Advances in Agricultural Technology & Plant Sciences
ISSN: 2640-6586

Academic Strive
Researcher's perception is our reality

Research Article *Volume 6 Issue 2*

Contribution of Wheat Rust Diseases for Grain Yield Reduction of Bread Wheat Genotypes at Kulumsa

Solomon T*, Zewdu D, Sime B, Asefa B, Geleta N, Dabi A, Alemu G, Delesa A, Zegeye H, Duga R, Tolcha A, Ayele A, Muche G, Negash T, Kasa D, Asnake D, Shewaye Y, Getamesay A and Degefa N

Ethiopian Institute of Agricultural Research (EIAR), Kulumsa Agricultural Research Center, Ethiopia

***Corresponding author:** Tafesse Solomon Bekele, National Wheat Research Program, Ethiopian Institute of Agricultural Research (EIAR), Kulumsa Agricultural Research Center, Asella, Ethiopia, Tel: +251 251911833888; Email: tafessesolomon@ymail.com

Received Date: October 23, 2023; **Published Date:** December 04, 2023

Abstract

In Ethiopia, stem and yellow rust diseases are characterized by recurrent epidemics and cause significant damage to the wheat crop annually. Stem rust is the most devastating fungal disease of wheat which mainly occurs in the low and mid-altitude wheat-producing areas of the country. On the other hand, yellow or strip rust is more challenging for wheat growers in the highland areas. Therefore, the objective of this study was to evaluate the amount of yield reduction due to wheat rust diseases on bread wheat genotypes. Eighteen genotypes were advanced to Multi Environment Trial (MET) from the Elite Spring Wheat Yield Trial (ESWYT) in 2020. Row-column and alpha lattice designs were used for MET and ESWYT with three and two replications, respectively. MET was conducted under diseases control using fungicides, whereas, the ESWYT was conducted without applying any disease control option. The yield of the eighteen genotypes common in ESWYT and MET was recorded, and then the yield reduction was computed. The means grain yield of these genotypes were 4.45 t/ha and 9.38t/ha in the ESWYT and MET, respectively. Grain yield was decreased by 4.93t/ha in ESWYT as compared to MET which is about a 53% yield reduction. Although weather variation had some contributions to the average 53.09 % yield reduction of the eighteen genotypes, the loss in yield was mainly due to the stem rust disease. Thus, it is crucial to manage this rust to increase production and productivity of wheat in the country. Among wheat rust management options, the safest and feasible means is breeding for durable rust resistance. Therefore, wheat research program should work to address the gap by developing high yielding, good quality and diseases resistant variety for wheat producing farmers.

Keywords: Bread Wheat; Genotype; Fungicide; Stem Rust; Yellow Rust

Introduction

Wheat is one of the most important cereal crops in the world. It is the staple food for around 2.8 billion people. Moreover, it is in first place among the crops in delivering more calories and protein in the world's diet [1]. Besides, the unique properties of the gluten protein fraction in wheat make easy to produce bread, biscuits, cakes, cookies, noodles and pasta, and a range of functional ingredients. As a result, it is preferable in many dish.

About 785 million metric tons of wheat produced globally in 2023/2024 [2]. In Ethiopia, wheat production and productivity increased. It covers an area of 1.7 million hectares, with a total production estimated at between 5 and 6 million tons [3]. However, the wheat production affected by complex and interactive effects of biotic, abiotic, and socio-economic factors. Wheat rust diseases, weed, insects are among the main biotic challenges in wheat production in the country [4-7]. Other major abiotic factors, such as lack of access to improved varieties, primordial agronomic practices, use of marginal agricultural land, and drought stress, cause siginificant yield loss [8-11].

Rusts are among the most dominant fungal diseases of wheat worldwide. There are three types of rusts that affect wheat: Leaf, stripe, and stem rust are caused by *Puccinia recondita f. sp. tritici, Puccinia striiformis f. sp. tritici,* and *Puccinia graminis f. sp. tritici,* respectively [12]. In Ethiopia, stem and yellow rusts are more frequently out breaks and cause significant damage on the wheat crop.

Stem rust is the most devastating fungal diseases of wheat. It mainly occurs in the low and mid altitude wheat producing areas. In the year epidemic of this disease in 2013 causes a total crop loss on susceptible bread wheat varieties within weeks [13-15]. Due to stem and yellow rust diseases outbreak, the country losses up to 180 million USD per single cropping season [16].

Yellow or strip rust is more challenge for wheat growers in the highland of the country [17-19]. In 2010, the outbreak of this disease on popular cultivated bread wheat variety causes a serious crop loss [16].

Wheat researchers in Ethiopia have been continuously breeding for disease resistance, wide adaptability and high yield, which resulted in the development and release of many cultivars to farmers. However, most of these cultivars become susceptible and out from production short after released. It is due to more frequent race shifting that causes the resistance gene in money widely adopted bread wheat varieties to break down by these disease and become highly susceptible [20].

The objective of this study was to evaluate the extent of yield reduction due to wheat rust diseases on bread wheat genotypes at early stage of breeding pipelines.

Material and Method

The Study Material and Design

In this study, two different trials were used to compare the genotypes using grain yield and diseases performances. The first trial, 40th Elite Spring Wheat Yield Trial (40thESWYT), had forty nine introduced genotypes from CIMMYT, Mexico and one released bread wheat variety as a check. Thus, a total of fifty genotypes were planted in Alpha Lattice Design with two replications in 2020 cropping season. The replications had five sub-blocks of ten plots in each sub block. The plot had six rows of 1.2m width by 2.5m length. The total area of the plot was 3m2. The second trial, Multi Environment Trial (MET), consisted of eighteen genotypes selected from 40thESWYT, thirty seven genotypes from 20BWelite, and four released bread wheat varieties as checks; a total of sixty genotypes were planted in row column design with two replications during 2021 cropping season.

From 40thESWYT, eighteen genotypes were advanced to MET in 2020 G.C. These genotypes were evaluated along with other genotypes as MET across different locations in 2021G.C. Grain Yield data of the eighteen genotypes was gathered from 40thESWYT and MET, and then reduction of yield was computed.

No	Entry number in 40ESWYT	Genotype name in MET	Pedigree
1	108	EBW202104	SAUAL/3/ACHTAR*3//KANZ/KS85-8-4/4/SAUAL*2/5/ATTILA*2/PBW65//MUU #1/3/FRANCOLIN #1
2	109	EBW202105	MUCUY/3/PBW343*2/KUKUNA*2//FRTL/PIFED/4/MUCUY
3	111	EBW202106	ITP40/AKURI//FRNCLN*2/TECUE #1
4	112	EBW202107	FRNCLN*2/TECUE #1//TRCH/HUIRIVIS #1
5	117	EBW202108	NADI#1*2/3/MUTUS/AKURI #1//MUTUS
6	118	EBW202109	MUCUY//STLN/MUNAL #1/3/MUCUY
7	120	EBW202110	BORL14/FITIS
8	128	EBW202111	FITIS*2//KACHU/KIRITATI
9	130	EBW202112	MUTUS/ROLF07//2*MUCUY

10	131	EBW202113	KACHU #1//WBLL1*2/KUKUNA*2/6/BECARD #1/5/ KIRITATI/4/2*SERI.1B*2/3/KAUZ*2/BOW//KAUZ
11	132	EBW202114	SUP152/BAJ #1*2/3/KACHU//WBLL1*2/BRAMBLING
12	133	EBW202115	MUTUS*2/MUU//2*MUCUY
13	134	EBW202116	MUTUS*2/MUU//2*MUCUY
14	135	EBW202117	MUTUS*2/MUU/6/ATTILA/3*BCN//BAV92/3/ PASTOR/4/TACUPETO F2001*2/BRAMBLING/5/ PAURAQ/7/MUCUY
15	140	EBW202118	KACHU/DANPHE//BORL14
16	142	EBW202119	SWSR22T.B./2*BLOUK #1//WBLL1*2/KURUKU/3/ BORL14
17	146	EBW202120	CHIPAK*2//SUP152/KENYA SUNBIRD
18	150	EBW202121	KACHU*2/3/ND643//2*PRL/2*PASTOR/4/2*KACHU/ DANPHE

Table 1: List and Pedigree of Eighteen Genotypes Selected in 2020 from 40thESWYT and Advanced to MET.

Description of the Study Area

Kulumsa Agricultural Research Center (KARC) is regional center of excellence and national coordination center for wheat and is found in Ethiopian Institute of Agricultural Research (EIAR). KARC represents an optimum area for wheat production based in Arsi zone, Oromia region and wheat belt areas of the country. KARC is located at 8°02′N 39°10′E latitude and longitude with an Altitude of 2200m.a.s.l. The mean minimum and maximum temperatures are 10.7°C and 26.4°C in 2020G.C. and 10°C and 22°C in 2021G.C. respectively. The mean annual rainfall at Kulumsa was about 1048mm in 2020G.C. and 700mm in 2021G.C (Table 2).

	2020G.C.				2021G.C.			
Month	**Rainfall**	**TMAX**	**TMIN**	**RH**	**Rainfall**	**TMAX**	**TMIN**	**RH**
January	8.8	23.6	11.2	57.5	0	23.9	9.3	36.9
February	3.9	25.5	11.2	58.4	5.6	24.6	11.3	42.6
March	68.4	26.4	13.4	57.4	0.4	26.8	12.3	27.1
April	104.6	26.2	12.9	53.1	70.3	26.4	13.4	44.6
May	145.1	24.9	12.9	60.9	0	24.8	12.5	56.4
June	123.7	23.8	13	68.1	59.9	24.8	12	57.2
July	251.4	21.2	13	78.4	170.6	20.6	13	78.5
August	143.5	21.2	13.1	76.5	131.9	21.3	12.6	79.2
September	130.8	22	12.2	74	191.2	20.9	11.9	77.6
October	64	24	12.8	44.4	64.3	22.8	12.6	65.6
November	1	23.5	12.6	43.7	6	23.6	11.4	61.1
December	3.2	23	10.7	44.2	0	23.3	9.3	60.5
MEAN	1048	26.4	10.7		700	22	10	

Table 2: Weather Data of Kulumsa in 2020 G.C. and in 2021G.C.

Data Collection and Analysis

All data were taken electronically from the field and laboratory using a field scorer. Stem rust disease, yellow rust disease, days to heading, days to maturity and plant height were recorded on the field whereas yield, thousand kernel weight and hectoliter weight were collected in the laboratory for 40thESWYT and all the above data except stem rust and yellow rust were recorded for MET, which was conducted in order to evaluate the yield potential of the genotypes under disease control by using effective fungicide at appropriate rate, time and frequency. Hence, for MET, fungicides were sprayed three times in order to totally control the wheat rust diseases.

For scoring yellow rust and stem rust modified cobb scale was used [21,22]. The modified cobb scale is a combination of numbers and letters, where the number stands for the severity percent of the disease and the letter stands for the reaction of the host.
Severity =percentage of rust infection on the plant
For the present trials, scoring used for wheat rust diseases severity are: 1= trace, 5%, 10%, and multiple of 5 up to 100%

Reaction = field response/host response
The letters used to score the rust reaction are: 0= no visible infection on the plant; R= resistance: visible chlorosis or necrosis with the absence of uredia
MR= moderately resistance: small uredia are present and surrounded by either chlorotic or necrotic area
M= Intermediate: variable sized uredia are present some with chlorotic, necrosis, or both
MS= moderately susceptible: Medium size uredia are present and possible surrounded by chlorotic areas
S= Susceptible: Large uredia present, generally with little or no chlorosis and no necrosis
Genotypic and phenotypic correlations between wheat rust diseases and yield were computed for 40thESWYT to see the association using a method suggested by Fehr WR & Singh RK [23,24].

$$rg = \frac{g\,\text{cov}\,x-y}{d\sqrt{\delta^2 gx\delta^2 gy}} \text{ and } rp = \frac{p\,\text{cov}-\text{y}}{d\sqrt{\delta^2 px\delta^2 py}} \text{ Where;}$$

rg and rp are genotypic and phenotypic correlation coefficients, respectively;
gcov x-y and pcovx -y are genotypic and phenotypic covariances between variables x and y, respectively;
δ2gx and δ2px are genotypic and phenotypic variances, respectively, for variable x;
δ2gy and δ2py are genotypic and phenotypic variances, respectively, for variable y;

Results and Discussion

The main objective of crossing in wheat breeding is to generate variation among the population in the breeding pipeline. The higher genetic variation among the genotypes means a higher probability of developing and releasing potential varieties for growers [13,14]. Results from the analysis of variance showed that high significant variation existed among tested genotypes in grain yield (P<0.001) (Table 3). Thus, the best genotypes for grain yield were selected and advanced to the next stage of breeding pipelines. The eighteen genotypes in the study were among selected genotypes from 40ESWYT.

Source of variation	DF	SS	MS	F-value	Pr(>F)
Rep	1	5.62	5.617	1.83E-05	***
Genotype	49	106.25	2.168	5.57E-09	***
Sub-block	8	6.29	0.787	0.033793	*
Residuals	41	13.61	0.332		

Sign: 0 ‘***’, 0.001 ‘**’, 0.01 ‘*’, 0.05 ‘

Table 3: Analysis of Variance (ANOVA) for Grain yield of Fifty Genotypes Tested in ESWYT trial.

The stem and yellow rusts are the main biotic production constraints to wheat production in Ethiopia. Stem rust occurs when uredial (pustules) are developed on stems and leaf sheaths. Occasionally, they may occur on awns, glumes and seeds. The spots form on both upper and lower leaf surfaces. Yellow rust disease pustules mainly occur on leaves. They rarely exist on glumes and awns. Sever infection of stem rust weakened, broke the stem, caused entire lodging and even total crop loss [25]. The grains become shriveled and prematurely forced to ripe. Several studies have shown that grain yield, TKW, and HLW were the main economic and quality traits that were mainly affected by wheat rusts [26-30]. Stem and yellow rust diseases were the most damaging wheat production constraints mainly due to narrow genetic bases of varieties in use, rusts capacity to produce a large number of spores, mono-cropping, ineffective crop production practices, inflation, political instability, high population growth, frequent evolvement of new virulent and more aggressive races and their long distances migration into new regions or zones on top of climate changes [31].

Result from the present study revealed very highly negative genotypic correlation between yield and stem rust r=-0.419**(P<0.01), yield and yellow rust r=-0.749***(P<0.001). Likely, negative, very high phenotypic correlation obtained between yield and stem rust r=-0.600***(p<0.001), as well as yield and yellow rust r=-0.309** (p<0.01) indicating highly significant yield reduction in bread wheat due to rusts infection. Thus, integrated rusts management options shall be adopted and practiced in order to produce profitable wheat and become self-sufficient. Similar results were reported by Nzuve FM, et al. [31,32].

The two rust diseases were also associated with core quality traits namely Thousand Kernel Weight (TKW) and Hectoliter Weight (HLW). Yellow rust disease was negatively associated with TKW and HLW. The genotypic correlations were highly significant with r= -0.454*** between yellow rust coefficient of infection (YRCI) and TKW; and r=-0.627*** between yellow rust coefficient of infection (YRCI) and HLW. Similarly, the phenotypic correlations were highly significant with r= -0.454*** between Yellow Rust Coefficient of Infection (YRCI) and TKW; and r=-0.627*** between Yellow Rust Coefficient of Infection (YRCI) and HLW (Table 3).

The Stem Rust Coefficient of Infection (SRCI) was associated with TKW and HLW. For these traits, highly significant negative genotypic correlations were obtained with r= -0.402** between SRCI and TKW, and r= -0.505*** between SRCI and HLW. Also, highly significant phenotypic correlations gain with r=-0.315*between SRCI and TKW, and r= -0.482***between SRCI and HLW (Table 4) were recorded. In general, the result from the experiment showed that, the stem rust and the yellow rust diseases significantly affected yield, TKW, and HLW of bread wheat genotypes. Most of the levels of significance were very high. Indicating that loss due to these diseases was very high.

Traits	DTH	DTM	PHT	YRCI	SRCI	TKW	HLW	YLD
DTH		0.211ns	0.276ns	-0.177ns	-148ns	-0.142ns	0.040ns	-0.043ns
DTM	0.373**		0.077ns	-0.355*	-0.186ns	0.244ns	0.162ns	0.226ns
PHT	0.332*	-0.145ns		-0.210ns	0.064ns	0.039ns	0.159ns	0.146ns
YRCI	-0.213ns	-0.658***	-0.499***		0.184ns	-0.384**	-0.584***	-0.600***
SRCI	-0.263	-0.548***	-0.102ns	0.189ns		-0.315*	-0.482***	-0.309**
TKW	-0.155ns	0.574***	0.117ns	-0.454***	-0.402**		0.795***	0.784***
HLW	0.076ns	0.329*	0.349*	-0.627***	-0.505***	0.986***		0.809***
YLD	-0.009ns	0.292*	0.105ns	-0.749***	-0.419**	1.000***	0.875***	

Sign: 0 '***', 0.001 '**', 0.01 '*', 0.05 '

Table 4: Estimate of Genotypic Correlation Coefficient (Above Diagonal) and Phenotypic Correlation Coefficient (Below Diagonal) in Fifty Bread Wheat Genotypes.

Severity percentage and field responses for bread wheat genotypes evaluated in 40thESWYT showed that some of the genotypes were highly susceptible to yellow and stem rust diseases (Table 4). A few genotypes revealed resistance to moderately resistance to yellow rust and stem rust diseases. Some of genotypes showed resistance to moderately resistance for one of the two diseases. The highest yellow rust disease score ≥30S was recorded for entry numbers 105, 106, 113, 115,138, 141, 147, 148, and 149, indicating their susceptibility to yellow rust. On the other hand, 36 tested genotypes (72%) exhibited resistance to moderately resistance reactions and less than or equal to 10 severity percent to yellow rust. Fifty two percent of the tested genotypes (26 genotypes) with entry number 101, 103, 104, 105, 107, 110, 114, 116, 119, 121, 122, 123, 124, 125, 126, 127, 130, 136, 137, 138, 139, 143, 144, 145, 147, and 148 had score of ≥30S considering stem rust and, therefore, these genotypes were highly susceptible to stem rust diseases (Table 5). On the other hand, thirty four percent (17 genotypes) showed moderately susceptible reaction to stem rust with severity percent less than or equal to 15. Considering both diseases 15 genotypes (102, 108, 109, 111, 112, 117, 118, 128, 130, 131, 132, 133, 134, 135 and 150) showed relatively resistance reaction with low severity percent. Thus, these genotypes were promising to be promoted to yield trial. Genotypes that produced very high grain yield (>6t ha^{-1}) with good quality seed, by tolerating these diseases, shall be re-evaluated in order to double check the reputability of their agronomic and quality performances. Similarly, Delesa, et al. [33] identified 12 promising and relatively rusts resistant bread wheat genotypes by evaluating 25 genotypes in nine environments in Ethiopia.

Entry	DTH	DTM	PHT	TKW	HLW	YLD	YR	SR
101	71.5	120	98	29	66.82	4.05	1MR	60S
102	74	124	88	26	66.55	3.91	0	15MSS
103	70	121.5	95	33	65.68	3.24	15MSMR	70S
104	71	123	91	33	69.65	4.27	20MSMR	60S
105	68	120	95	29	67.45	3.46	60S	50S
106	74	123	97	27	66.07	3.45	30S	20MSS
107	74	124	96	32	68.73	4.8	1MR	30S
108	72.5	124	93	39	71.44	4.31	0	10MSS
109	72.5	124	98	34	67.05	5.01	0	15S
110	72.5	121	87	29	67.25	3.93	10MR	30S
111	72.5	122.5	97	27	65.13	3.75	1MR	10MSS
112	70	122.5	88	27	63.65	3.54	0	5MS
113	70.5	119	90	32	67	2.84	70S	10MSS
114	70.5	123	97	41	72.29	6.67	5MR	30S
115	72	119.5	90	26	59.97	2.57	70S	15MSS
116	71.5	119	87	27	60.7	3.45	20MRMS	50S
117	70.5	119	94	34	66.7	4.29	5MR	15S
118	71	125.5	86	31	63.97	4.14	0	15MSS
119	70	123	88	44	72.85	6.99	1MR	40S
120	74	123	101	40	73	6.01	1MR	20S
121	73	123	100	28	62.55	4.01	1MR	60S
122	73.5	123	101	26	61.91	3.31	10MRMS	60S
123	72.5	126	99	28	66.72	3.65	1MR	40S
124	74	125	99	32	65.27	3.72	1MR	40S
125	74	121.5	88	30	67.96	5.02	1MR	40S
126	73.5	123	97	33	67.55	4.32	1MR	50S
127	74	122	98	34	70.67	4.35	5MR	30S
128	73	122.5	93	31	70.61	5.39	5MR	10MSS
129	73	123	97	41	74.61	6.26	5MR	30S
130	73	124	90	35	68.86	4.96	0	15MSS
131	73.5	123	97	38	71.22	3.89	5MR	10MSS
132	73.5	123	97	35	69.56	4.53	0	10MSS
133	72.5	123	95	34	69.21	4.25	1MR	15MSS
134	72.5	123.5	90	33	70.83	4.37	1MR	10MSS
135	72	123	96	34	71.85	4.35	1MR	10MSS
136	72.5	121	99	25	64.77	3.15	5MR	50S
137	69	119	94	28	66.72	3.86	15MSMR	50S
138	71.5	119	89	18	48.38	1.01	80S	80S

139	72.5	120	89	26	68.06	3.28	1MR	30S
140	73.5	123	93	33	66.66	4.21	20MRMS	10MSS
141	73.5	120	89	34	67.54	3.46	40S	15MSS
142	74	112	100	27	70.44	4.73	1MR	20MSS
143	67	121	89	42	72.27	5.06	1MR	40S
144	72.5	121.5	101	36	70.99	4.45	5MR	40S
145	69.5	120.5	93	44	71.13	5.2	5MR	30S
146	74	123	88	40	70.87	4.85	1MR	20S
147	74	120.5	93	27	62.87	2.58	50S	30S
148	74	123	96	32	67.96	4.17	40S	20S
149	73.5	121	90	37	72.77	3.92	30MSS	40S
150	73.5	123	90	30	67.59	3.52	1MR	15MSS
Mean	72.29	121.93	93.72	32.22	67.61	4.17		
LSD	1.35	3.06	6.29	7.3	3.39	1.12		
CV	0.9	1.9	4.72	13.3	2.59	13.8		

DTH= Days to heading; DTM; Days to maturity; PHT= plat height in centimeter CM; TKW= Thousand kernel weight in gram; HLW= Hectoliter weight in kilogram per hectoliter weight; YLD=yield in tone per hectare; YR= Yellow rust severity percent with field response; SR= Stem rust severity percent with field response; LSD=Least significant difference; CV=Coefficient of variation Legend?

Table 5: Wheat Rust Diseases Scores and Important Agronomic Traits of 40thESBWYT.

The mean grain yield of the eighteen genotypes were 4.45 t/ha and 9.38t/ha in 40th ESBWYT and MET, respectively, indicating that it was decreased by 4.93 t/ha in 40thESWYT as compared to that of MET, which is about 53% of yield reduction. The highest reduction, 61.2%, was recorded for EBW202118 genotype; yield loss was from 10.85 t/ha in MET to 4.21 t/ha in 40ESWYT for this genotype. The highest yellow rust disease severity recoded for this genotypes besides the moderately susceptible to susceptible reaction for stem rust disease (Table 5). On the other hand, the lowest yield reduction, 42.2 %, was recorded for EBW202112 genotype with the yield decreased from 8.59 t/ha to 4.96 t/ha. This genotype showed completely immune for yellow rust Generally, out of the eighteen genotypes, twelve genotypes showed yield loss by more than 50% which showed that this reduction was as result of Rust diseases influence on the evaluated genotypes.

In comparison to stem rust, yellow rust of the eighteen genotypes under this study was zero to moderately resistance except one genotype, EBW202118, which had both moderately resistance and moderately susceptible reactions. And also, the severity recorded for this rust was less than or equal to five, except for EBW202118 genotype, which was 20. Therefore, due to strong response from the genotypes for yellow rust, the disease was unable to reduce the yield significantly.

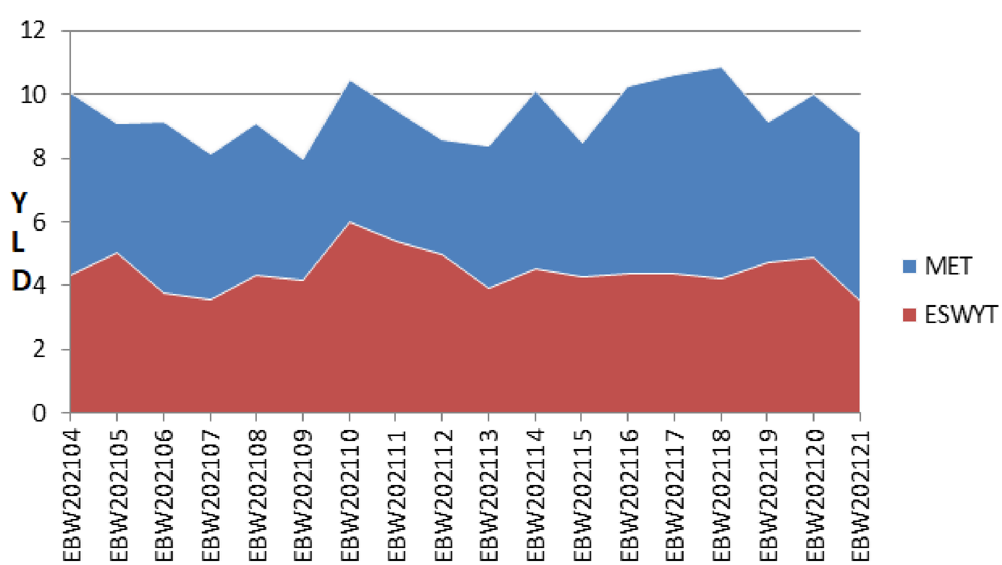
But, all the genotypes showed moderately susceptible to susceptible reactions to stem rust diseases, where most had both reactions. Thus, the severities of the disease were 5 in one genotype, 10 in eight genotypes, 15 in six genotypes, and 20 in three genotypes (Table 6). Thus, the reduction in the genotypes was due to the susceptibility of the genotypes to stem rust disease. Similarly, weather variation had some contribution to the average 53.09 % yield reduction of the eighteen genotypes; the yield loss was mainly due to the stem rust disease. Stem rust is the most destructive wheat rust disease that can cause up to 100% yield loss in susceptible genotypes/variety [13,15].

The area chart visualize the gap between the actual yield potential of the genotypes and the reduction in yield mainly due to stem rust diseases (Graph 1). The yield potential under rust diseases control trial was very incredible which was almost three fold of the national average yield of the country, 3.03 t/ha, [34]. So, wheat rust diseases are the most constraints in wheat productivity and production in the study areas [35-37].

Entry	Genotype	YLDMET	YLDESWYT	Difference	Reduction in %	YR ESWYT	SRESWYT
108	EBW202104	10.08	4.31	5.77	57.24	0	10MSS
109	EBW202105	9.12	5.01	4.11	45.07	0	15S
111	EBW202106	9.13	3.75	5.38	58.93	1MR	10MSS
112	EBW202107	8.14	3.54	4.6	56.51	0	5MS
117	EBW202108	9.1	4.29	4.81	52.86	5MR	15S
118	EBW202109	7.99	4.14	3.85	48.19	0	15MSS
120	EBW202110	10.48	6.01	4.47	42.65	1MR	20S
128	EBW202111	9.53	5.39	4.14	43.44	5MR	10MSS
130	EBW202112	8.59	4.96	3.63	42.26	0	15MSS
131	EBW202113	8.37	3.89	4.48	53.52	5MR	10MSS
132	EBW202114	10.12	4.53	5.59	55.24	0	10MSS
133	EBW202115	8.5	4.25	4.25	50	1MR	15MSS
134	EBW202116	10.26	4.37	5.89	57.41	1MR	10MSS
135	EBW202117	10.64	4.35	6.29	59.12	1MR	10MSS
140	EBW202118	10.85	4.21	6.64	61.2	20MRMS	10MSS
142	EBW202119	9.14	4.73	4.41	48.25	1MR	20MSS
146	EBW202120	10.02	4.85	5.17	51.6	1MR	20S
150	EBW202121	8.8	3.52	5.28	60	1MR	15MSS
	Mean	9.38	4.45	4.93	53.09		

YLDMET= Yield in MET in t/ha; YLDESWYT= Yield in 40thESWYT in t/ha; YRESWYT= Yellow rust score in 40thESWYT; SRESWYT= Stem rust score in 40thESWYT, MET= Multi Environment Trial; ESWYT= Elite Spring Wheat Yield Trial Legend

Table 6: Grain Yield of Eighteen Bread Wheat Genotypes Common in 40ESWYT and MET Trials.



MET= Multi Environmental Trial; ESWYT= Elite Spring Wheat Yield Trial; YLD= yield; EBW+numbers= Genotypes

Graph 1: Graphical presentation of yield differences among eighteen bread wheat genotypes in common for 40thESWYT and MET

Conclusion

Genotypes such as EBW202104, EBW202110, EBW202114, EBW202116, EBW202117, EBW202118, and EBW202120 delivered grain yield of more than 10 t ha-1 under wheat rust diseases control practice by using effective fungicides at appropriate rate, time and frequencies. The present studies revealed the damaging impact of stem and yellow rusts in wheat productivity and production and, these studies also indicated the existence of high potential for increasing productivity and production of bread wheat in the country. Environmentally safest and economically feasible wheat rusts management option is breeding for durable rust resistance. Therefore, the wheat research program needs to address the gap by developing high yielding, good quality and diseases resistant varieties as well as integrated and effective managerial options for wheat farmers in the country.

Conflict of Interest

The authors have declared no conflict of interest exist

Acknowledgment

Authors would like to gratefully acknowledge The Ethiopian Institute of Agricultural Research (EIAR), Accelerating Genetic Gain in Wheat (AGGW) Project for the financial support. Besides, we gratefully acknowledge CIMMYT for providing us the germplasm and Kulumsa Agricultural Research Center for hosting the trial.

References

1. Erenstein O, Jaleta M, Mottaleb KA, Sonder K, Donovan J, et al. (2022) Global Trends in Wheat Production, Consumption and Trade. In: Reynolds MP, Braun HJ (Eds.) Wheat Improvement. Springer, Cham.

2. Shahbandeh M (2024) Wheat: production volume worldwide1990/1991-2023/2024. Statista.

3. Effa K, Fana DM, Nigussie M, Geleti D, Abebe N, et al.(2023) The irrigated wheat initiative of Ethiopia: a new paradigm emulating Asia's green revolution in Africa. Environment, Development and Sustainability.

4. Dawit D, Sharma JJ, Tamado T (2014) Evaluation of Herbicides and Their Combinations for Weed Management in Bread Wheat (*TriticumAestivum L.*) In Southern Ethiopia. International Journal of Novel Research in Life Sciences 1(1): 31-47.

5. Amare T, Sharma JJ, Zewdie K (2014) Effect of weed control methods on weeds and wheat (*Triticumaestivum L.*) yield. World journal of agricultural research 1(2): 124-128.

6. Nigus M, Shimelis H, Mathew I, Abady S (2022) Wheat production in the highlands of Eastern Ethiopia: opportunities, challenges and coping strategies of rust diseases. acta agriculturae scandinavica, section b-soil & plant science 72(1): 563-575.

7. Tadesse W, Zegeye H, Debele T, Kassa D, Shiferaw W, et al. (2022) Wheat Production and Breeding in Ethiopia:Retrospect and Prospects. Crop Breed Genet Genom 4(3): e220003.

8. Yami M, Fufa F, Fita T, Usman S (2012) Prospects and challenges of wheat production in Ethiopia: evidence from major wheat producing regions of the country. wheat for food security in Africa. Addis Ababa, Ethiopia, pp: 49-51.

9. Belay T, Araya A (2015) Grain and biomass yield reduction due to Russian wheat aphid on bread wheat in northern Ethiopia. Africa Crop Society Journal 23(2): 197–202.

10. Hei N, Shimelis HL, Laing M (2017) Appraisal of farmers' wheat production constraints and breeding priorities in rust-prone agro-ecologies of Ethiopia. Africa Journal of Agricultural Research 12(2): 944-952.

11. Semahegn Y, Shimelis H, Laing M, Mathew I (2021) Farmers' preferred traits and perceived production constraints of bread wheat under drought-prone agro-ecologies of Ethiopia. Agric& Food Secur 10(18): 1-13.

12. Crop Science (2022) Wheat Rust Diseases. Bayer Global.

13. Sanders R (2011) Strategies to reduce the emerging wheat stripe rust disease. International wheat stripe rust symposium. Aleppo.

14. Hodson D (2016) Building Plant Pathogen Surveillance Networks in Sub Saharan Africa. AAAS 2016 Annual Meeting, Washington DC.

15. Hailu A, Woldeab G, Dawit W, Hailu E (2015) Distribution of wheat stem rust (PucciniaGraminis F. Sp. Tritici) in West and Southwest Shewa Zones and identification of its physiological races. Advances in Crop Science and Technology 3(4): 189.

16. Meyer M, Bacha N, Tesfaye T, Alemayehu Y, Abera E, et al. (2021) Wheat rust epidemics damage Ethiopian wheat production: A decade of field disease surveillance reveals national-scale trends in past outbreaks. PLoSONE 16(2): e0245697.

17. WorkuAbebeb (2020) Wheat Yellow Rust Disease Management: A Review. International Journal of Novel Research in Life Sciences 7(2): 35-69.

18. Tilahun B (2018) Identification of Slow Rusting Resistance to Yellow Rust (*Pucciniastriiformisf.sp. tritici*) inBread Wheat (*Triticumaestivum l.*)Genotypes and Association of Yield and Disease Parameters in SoutheasternEthiopia. Msc Thesis, Haramaya University.

19. Alemu SK, Badebo A, Tesfaye K, Uauy C (2019) Identification of Stripe Rust Resistance in Ethiopian DurumWheat by Phenotypic Screening and Kompetitive Allele Specific PCR (KASP) SNP Markers. Plant Pathol Microbiol 10(8): 483.

20. Beyene BE (2018) Status and challenges of wheat stem rust (PucciniaGraminisF.Sp. Tritici) and threats of new races in Ethiopia. International Journal of Forestry and Horticulture 4(4): 22-31.

21. Rennie SJ (1985) The modified Cobb scale for estimating bean rust intensity.

22. Peterson RF, Campbell AG, Hannah AE (1948) A diagrammatic scale for estimating rust intensity on leaves and stems of cereals. Can J Res 26c(5): 496-500.

23. Fehr WR (1993) Principles of cultivar development. Theory and technique. Vol: 1, Macmillan Publishing Co, USA.

24. Singh RK, Chaudhary BD (1985) Biometrical methods in quantitative genetic analysis. Kalyani Publishers, New Delhi, India, pp: 318.

25. Vidal J (2009) Airborne fungus Ug99 threatens global wheat harvest. Infinite Unknown.

26. Dimmock JPRE, Gooding MJ (2002) The influence of foliar diseases, and their control by fungicides, on the protein concentration in wheat grain: a review. The Journal of Agricultural Science 138(4): 349-366.

27. Andualem MM, Abera MA, Bacha NH (2019) Sources of Resistance to Stem Rust (Puccinia graminis f. sp. tritici) in Improved Durum Wheat (Triticum turgidum L.) Varieties of Ethiopia. Current Research in Agricultural Sciences 6(2): 141-156.

28. Grow further (2022) Keeping Ethiopia's Wheat from "Rusting". Grow further.

29. Ashenafi Gemechu Degete (2021) Losses Caused by Stem Rust (Pucciniagraminisf.sp. tritici) on Durum Wheat in Ethiopia. American Journal of Biological and Environmental Statistics 7(4): 104-110.

30. Afzal A, Syed S, Saeed M, Sultan R, Kanwal M, et al. (2022) Breeding Wheat for Rust Resistance: Conventional and Modern Approaches. Plant Protection 6(3): 285-298.

31. 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. African Journal of Plant Science 6(15): 426-432.

32. Solomon T (2022) Effect of Wheat Rust Diseases on Grain Yield and Yield Components of Bread Wheat Genotypes at Low to Mid Altitude inEthiopia. Science Development 3(3): 98-103.

33. Delesa A, Dabi A, Alemu G, Geleta N, Solomon T, et al. (2023) Stability and Performance Evaluation of Advanced Bread Wheat (Triticum aestivum L.) Genotypes in Low to Mid Altitude Areas of Ethiopia. International Journal of Bio-resource and Stress Management 14(1): 19-32.

34. Senbeta AF, Worku W (2023) Ethiopia's wheat production pathways to self-sufficiency through land area expansion, irrigation advance, and yield gap closure. Heliyon 9(10): e20720.

35. Anteneh A, Asrat D (2020) Wheat production and marketing in Ethiopia: Review study. Cogent Food & Agriculture 6(1): 1-14.

36. Kumar A, Kumar J, Gaurav SS (2020) Genetic Variation, Heritability and Diversity Analysis in Wheat Genotypes Based on Quantitative Traits. Int J Curr Microbiol App Sci 9(4): 2413-2424.

37. Grzesiak S, Hordyńska N, Szczyrek P, Grzesiak MT, Noga A et al. (2019) Variation among wheat (*Triticum easativum* L.) genotypes in response to the drought stress: I-selection approaches. Journal of Plant Interactions 14(1): 30-44.