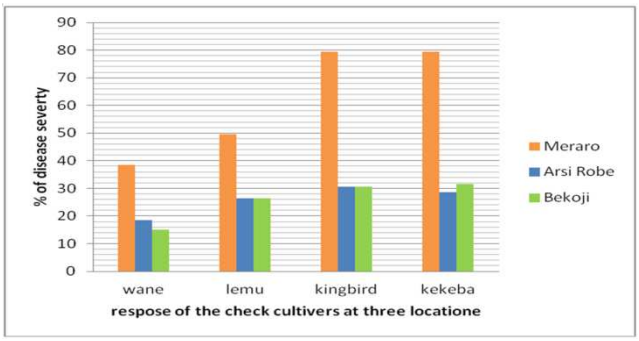

Figure 3. *Disease severty of the check cultivers and it is respons of the yellow rust at Meraro, Arsi Robe and Bekoji in 2019.*

4. Discussion

According to Admassu *et al.* [2] reported that indigenous germplasm evaluations against yellow rust in field condition indicated that most of the lines were moderately resistant after the resistance status which is suggested to use in the wheat breeding program because resistant varieties are the best option for successful wheat production. The field data indicated that the variability of yellow rust in severity and infection response of genotype/elite lines, and check cultivars at all testing site, Meraro, Bekoji and Arsi-robe respectively (Tables 2 and 3), indicated that the yellow rust pathogen populations have differences in their virulence profiles. More genotype/lines were found to be more susceptible at Meraro and Bekoji than Arsi-robe. The results clearly indicate the broad range of yellow rust in reaction from resistance to susceptible for yellow rust in breeder's germplasm. Therefore, it is concluded that some of the wheat germplasm had a great potential to be used against yellow rust. this result similar with Ayele, 2002 Some of the advanced bread wheat lines and commercial cultivars, which showed susceptible reaction at seedling stage exhibited low terminal yellow rust severities under field conditions in Ethiopia (Ayele, 2002). Finally, this study indicated that most of the bread wheat genotype/lines contained different resistance range when compared to the commercial cultivars. Therefore, identifying resistant bread wheat genotype/lines have been vital as sources of resistance to the prevailing races of yellow rust in Ethiopia.

5. Conclusion

The genotype/lines that confirm low level of yellow rust severities from R to MR reactions to yellow rust in all test locations, can be utilized as resistant parental lines in the wheat breeding programmed or they can be advanced to yield trials for the development of high yielding and yellow rust resistant cultivars to fight for new evolving races of yellow rust.

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