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Research Article

Field Assessment of Commercial Wheat Varieties, Advanced Lines and Trap Nurseries against Yellow Rust in South East Ethiopia

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ABSTRACT

Wheat rusts caused by *Puccinia* spp. is economically significant foliar syndrome in the main wheat-growing areas of Ethiopia. Safeguard of wheat from rust diseases has very exceptional worth to be profitable and reduce hunger. Screening of wheat genotypes against rust and monitoring of race development and monitoring of variability in wheat rust pathogens by international trap nurseries is vital to mitigate rust impact. In this experiment, resistance to wheat yellow rusts of 119 wheat germplasm comprising varieties, advanced lines along with 19 international yellow rust trap rust nurseries were studied under natural infection in 2018-2019 years in different geographic zones of Ethiopia. The information of this finding revealed that majority of the test cultivars displayed susceptible reaction to the prevalent yellow rust races. However, few cultivars and candidate lines exhibited lower diseases severities. Among the differentials, *Yr5+*, *Yr10* and *Yr15* are still effective to the prevalent yellow rust races. Thus, those candidate wheat genotypes tested in this experiment and showed lower diseases severities will contribute a significant role to wheat breeding program in diversification and development of cultivars with durable or long lasting resistance.

Keywords: Bread; Durum; Genotype; *Septoria tritici* blotch; Wheat

INTRODUCTION

Wheat is one of the world's most important staple grains and is the leading source of calories and plant-derived protein in human food, with an annual global production of 772.6 million tons. A latest valuation of wheat production by the Food and Agricultural Organization of the United Nations shows that current wheat quantity is ample for global demand. Nevertheless, future production must increase as the global population is growing fast, projected to exceed nine billion people by 2050 [1].

In Ethiopia, the annual wheat production is around 5.8 million tons with mean productivity of 3 tons per hectare (tha^{-1}), which is quite lower than the realizable harvest of the yield, attainment upto 5 tha-1. Wheat accounts for about 17% of total grain production in Ethiopia making it the third principal cereal crop after teff *Eragrostis tef* (Zucc.) Trotter and maize (*Zea mays L.*). In general, the agricultural, production growth shows oscillating trends compared to population growth.

Thus, there should be a serious necessity to produce highly productive crops like wheat to feed the world population soon. Despite, the rapid increment of wheat in area coverage and grain yield, about 15%-20% yield losses per annum are recorded due to fungal diseases of which rusts come first.

Wheat rust pathogens are the key constraints of global wheat production since the domestication of the crop and continue to threaten the world's wheat supply. It is expected that universal yearly losses to wheat rust pathogens array between US$ 4.3 billion to 5.0 billion; even escalate up to 5.5 million tons per year at worldwide level due to yellow rust alone. While in Ethiopia, the recurrent rust outbreaks lead to substantial economic losses, which are estimated to be of the order of 10 s of millions of US-D annually [2].

During the past decades the epidemic of wheat rust and associated losses was more sever causing global concern to wheat production. To tackle the issue, breeding of new varieties and their implementation is economically and ecologically reasonable method for control rust diseases. However, the continuous evolution of new pathotypes which is exacerbated by climatic stress, especially in rain fed areas and airborne nature pose a serious threat to wheat production worldwide.

Trap nursery consists of isolines with confrontation genes, genetic stocks for additional *Yr*, *Sr* and *Lr* genes, selected differentials,

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wheat diversities resonant blends of key resistance genes, and main commercial varieties presently cultivated in diverse regions. Rusts trap nurseries are targeted for wheat growing areas and are planted at sites anywhere rusts is identified to occur naturally every year with the objective to collect information on virulence and race formation of rusts, behavior of resistant and susceptible varieties, tested under different environmental conditions. Thus, the nurseries are very imperative for Ethiopia, where all three rusts are accessible essentially everywhere where cereals are grown [3-6].

MATERIALS AND METHODS

Description of the study areas

The experiment was executed at three yellow rust hotspot locations *viz*; Meraro and Bekoji (research stations) and Kulumsa (main research center) of Arsi Zone South eastern Ethiopia. Meraro substation is situated at 07°24'27''N, 39°14'56''E and 2990 m.a.s.l. Its regular annual rainfall is 1196 mm signifying extreme highland and frost prone agro ecology. The lowest and supreme hotness is 5.7°C and 18.1°C, respectively. Bekoji location is found at latitude 07°32'37''N and longitude 39°15'21''E with an altitude of 2780 meter above sea level. The maximum and minimum temperature was 3.8°C and 20.4°C respectively with annual rain fall 939 mm. Kulumsa research center is located at 08°01'10''N, 39°09'11''E and at 2200 meters above sea level (m.a.s.l). The site gets mean yearly rainfall of 820 mm representing highland and high rainfall agro ecology. The regular mean least and supreme hotness is 10.5°C and 22.8°C, respectively. The sites foremost soil type is loam type, which is fertile [7].

Planting materials: A set of 119 bread and durum wheat genotypes comprising commercial cultivars, advanced breeding lines and differentials lines obtained from Ethiopian national bread wheat breeding program were studied under natural infection in 2018-2019 years in at three different locations of Ethiopia [8].

Field layout and diseases assessment

To assess the intensity of slow rusting of wheat genotypes in the field, test materials and checks were arranged in augmented design [9]. The entries were established in plots comprising of paired rows of 1 m long with spacing of 0.2 m intra row, 1 m between blocks and 0.5 m between plots. Plots were seeded in 150 $kgha^{-1}$ DAP and urea fertilizers were applied based on the recommended rate to the area. Weeds were managed by hand weeding. Disease severity notes were taken by estimating the approximate percentage of leaf area affected using modified Cobb scale. Data recording was started from the first appearance of yellow rust on the susceptible check and continued every 14 days from all plants until the early dough stage. Scorings of disease severity and response were noted together with severity first followed by infection type [10]. The host response is as: TR=Trace Severity of Resistant Type Infection; 10R-MR=10% Severity of Resistant to Moderately Resistant Infection Type; 20MR=20% Severity of a Moderately Resistance Infection Type; 30MR-MS=30% Severity of a Moderately Resistance to Moderately Susceptible; 40MS=40% Severity of a Moderately Susceptible; 50MS-S=50% Severity of a Moderately Susceptible to Susceptible; and 70S=70% Severity of Susceptible Infection Types. The data acquired from disease severities and host reactions were combined to compute coefficient of infection (ACI).

RESULTS AND DISCUSSION

Among the three locations, Meraro is characterized as too cold, high altitude and low temperature makes more conducive to occurrences of yellow rust compared with two locations; Bekoji and Kulumsa. In 2019 yellow rust developed more vigorously than 2018 since the crop season was more favorable. 2018 crop season was manifest by arid conditions along all the three locations and yellow rust developed very weakly than in 2019.

In 2018 a total of 115 wheat genotypes were evaluated of which 47.8%, 73.9% and 68.7% of tested entries had lower or, <20 average coefficient of infections were recorded at Meraro, Bekoji and Kulumsa respectively; indicating that maximum diseases pressure was avail at Meraro. The growing year was a little bit arid as compared with 2019; thus many of the tested wheat genotypes have disease severity of 0S to 80S while on universal susceptible check "Morocco" scored 90S (Table S1 and Figure 1). Most of mega and popular bread wheat cultivars which covered majority of wheat growing areas in research area like (Ogolcho, Kubsa, Hidassie, Dandaa' Kingbird and Digalu) showed susceptible reaction near to similar severity levels to the universally susceptible check and local susceptible check Morocco and PBW343 respectively.

Similarly, wheat varieties like Pavon 76, Mitike, Galema, Abola, Tusie, Katar, Shina, Hawi, Tura, Madawalau, Simba, Sofumar, Tossa, Senkegna, Meraro and Tsehay displayed susceptible reaction with average coefficient of infection exceeding 20 at Meraro, Bekoji and Kulumsa in both cropping seasons. On contrary, the formerly most popular variety" Dashen" which carries *Yr9* gene exhibited low yellow rust severity. This might be due to the elimination of the race virulent to *Yr9* gene.

On the other hand, among the candidate lines *viz* ETBW5800, ETBW5879, ETBW5890, ETBW6093, ETBW6094, ETBW6098, ETBW6647, ETBW6496, ETBW6696, ETBW7698, ETBW6939 and ETBW7255 only ETBW5879, ETBW5890, ETBW6696 and ETBW7698 showed ACI below 20 across all the three locations. However, in 2019 none of them displayed lower ACI especially at hotspots; Meraro and Bekoji.

Data on trap nurseries over two years indicated that several known resistance genes *Yr6*, *Yr7*, *Yr8*, and *Yr18* have limited utility as host lines carrying them displayed susceptibility in both years. The varieties Kubsa (*Yr27+*), Medawlabu, Hoggana, Millinium and Meraro that carried *Yr17* shown disease severities from trace MS under relatively hot weather (Kulumsa) to 80S at highland hot spot (Meraro and Bekoji) conditions. Broadly speaking, cultivars and candidate lines that are not consisting *Yr5+*, *Yr10* and *Yr15* showed highly susceptible reaction where epidemics is more sever on highlands. The assessments information revealed that, genes *Yr5*, *Yr6*, *Yr7*, *Yr9*, *Yr17*, *Yr18*, *Yr26* and *Yr27* were heavily injured over time and space. Moreover, even if the degree of virulence varies, majority of the genes under diffentials broken by the prevalent yellow rust races at all locations (Table 1).

The two most popular cultivars Kubsa which carried *Yr27* but affected by yellow rust race PStS6 and Ogolcho affected by a race PStS16 remained ineffective even under warm weather conditions. Over all, wheat yellow rust resistant genes of *Yr5+*, *Yr10* and *Yr15* are still persisted effective and could have a significant contribution in the development of new wheat varieties under breeding program in Ethiopia.

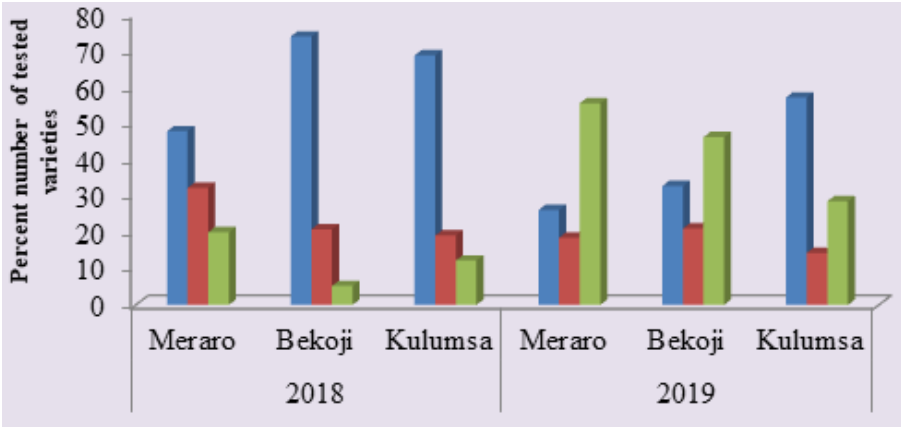

Figure 1: Response of commercial and candidate wheat genotypes to yellow rust at Meraro, Bekoji and Kulumsa in 2018 and 2019 cropping seasons.
Note: (▬) ≤20; (▬) 21-40; (▬) >40.

Table 1: The response of wheat varieties at three locations Meraro, Bekoji and Kulumsa in 2018 and 2019.

S.No.	Wheat Varieties	*YR* Gene	2018						2019					
			Meraro		Bekoji		Kulumsa		Meraro		Bekoji		Kulumsa	
			TRS	CI	TRS	CI	TRS	CI	CI	TRS	CI	TRS	TRS	CI
1	*YR1/6** Avocet S	*YR1*	20S	20	20S	20	5MR	3	30s	30	30s	30	20s	20
2	*YR5/6** AOC CX86.6.1.20	*YR5*	50S	50	40S	40	40S	40	70s	70	80s	80	80s	80
3	*YR6/6** AOC CX94.2.2.25	*YR6*	60S	60	60S	60	90S	90	90s	90	100S	100	70S	70
4	*YR7/6** Avocet S	*YR7*		0	0	0	0	0	90s	90	100S	100	70S	70
5	*YR8/6** Avocet S	*YR8*	40S	40	60S	60	60S	60	30s	30	30S	30	10S	10
6	*YR9/6** Avocet S	*YR9*	50S	50	50S	50	60S	60	90s	90	100S	100	50S	50
7	*YR10/6** Avocet S	*YR10*	0	0	0	0	0	0	0	0	0	0	0	0
8	*YR15/6** Avocet S	*YR15*	0	0	0	0	0	0	0	0	0	0	0	0
9	*YR17/3** AOC CX94.8.1.25	*YR17*	60S	60	60S	60	60S	60	90s	90	100S	100	80S	80
10	*YR18/3** AOC CX94.10.1.7	*YR18*	60S	60	60S	90	90S	90	90s	90	100S	100	70S	70
11	*YR26/3** AOC CX96.8.17.1.	*YR26*	40S	40	40S	40	10MS	8	80s	80	80S	80	60S	60
12	*YRSP/3** AOC CX94.14.1.1	*YRSP*	40S	40	50S	50	30S	30	90s	90	70S	70	10MR	6
13	*YR27/3** AOC CX94.94.1.1	*YR27*	50S	50	50S	50	20S	20	90s	90	100S	100	70	70
14	AVOCET R	R	60S	60	60S	60	80S	80	60s	60	80S	80	60S	60
15	AVOCET S	S	10S	10	TR	0.2	0	0	0	0	30S	30	0	0
16	Lassik(*-Yr5*)	Lassik(*-Yr5*)	30S	30	TMR	0.4	0	0	60s	60	40S	40	10MR	6
17	Lassik(*+Yr5*)	Lassik(*+Yr5*)	TR	0	0	0	0	0	0	0	0	0	0	0
18	*Yr* morocco	Yr morocco	90S	90	90S	90	100S	100	100s	100	NA	100	90S	90
19	Morocco	Morocco	90S	90	80S	80	80S	80	100s	100	NA	100	90S	90
20	Kubsa/local check	Kubsa	80S	80	60S	60	50S	50	90s	90	100S	100	80S	80

CONCLUSION

The information of this finding revealed that majority of the test cultivars displayed susceptible reaction to the prevalent yellow rust races. However, few cultivars and candidate lines exhibited lower diseases severities. Among the differentials, *Yr5+*, *Yr10* and *Yr15* are still effective to the prevalent yellow rust races. Thus, those candidate wheat genotypes tested in this experiment and showed lower diseases severities will contribute a significant role to wheat breeding program in diversification and development of cultivars with durable or long lasting resistance.

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CONFLICTS OF INTEREST

The author declares no conflict of interest. The funders had no role in the study design; data collection analysis or interpretation; in writing of the manuscript, or in the decision to publish the result.

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