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Evaluation of Stripe Rust (*Puccinia Striformis* f. sp. *Tritici*) Resistance in Bread Wheat (*Triticum aestivum* L.) Genotypes in Ethiopia

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Abstract: Adult Plant Resistance (APR) based on partial resistance is an important and effective way to combat yellow rust (*Puccinia striiformis*) in wheat production. The objective of current research was planned to evaluate the response of 436 wheat (*Triticum aestivum*) genotypes against yellow rust resistance under field conditions during 2020 main cropping season. Over locations, Partial resistance screening was evaluated through Final Rust Severity (FRS), Area under Disease Progress Curve (AUDPC), Coefficient of Infection (CI), Relative Area under Disease Progress Curve (rAUDPC) and field reaction have used for differentiating Adult plant resistances. Responses of four hundred thirty six genotypes, one hundred fourteen wheat lines were high adult plant resistance, fifty eight lines were found to be intermediate adult plant resistant and two hundred sixty four were low adult plant resistance over location. With rAUDPC values over location twenty seven were 1-10 shown resistant, eighty seven lines were 11-30 categorized as moderately susceptible and three hundred twenty two genotypes exhibited susceptible response against yellow rust with more than 31-100 rAUDPC value. High values above 31 prcent of rAUDPC showed greater severity of yellow rust on wheat genotypes while lower rAUDPC values indicated resistance to yellow rust. Fifty bread wheat genotypes that were selected based on overall agronomic performance (biomass, spike length, number of spikes/m^2, tillering capacity, stalk strength or lodging resistance, shattering resistance and diseases resistance especially yellow rust and Septoria blotch. Three genotypes were EBW192345, EBW192346 and EBW192347 extraordinarily out performed evaluated materials phenotypically in terms of agronomic performance and diseases resistance over locations. The present study revealed that the lines were having enough diversity regarding slow rusting behavior and yellow rust resistance, ranging from immunity to partial resistant lines. Present research provided the resistant wheat lines to the breeders to incorporate in their breeding program against yellow rust.

Keywords: Bread Wheat, Yellow Rust, Partial Resistance, Adult Plant Resistance

1. Introduction

Stripe rust (*Puccinia striiformis* f. sp. *tritici*, Pst) is the most devastating rust disease that attacks much of global wheat production. The rapid emergence of virulent *Pst* races has overcome most of the known stripe rust resistance genes in wheat. Stripe rust of wheat is serious problem for wheat production worldwide and has reportedly caused significant yield losses in more than 60 countries. [1]. Epidemics of the disease can rapidly destroy leaf tissue and significantly reduce grain yield and quality. In most wheat-producing areas, yield losses caused by stripe rust range from 2.7 to 96.7% depending on the degree of susceptibility of the cultivar, timing of the initial infection, rate of disease development, areas of hotspot and duration of disease [2]. Currently, 80 yellow rust resistance (Yr) genes have been permanently named in wheat, including the recently mapped Yr79 [3] and Yr80 [4]. Development and use of resistance genes in wheat breeding is the most effective, economic and environmental friendly approach for controlling stripe rust of wheat [1]. Resistance to stripe rust is broadly categorized as: all stage resistance (also called seedling resistance), which can be detected at the seedling stage, but is also expressed at all stages of plant growth; and adult plant resistance (APR), which is expressed at later stages of plant growth. The cultivation of resistant varieties remains the most economic and environmentally preferable method to manage this disease. Some of the resistance genes are effective at seedling stage and they are race specific. Several of these genes may become ineffective due to the emergence of new virulent races and also because of rapid evolution and adaptation of pathogen [5]. In contrast, others are effective through the adult plant stage and are referred to as slow rusting genes and they are race non-specific provide durable resistance or a broad spectrum of races. Therefore, a cultivar that only has slow rusting resistance to leaf rust will display susceptible infection type response throughout the entire lifecycle of the plant [6]. Although several studies have been carried out to assess stripe rust resistance in different wheat genotypes in Ethiopia, many of them were based on race specific resistance. Adult plant resistance can be measured in the field by recording disease severity at weekly intervals and then calculating the area under disease progress curve (AUDPC) [7]. The present study was thus designed to assess the levels of slow rusting resistance in national bread wheat genotypes to yellow rust under field conditions.

2. Materials and Methods

2.1. Plant Materials

Four hundred thirty six bread wheat genotypes that were obtained from Ethiopian Institute of Agricultural Research (EIAR) Kulumsa Agricultural research Center which is national wheat research program coordinating center in Ethiopia, evaluated under field conditions at Kulumsa main station, Bekoji and Meraro experimental sites for 2020 main cropping season. The lines were sown small adjacent plots of two rows per plot, with each row of 1m length separated by 0.2 m with a distance of 0.4 m between entries which were selected due to severely affected hotspot areas for yellow rust in Ethiopia. A mixture of Morocco, PBW343, Kubsa and Digalu which are a super susceptible wheat cultivars, were sown around entries as spreader rows and also to serve as an adult plant susceptible check.

2.2. Disease Scoring

Disease Scoring was made three times at Kulumsa and Bekoji, and four times at Meraro experimental stations at fourteen days interval, starting when susceptible spreader rows reached 20% severity according to the Modified Cobb Scale [8].

2.3. Final Rust Severity (FRS)

Final rust severity (FRS) was used to classify wheat genotypes into different group such as 1-30 percent as moderately resistant, 31-50 percent as moderately susceptible and 51-90 percent as susceptible.

2.4. Coefficient of Infection (CI)

Coefficient of infection was calculated by using data on disease severity and host reaction by multiplying the severity value by a value of 0.10, 0.4, 0.8 or 1.00 for host response rating of R, MR, MS or S, respectively and was used to classify genotypes in to three groups such as 1-20 High adult plat resistance, 21-40 intermediate and 41-100 low adult plant resistance [9].

AUDPC and rAUDPC value; - were calculated as [10] and, [11].

$$AUDPC = \frac{N1(X1+X2}{2} + \frac{N2(X2+X3)}{2} + \frac{N3(X3+X4)}{2}$$

Where, X1, X2, X3 and X4 are rust intensities recorded on first, second, third and fourth recording date and N1 is interval day between X1 and X2 N2 is interval day between X2 and X3, N3 is interval day between X3 and X4

$$rAUDPC = \left(\frac{line\ AUDPC}{Susceptible\ AUDPC}\right)100$$

3. Results and Discussion

3.1. Final Rust Severity

Diverse field reactions ranging from resistance (R) to susceptible (S) responses were observed at the Kulumsa, Bekoji and Meraro experimental sites. The final rust severities of the genotypes and their infection types are presented in figures 1 and 2. Final rust severity represents the cumulative result of all resistance factors during the progress of epidemics [12]. Based on final rust severity, the tested wheat genotypes were grouped into three groups of slow rusting resistance, that is, high, intermediate and low levels of adult plant resistance(APR) having 1-30 and 31- 50 and 51-100% FRS, respectively. At Bekoji experimental station two hundred thirty three wheat genotypes displayed disease severities of up to 30%. Of these sixteen genotypes had resistant(R), one hundred sixty four had moderately resistant (MR), fifty three moderately susceptible (MS) responses while two hundred three showed susceptible(S) field reactions. On the other hand, at Kulumsa six, forty three, one hundred thirty five, ninety three and one hundred fifty nine genotypes were showed immune, R, MR, MS and S field reaction to the yellow rust. Despite the heavy yellow rust disease pressure at Meraro, four and ninety three genotypes remained in the first group, exhibiting final rust severities ranging from 1 to 30%, with compatible R and MR responses and are of great importance to achieve effective breeding for durable resistance to yellow rust [13]. The available resistance genes in these materials overcame the yellow rust virulence in the field and led to statistically low disease severities despite the compatible host-pathogen reactions [14]. Previously, final rust severity also used to assess slow rusting behavior of wheat lines [15-20]. On the other hand fifty eight genotypes showed final rust severities between 31 and 50% and two hundred sixty four genotypes showed at all experimental stations and were regarded as possessing high levels of slow rusting resistance. The immune response on these tested genotypes could be as a result of hypersensitive responses; resistance often breaks down due to the development of new races of the pathogen. A suitable breeding strategy like the use of inter-specific and remote crosses or even the direct transfer of these resistances through backcrosses could be used to improve the adopted but highly susceptible wheat varieties being grown in Ethiopia [21]. On the other hand, the susceptible check, PBW343, Digalu, Kubsa and Morocco displayed the highest disease severities of 90% with completely susceptible (S) responses at Meraro, Bekoji and Kulumsa experimental stations, indicating that an acceptable epidemic pressure was established over the seasons for field experiments.

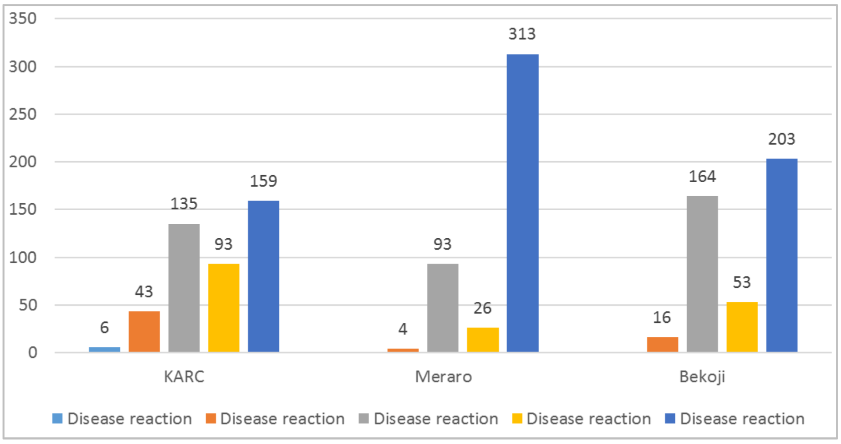

Figure 1. *Response of bread wheat genotypes to yellow rust.*

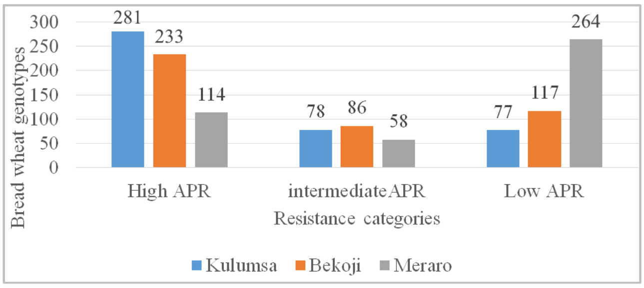

Figure 2. *Yellow rust severity of wheat genotypes under resistance category.*

3.2. Average Coefficient of Infection

The data on disease severity and host reaction were combined to calculate CI (Figure 3). The lines with CI values of 0-20, 21-40, 41-60 were regarded as possessing high, moderate and low levels of slow rusting resistance, respectively [22]. In the present study, all the test genotypes over locations ninety nine genotypes showed CI values between 0 and 20 were designated as having a high level of slow rusting. It was, therefore, concluded that these genotypes had a great potential to be used as a resistance sources against yellow rust. Only forty eight genotypes, had CI values of 21 to 40, designated as having moderate levels of slow rusting resistance and two hundred eighty eight genotypes had a CI value of more than 40, designated as having low levels of slow rusting and grouped as susceptible genotypes. Many earlier researchers also appraised slow rusting resistance to wheat leaf rust using coefficient of infection and reported the presence of different partial resistance conferring genes in wheat lines [23, 10, and 24].

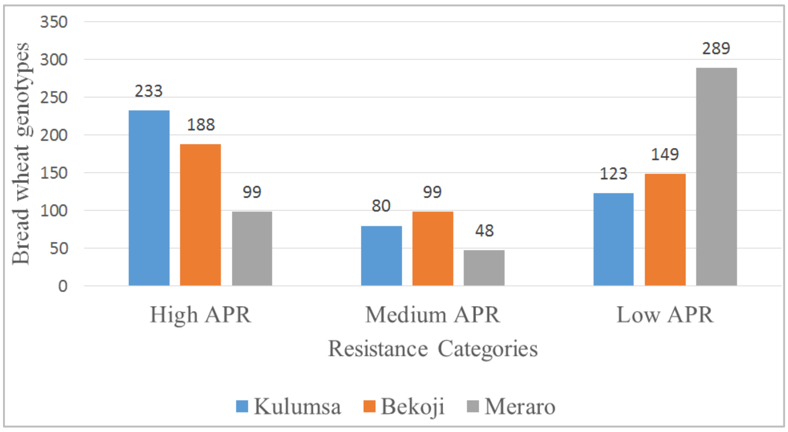

Figure 3. *Average coefficient of infection of wheat genotypes under resistance category to yellow rust.*

Table 1. *Final rust severity, Response reaction and coefficient of infection of the selected bread wheat genotypes at three locations.*

S/N	Source Trial	Genotype	Seed source	KARC			Meraro			Bekoji		
				FRS	Response	CI	FRS	Response	CI	FRS	Response	CI
1	20BWNE	BW172619	KU19BWPE-2-9-146	trace	MR	1.6	15	MR	6	10	MRMS	6
2	20BWNE	BW172620	KU19BWPE-13-2-24	10	MR	10	15	MR	6	10	MR	4
3	20BWNE	BW172709	KU19BWPE-4-1-4	10	MR	10	20	MR	8	10	MR	4
4	20BWNE	BW172831	KU19BWPE-5-10-176	trace	MR	1.6	10	MR	4	5	MR	2
5	20BWNE	ETBW9396	KU19BWPE-10-3-46	10	MRMS	6	20	MRMS	12	20	MRMS	12
6	20BWNE	EBW192353	KU19BWElite---39	10	MR	4	10	MRMS	6	5	MR	2
7	20BWNE	EBW192370	KU19BWElite---56	trace	MR	1.6	20	MR	8	5	MR	2
8	20BWNE	EBW192371	KU19BWElite---57	trace	MR	1.6	20	MR	8	5	MR	2
9	20BWNE	EBW192375	KU19BWElite---61	trace	MR	1.6	20	MR	8	10	MR	4
10	20BWNE	EBW192377	KU19BWElite---63	trace	MR	1.6	20	MR	8	5	MR	2
11	20BWNE	EBW192380	KU19BWElite---66	trace	MR	1.6	20	MRMS	12	10	MR	4
12	20BWNE	EBW192382	KU19BWElite---68	trace	MR	1.6	10	MRMS	6	5	MR	2
13	20BWNL	BW172088	KU19BWPL-11-7-143	trace	MR	1.6	5	MRMS	3	5	MR	2
14	20BWNL	BW172093	KU19BWPL-9-4-80	5	MR	2	20	MRMS	12	10	MRMS	6
15	20BWNL	BW172474	KU19BWPL-18-10-203	10	MR	4	5	MRMS	3	5	MR	2
16	20BWNL	BW172862	KU19BWPL-6-5-94	15	MR	6	20	MRMS	12	20	MR	8
17	20BWNL	BW172864	KU19BWPL-19-6-114	trace	MR	1.6	15	MR	6	20	MRMS	12
18	20BWNL	BW172936	KU19BWPL-10-7-142	trace	MR	1.6	20	MR	8	Trace	MR	1.6
19	20BWNL	BW173353	KU19BWPL-1-4-88	trace	MR	1.6	5	MR	3	5	MR	2
20	20BWNL	BW173366	KU19BWPL-22-3-66	10	MSMR	6	20	MSMR	12	15	MRMS	9
21	20BWNL	BW173378	KU19BWPL-17-3-61	trace	MR	1.6	20	MR	8	15	MR	6
22	20BWNL	BW174116	KU19BWPL-3-4-86	10	MS	8	20	MR	8	20	MRMS	12
23	20BWNL	BW182052	KU19BWPL-15-3-59	trace	MR	1.6	10	MR	4	Trace	MR	1.6
24	20BWNL	ETBW 9077	KU19BWPL-16-2-29	0	0	0	Trace	MR	1.6	Trace	MR	1.6
25	20BWNL	EBW192343	KU19BWElite---29	trace	MR	1.6	5	MR	2	Trace	MR	1.6
26	20BWPE	BW182111	KU19BWOE-4-20-61	10	MR	4	20	MR	8	10	MR	4
27	20BWPE	BW182463	KU19BWOE-7-3-123	0	0	0	Trace	MR	1.6	Trace	MR	1.6
28	20BWPE	BW184200	KU19BWOE-3-20-60	5	MR	2	Trace	MR	1.6	Trace	MR	1.6
29	20BWPE	BWKU13058	KU19BWOE-2-20-21	trace	MR	1.6	5	MR	2	Trace	MR	1.6
30	20BWPE	BWKU13072	KU19BWOE-1-11-11	0	0	0	5	MR	2	Trace	MR	1.6
31	20BWPE	BWKU13075	KU19BWOE-7-4-124	0	0	0	5	MR	2	Trace	MR	1.6
32	20BWPE	BWKU13105	KU19BWOE-1-13-13	20	MSMR	12	10	MSMR	6	10	MR	4
33	20BWPE	BWKU13171	KU19BWOE-5-6-86	0	0	0	10	MR	4	Trace	MR	1.6
34	20BWPE	BWKU13206	KU19BWOE-4-2-79	10	MR	4	20	MR	8	10	MR	4
35	20BWPE	BWKU13207	KU19BWOE-6-3-118	trace	MR	1.6	5	MR	2	10	MR	4
36	20BWPE	BWKU13208	KU19BWOE-2-15-26	15	MR	6	20	MRMS	12	10	MR	4
37	20BWPE	EBW192020	KU19BW8SATYN-7-3-21	trace	MR	1.6	10	MR	4	5	MR	2
38	20BWPE	EBW192920	MK19BW17HTWYT-3-7-27	trace	MR	1.6	20	MRMS	12	20	MRMS	12
39	20BWPL	BW182005	KU19BWOL-8-21-268	20	MSMR	12	10	MR	4	Trace	MR	1.6
40	20BWPL	BW182767	KU19BWOL-6-3-214	0	0	0	10	MR	4	5	MR	2
41	20BWPL	BW184019	KU19BWOL-8-2-287	10	MR	4	10	MR	4	5	MR	2
42	20BWPL	BWKU13258	KU19BWOL-8-27-262	trace	MR	1.6	20	MRMS	12	Trace	MR	1.6
43	20BWPL	EBW192858	KU19BW39ESWYT-2-9-12	trace	MR	1.6	20	MR	8	10	MR	4
44	20BWPL	EBW192022	KU19BW1CWYT-5-2-42	5	MR	2	10	MR	4	5	MR	2
45	20BWPL	EBW192345	KU19BWElite-2-18-31	trace	MR	1.6	Tace	MR	1.6	5	MR	2
46	20BWPL	EBW192346	KU19BWElite-2-17-32	trace	MR	1.6	5	MR	2	Trace	MR	1.6
47	20BWPL	EBW192347	KU19BWElite-2-16-33	trace	MR	1.6	10	MR	4	Trace	MR	1.6
48	20BWPL	EBW192434	KU19BWElite-5-24-120	10	MSMR	6	20	MSMR	12	10	MR	4
49	20BWPL	EBW194030	KU19BW19ESBWYT-2-8-13	20	MS	16	10	MS	8	10	S	10
50	20BWPL	EBW194086	KU19BW19ESBWYT-3-10-30	10	MSMR	6	25	MSMR	15	10	MR	4
		Morocco		90	S	90	90	S	90	90	S	90

Final Rust Severity (FRS), Coefficient of Infection (CI), Moderately Resistance (MR), Moderately Susceptible (MS), moderately Resistant to Moderately Susceptible (MRMS)

3.3. Area under Disease Progress Curve (AUDPC) and Relative Area Under Disease Progress Curve (rAUDPC)

Disease progress curve is a better indicator of disease expression over time [11]. Therefore, selection of genotypes having lower rAUDPC values is acceptable for practical purposes. The tested wheat genotypes were categorized into three distinct groups for slow rusting resistance, based on the rAUDPC values. Wheat genotypes exhibiting rAUDPC values up to 11% of the check were grouped as having high level of partial resistance, consisted of 27, 133, 53 wheat genotypes, while those having rAUDPC values to 30% of the check were grouped as moderately resistant genotypes included 87, 158 and 138 genotypes at Meraro, Kulumsa and Bekoji experimental stations respectively (Figure 4). Of the wheat genotypes under group resistant over location were 166 genotypes exhibiting low disease pressure and high level of partial resistance to yellow rust showed R to MR and 130 showed MRMS types of infection in the field. According to Genotypes which had MS infection type may be carrying durable resistance genes, such as slow rusting resistance [14, 25, 26, and 27]. These wheat genotypes first shown rust infection and sporulation but the final host reaction was characterized as chlorotic and necrotic lesions. Subsequently, the disease progression remained slower and highly retarded among these genotypes. Such partially resistant lines could highly delay evolution of new virulent races of the pathogen because multiple point mutations are extremely rare in normal circumstances [28-30]. Likewise, despite the MS infection type exhibited on moderately slow rusting genotypes, rust developed slowly as indicated by their AUDPC values. Other researchers have also reported variation among different wheat lines for slow rusting resistance using AUDPC [23, 24].

Table 2. *AUDPC and rAUDPC values of the selected bread wheat germ-plasms at three Experimental stations.*

S/N	Source Trial	Genotype	Seed source	Kulumsa		Meraro		Bekoji	
				AUDPC	rAUDPC	AUDPC	rAUDPC	AUDPC	rAUDPC
1	20BWNE	BW172619	KU19BWPE-2-9-146	84	3.870968	420	13.63636	280	14.28571
2	20BWNE	BW172620	KU19BWPE-13-2-24	280	12.90323	413	13.40909	280	14.28571
3	20BWNE	BW172709	KU19BWPE-4-1-4	154	7.096774	385	12.5	280	14.28571
4	20BWNE	BW172831	KU19BWPE-5-10-176	112	5.16129	308	10	133	6.785714
5	20BWNE	ETBW9396	KU19BWPE-10-3-46	175	8.064516	595	19.31818	308	15.71429
6	20BWNE	EBW192353	KU19BWElite---39	168	7.741935	378	12.27273	140	7.142857
7	20BWNE	EBW192370	KU19BWElite---56	84	3.870968	658	21.36364	140	7.142857
8	20BWNE	EBW192371	KU19BWElite---57	112	5.16129	455	14.77273	140	7.142857
9	20BWNE	EBW192375	KU19BWElite---61	112	5.16129	588	19.09091	175	8.928571
10	20BWNE	EBW192377	KU19BWElite---63	112	5.16129	588	19.09091	140	7.142857
11	20BWNE	EBW192380	KU19BWElite---66	112	5.16129	518	16.81818	280	14.28571
12	20BWNE	EBW192382	KU19BWElite---68	112	5.16129	385	12.5	140	7.142857
13	20BWNL	BW172088	KU19BWPL-11-7-143	112	5.16129	203	6.590909	140	7.142857
14	20BWNL	BW172093	KU19BWPL-9-4-80	35	1.612903	455	14.77273	175	8.928571
15	20BWNL	BW172474	KU19BWPL-18-10-203	280	12.90323	203	6.590909	140	7.142857
16	20BWNL	BW172862	KU19BWPL-6-5-94	273	12.58065	378	12.27273	350	17.85714
17	20BWNL	BW172864	KU19BWPL-19-6-114	28	1.290323	420	13.63636	315	16.07143
18	20BWNL	BW172936	KU19BWPL-10-7-142	112	5.16129	350	11.36364	84	4.285714
19	20BWNL	BW173353	KU19BWPL-1-4-88	28	1.290323	203	6.590909	140	7.142857
20	20BWNL	BW173366	KU19BWPL-22-3-66	154	7.096774	728	23.63636	280	14.28571
21	20BWNL	BW173378	KU19BWPL-17-3-61	112	5.16129	595	19.31818	385	19.64286
22	20BWNL	BW174116	KU19BWPL-3-4-86	175	8.064516	595	19.31818	385	19.64286
23	20BWNL	BW182052	KU19BWPL-15-3-59	28	1.290323	308	10	84	4.285714
24	20BWNL	ETBW 9077	KU19BWPL-16-2-29	0	0	84	2.727273	84	4.285714
25	20BWNL	EBW192343	KU19BWElite---29	28	1.290323	105	3.409091	112	5.714286
26	20BWPE	BW182111	KU19BWOE-4-20-61	238	10.96774	770	25	280	14.28571
27	20BWPE	BW182463	KU19BWOE-7-3-123	0	0	28	0.909091	112	5.714286
28	20BWPE	BW184200	KU19BWOE-3-20-60	105	4.83871	84	2.727273	112	5.714286
29	20BWPE	BWKU13058	KU19BWOE-2-20-21	28	1.290323	35	1.136364	112	5.714286
30	20BWPE	BWKU13072	KU19BWOE-1-11-11	0	0	35	1.136364	84	4.285714
31	20BWPE	BWKU13075	KU19BWOE-7-4-124	0	0	35	1.136364	84	4.285714
32	20BWPE	BWKU13105	KU19BWOE-1-13-13	196	9.032258	238	7.727273	210	10.71429
33	20BWPE	BWKU13171	KU19BWOE-5-6-86	0	0	224	7.272727	28	1.428571
34	20BWPE	BWKU13206	KU19BWOE-4-2-79	210	9.677419	378	12.27273	168	8.571429
35	20BWPE	BWKU13207	KU19BWOE-6-3-118	28	1.290323	203	6.590909	210	10.71429
36	20BWPE	BWKU13208	KU19BWOE-2-15-26	385	17.74194	770	25	245	12.5
37	20BWPE	EBW192020	KU19BW8SATYN-7-3-21	112	5.16129	385	12.5	133	6.785714
38	20BWPE	EBW192920	MK19BW17HTWYT-3-7-27	112	5.16129	525	17.04545	525	26.78571
39	20BWPL	BW182005	KU19BWOL-8-21-268	245	11.29032	385	12.5	28	1.428571
40	20BWPL	BW182767	KU19BWOL-6-3-214	0	0	280	9.090909	105	5.357143
41	20BWPL	BW184019	KU19BWOL-8-2-287	210	9.677419	308	10	133	6.785714
42	20BWPL	BWKU13258	KU19BWOL-8-27-262	112	5.16129	196	6.363636	84	4.285714
43	20BWPL	EBW192858	KU19BW39ESWYT-2-9-12	84	3.870968	735	23.86364	238	12.14286
44	20BWPL	EBW192022	KU19BW1CWYT-5-2-42	140	6.451613	385	12.5	119	6.071429
45	20BWPL	EBW192345	KU19BWElite-2-18-31	84	3.870968	28	0.909091	105	5.357143
46	20BWPL	EBW192346	KU19BWElite-2-17-32	84	3.870968	175	5.681818	112	5.714286
47	20BWPL	EBW192347	KU19BWElite-2-16-33	84	3.870968	210	6.818182	84	4.285714
48	20BWPL	EBW192434	KU19BWElite-5-24-120	245	11.29032	525	17.04545	168	8.571429
49	20BWPL	EBW194030	KU19BW19ESBWYT-2-8-13	315	14.51613	308	10	140	7.142857
50	20BWPL	EBW194086	KU19BW19ESBWYT-3-10-30	245	11.29032	560	18.18182	245	12.5
	Check	Morocco	ICARDA	2170	100	3080	100	1890	100

AUDPC-Area Under Disease Progress Curve, rAUDPC – relative Area under Disease Progress Curv

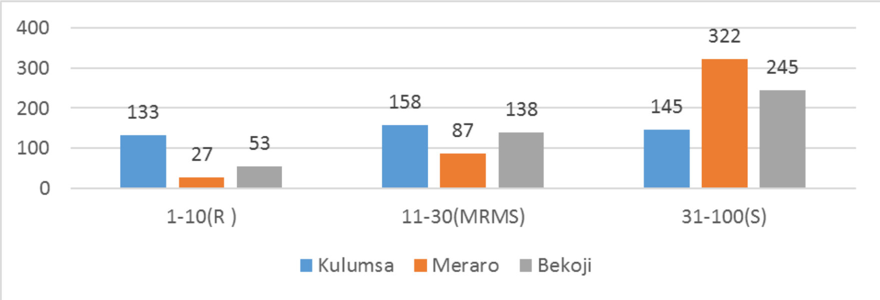

Figure 4. *Level of Partial Resistance of wheat genotypes in relative area under disease progress curve to yellow rust.*

4. Conclusion

The wheat genotypes showed variation in resistance reaction, ranging from immunity to slow rusting resistance. Most of the evaluated genotypes over locations exhibited better performance under high disease pressure shown by susceptible check. The four hundred forty six tested genotypes 114 exhibited lower levels of FRS (< 30% with R-MR responses), coefficient of infection (< 20) and rAUDPC less than 30% indicating a high level of slow rusting resistance.

Forty-five at Meraro and Fifty at Bekoji Bread wheat genotypes that were selected based on overall agronomic performance (Biomass, spike length, number of spikes/m^2, tillering capacity, stalk strength or lodging resistance, shattering resistance and Diseases resistance especially Septoria blotch and yellow rust. Three genotypes were EBW192345, EBW192346 and EBW192347 extraordinarily out performed evaluated materials phenotypically in terms of agronomic performance and diseases resistance at all locations. Hence, these genotypes can be verified across locations and registered as a variety in the coming year if they are already released somewhere in the world. Likewise, all selected materials shall be included under bread wheat national variety Trial (BWNVT) in the coming season. Moreover, these genotypes can also be included in multipurpose crossing blocks in order to improve weakness of commercial varieties.

It is concluded that from the current research that, the slow rusting genotypes identified from this study with better levels of adult plant resistance to be exploited for durable resistance in Ethiopian wheat breeding program. However, further testing for stability over years and locations for yellow rust along with other desirable characters must be made to abate yield losses and to ensure food security before approval.

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References

[1] Chen, X. M. 2005. Epidemiology and control of stripe rust [Puccinia striiformis f. sp. tritici] on wheat. Canadian Journal of Plant Pathology, 27: 314-337.

[2] Alemu Ayele, Getnet Muche, 2019. Yield Loss Assessment in Bread Wheat Varieties Caused by Yellow Rust (Puccinia striiformis f. sp. tritici) in Arsi Highlands of South Eastern Ethiopia. American Journal of BioScience. Vol. 7, No. 6, pp. 104-112. doi: 10.11648/j.ajbio.20190706.14

[3] Feng, J. Y., Wang, M. N., See, D. R., Chao, S. M., Zheng, Y. L. and Chen, X. M. 2018. Characterization of novel gene Yr79 and four additional QTL for all stage and high-temperature adult-plant resistance to stripe rust in spring wheat PI 182103. Phytopathology, 108: 737–747.

[4] Nsabiyera, V., Bariana, H. S., Qureshi, N., Wong, D., Hayden, M. J., and Bansal, U. K. (2018). Characterization and mapping of adult plant stripe rust resistance in wheat accession Aus27284. *Theor. Appl. Genet.* 131, 1–9. doi: 10.1007/s00122-018-3090-x.

[5] Kolmer, J. A., Singh, R. P., Garvin, D. F., Viccars, L. and William, H. M. (2008) Analysis of the Lr 34/Yr18 rust resistance region in wheat germplasm. Crop Science, 48: 1841-1852.

[6] Fahmi, A. I., Nazim, M., Khalifa, S. Z. and ElOrabey, W. M. (2005) Genetics of adult plant resistance to leaf rust in Egyptian wheat. Egyptian Journal of Phytopathology, 33: 1-10.

[7] Wilcoxson RD, Skovmand B, Atif AH (1975). Evaluation of wheat cultivars ability to retard development of stem rust. Annu. Appl. Biol. 80: 275-281

[8] Paterson, R. F., Campbell, A. B. and Hannah, A. E. 1948. A diagrammatic scale for estimating rust intensity on leaves and stems of cereals. Canadian Journal of Research, 26: 496–500.

[9] Pathan, A. K. and Park, R. F. 2006. Evaluation of seedling and adult plant resistance to leaf rust in European wheat cultivars. Euphytica, 149, 327–342.

[10] Van der Plank JE (1963). Plant diseases. Epidemic and Control. Academic Press, New York. pp. 17-27.

[11] Milus, E. A. and Line, R. F. 1986. Gene action for inheritance of durable, high temperature, adult plant resistance to stripe rust in wheat. Phytopathology, 76: 435-441.

[12] Parlevliet, J. E., Van-Ommeren, A. 1975. Partial resistance of barley to leaf rust, Puccinia hordei. II. Relationship between field trials, micro plot tests and latent period. Euphytica 24, 293-303.

[13] Parlevliet, J. E. 1988. Resistance of the Non-Race-Specific Type. In "The Cereal Rusts", Vol. II. Diseases, Distribution, Epidemiology and Control, Academic Press, Orelando. Wageningen Academic Publishers, Wageningen, p 198.

[14] Nzuve FM, Bhavani S, Tusiime G, Njau P, Wanyera R (2012). Evaluation of bread wheat for both seedling and adult plant resistance to stem rust. Afr. J. Plant Sci. 6: 426-432.

[15] Ali S, Jawad S, Shah A, Ibrahim M (2007). Assessment of wheat breeding lines for slow yellow rusting (Puccinia striformis west. tritici). Pak. J. Biol. Sci. 10: 3440-3444.

[16] Li ZF, Xia XC, He ZH, Li X, Zhang LJ, Wang HY, Meng QF, Yang WX, LiG Q, Liu DQ (2010). Seedling and slow rusting resistance to leaf rust in Chinese wheat cultivars. Plant Dis. 94: 45-53.

[17] Tabassum S (2011). Evaluation of advance wheat lines for slow yellow rusting (Puccinia striiformis f. sp. tritici). J. Agric. Sci. 3: 239-249.

[18] Getnet Muche Abebele, Merkuz Abera Admasu, Bekele Hundie Agdu, 2020. Field Evaluation of Bread Wheat (Triticum aestivum L.) Genotypes for Stripe Rust (*Puccinia striiformis* W.) Resistance in Arsi Highlands of Oromia Region, South -Eastern-Ethiopia. J. Plant Pathol Microbiol, Vol. 11 Iss. 10 No: 520.

[19] Safavi, S. A, Ahari, A. B., Afshari, F. and Arzanlou, M. (2010). Slow rusting resistance in 19 promising wheat lines to yellow rust in Ardabil, Iran. Pakistan Journal of Biological Science, 13: 240-244.

[20] Heena Attri and Tuhina Dey., 2021. Screening of Stripe Rust Resistance in Bread Wheat (Triticum aestivum L.) Genotypes. Int. J. Curr. Microbiol. App. Sci. 10 (01): 1236-1244.

[21] Bartos P, Sip V, Chrpova J, Vacke J, Stuchlikova E, Blazkova V, Sarova J, Hanzalova A (2002). Achievements and prospects of wheat breeding for disease resistance. Czech J. Genet. Plant Breed. 38: 16-28.

[22] Ali S, Shah SJA, Khalil IH, Raman H, Maqbool K, Ullah W (2009). Partial resistance to yellow rust in introduced winter wheat germplasm at the north of Pakistan. Aust. J. Crop Sci. 3: 37-43.

[23] Patil VS, Hasabnis SN, Narute TK, Khot GG, Kumbhar CT (2005). Rusting behaviour of some wheat cultivars against leaf rust under artificial epiphytotic conditions. Indian Phytopathol. 58: 221-223.

[24] Draz IS, Abou-Elseoud MS, Kamara AM, Alaa-Eldein OA, El-Bebany AF (2015). Screening of wheat genotypes for leaf rust resistance along with grain yield. Ann. Agric. Sci. 60: 29-39.

[25] Brown WMJ, Hill JP, Velasco VR (2001). Barley yellow rust in North America. Annu. Rev. Phytopathol. 39: 367-384.

[26] Singh RP, Huerta-Espino J, William HM (2005). Genetics and breeding for durable resistance to leaf and stripe rusts in wheat. Turk. J. Agric. For. 29: 121-127.

[27] Kaur J, Bariana HS (2010). Inheritance of adult plant stripe rust resistance in wheat cultivars Kukri and Sunco. J. Plant Pathol. 92: 391-394.

[28] Schafer, J. F., Roelfs, A. P. 1985. Estimated relation between numbers of urediniospores of Puccinia graminis tritici and rates of occurrence of virulence. Phytopath 75, 749-750.

[29] Ali S, Shah SJA, Maqbool K (2008). Field-based assessment of partial resistance to yellow rust in wheat germplasm. J. Agric. Rural Dev. 6: 99-106.

[30] Tsilo TJ, Jin Y, Anderson JA (2010). Identification of Flanking Markers for the Stem Rust Resistance Gene Sr6 in Wheat. Crop Sci. 50: 1967-1970.