Ukrainian Journal of Ecology

Ukrainian Journal of Ecology, 2023, 13(2), 44-49, doi: 10.15421/2023_429

ORIGINAL ARTICLE

Examining Ethiopian bread wheat genotypes for the novel sources of resistance to strip rust (*Puccinia striformis* f.sp. *Tritici*)

A. Ayele*, G. Muche, D. Kassa, T. Negash

Kulumsa Agricultural Research Center, Ethiopian Institute of Agricultural Research, P.O. Box. 489 Asella, Ethiopia

**Corresponding author E-mail: alemuayele81@gmail.com*

Received: *21 February, 2023; Manuscript No: UJE-23-89827;* ***Editor assigned:*** *23 February, 2023, PreQC No: P-89827;* ***Reviewed:*** *08 March, 2023, QC No: Q-89827;* ***Revised:*** *14 March, 2023, Manuscript No: R-89827;* ***Published:*** *21 March, 2023*

Stripe rust of wheat (yellow rust) is a regular production restraint in the majority of wheat growing areas of the world embracing Ethiopia. The trans boundary nature of the pathogen linked with its current virulence capabilities, favorable environmental conditions, continuous cultivation of susceptible varieties in stripe rust hot spot areas, and genetic uniformity of certain recently released 'mega-cultivars' were major driving forces in stripe rust epidemics worldwide including Ethiopia. Utilization of host plant resistance is the best and prosperous option to alleviate this epidemic rust disease, the most sustainable and profitable strategy to meet the needs of farmers and consumers. Thus, the present study was performed with aim of searching novel sources of Ethiopian bread wheat genotypes resistance to stripe (yellow) rust. A total of one thousand four (1004) genotypes exhibited 157 local cross, 663 CIMMYT introductions, 173 ICARDA sources and 11 commercial cultivars were screened for the resistance to yellow rust at both Bekoji and Meraro experimental sites which are yellow rust prone areas of Ethiopia. Out of 1004 tested materials only 5.5% genotypes exhibited 1.2%, 0.7% and 3.6%, local cross, ICARDA and CIMMYT introductions performed best resistance to yellow rust respectively at both Bekoji and Meraro testing sites.

Keywords: Bread wheat, Genotypes, Cultivars, Spreader rows, Yellow rust, Severity.

Introduction

Wheat is the most important strategic and food security cereal crop in Ethiopia, ranks 3rd in the area coverage after teff (*Eragrostis tef*) and maize and 2nd in volume of production next to maize. It is cultivated on a total area of 2.1 million hectares annually with a total production of 6.7 million tons (Tadesse, W., et al., 2003). The national average yield is 3.1 t ha^{-1} rain fed and 4t ha^{-1} irrigated which is below the average of 3.5 tha^{-1} world yield production and potential yield of 7 and 8 t ha^{-1} under rain fed and irrigated conditions respectively (Ulrik, G., et al., 2021; CSA, 2021). This low productivity is attributed to several scenarios of climate change, evolution of new virulent pathogen races, increased intensity of weeds and insect pests, increasing of soli acidity and salinity, increment of fertilizers cost and demand of biofuels and slow rate of adoption to new agricultural technologies (Dixon, J., et al., 2009).

Yellow rust is repeatedly production constraint in potential wheat growing areas of world. Regarding to rust epidemiology, Ethiopia and Yemen form ecological unit in playing important role in inoculum spread and evolving of new virulence pathotypes across Central and West Asia and North Africa (Badebo, A., et al., 1992). It is dynamic in nature and a serious problem to wheat production in all cropping season due to favorable climatic conditions, continuous planting of susceptible cultivars in hotspot areas of yellow rust and genetic uniformity of current cultivating mega cultivars favoring chance of evolving new virulent races in Ethiopia (Solh, M., et al., 2012).

Extensive surveys revealed that wheat rusts (stem and yellow) caused, 10s of millions of USD annually in in the country. This is due to evolution of new virulent strains which are cold tolerant stem rust races and warm temperature adapted yellow rust races. The rapid emergence of virulent races of *PSt11* and *PSt16* have overcome most of currently released cultivars and known stripe rust resistant genes of wheat in Ethiopia (Nazari, K., et al., 2008). To date, for the past five decades more than 88 bread wheat varieties of local cross, CIMMYT and ICARDA origin have been released with continuous progress in yield, acceptable end use qualities and improving disease resistance but, less than 20 varieties cover country's wheat growing areas and unfortunately most of mega cultivars are becoming out of production due to recurrent rust epidemics. Thus, taking into account on periodic outbreaks of rust epidemics and economic invasion, continuous work needs in adequate monitoring and searching of novel sources of durable resistant wheat genotypes against yellow (stripe) rust. The objective of the study was to identify novel sources of resistance to stripe (yellow) rust among one thousand four (1004) Ethiopian bread wheat genotypes exhibited 157 local cross, 663 CIMMYT introductions, 173 ICARDA sources and 11 commercial cultivars.

Materials and Methods

Description of the study area

The experiment was conducted at kulumsa research center substations of Bekoji and Meraro which is located at 7°32'37"N, 39°15'21"E and 2780 meters and 7°24'27"N, 39°14'56"E and 2990 meters above sea level respectively. Monthly maximum and minimum temperatures of Bekoji and Meraro have 7.9 and 18.6, and 5.7 and 18.1°C with annual rain fall of 102 mm and 1196 mm respectively. Both locations were characterized bimodal receiving extended rainfall and represents yellow rust host spot areas and major wheat production potential agro ecologies of Arsi, Ethiopia.

Planting materials

A total of one thousand four (1004) genotypes exhibited 157 local cross, 663 CIMMYT introductions, 173 ICARDA sources and 11 commercial cultivars were screened for the resistance to yellow rust. The genotypes were tested at preliminary yield trials and observation nurseries for different traits at quarantine site of kulumsa research center which is national wheat research coordinating center of Ethiopia and advanced lines were selected to test at severely affected hot spot areas to yellow rust in field condition.

Experimental design

The trail was implemented with partially replicated design consisted of 1508 entries. The spacing of each entry was planted 0.5 m length with 0.2 m row spacing in single row with 26 blocks which was consisted 58 entries in each blocks. Mixtures of different highly susceptible varieties namely Morocco, PBW343, Kubsa, Digalu and newly susceptible poplar variety Ogolcho were planted in each block as to receive uniform inoculum to the entries. All agronomic and weed management practice were applied as per recommendations for all entries.

Disease assessment

Disease assessment was performed three times at Bekoji and Meraro experimental sites at fourteen day's interval, started when susceptible spreader row morocco reached 40 percent yellow rust severity according to modified Cobb scale (8). Response of wheat genotypes were assessed through final rust severity (FRS) and coefficient of infection (CI). The host plant response to infection was scored according to Roelfs, A.P., et al., (1992), and average coefficient of infection (CI) was calculated by multiplying the percentage severity and the constant value assigned to each reaction type (Saari, EE., et al., 1974). The constant values were considered as Immune=0, R=0.2, R-MR=0.3, MR=0.4, MRMS=0.6, MS=0.8, MSS=0.9 and S=1.

Results and Discussion

Among one thousand four (1004) tested genotypes 993 and 11 were advanced bread wheat lines and released commercial cultivars respectively. Thus, genotypes exhibited, 157 local cross, 663 CIMMYT introductions and 173 ICARDA sources were screened for the resistance to yellow rust at Bekoji and Meraro which are nationally yellow rust prone areas. The final yellow rust severity and response of genotypes were presented in Fig. 1. Fortunately, the season was conducive to yellow rust disease epidemics result revealed, various field reactions ranging from immune to susceptible(s) response were assessed at both experimental sites. From 1004 tested advanced genotypes 2.2%, 7%, 31.4%, 8.5%, 13.5% and 37.4% showed immune, moderately resistant, intermediate reaction, moderately susceptible, moderately susceptible to susceptible, and susceptible diseases reaction and none of the tested genotypes showed resistant and resistant to moderately resistant disease reaction at Bekoji whereas, 1.6%, 1.9%, 8.5%, 8.1%, 11.7%, 7.7% and 60.5% of the 1004 screened genotypes showed immune, resistant to moderately resistant, moderately resistant, intermediate reaction, moderately susceptible, moderately susceptible to susceptible and susceptible disease reaction and none of the tested genotypes showed resistant response respectively at Meraro experimental site (Fig. 1).

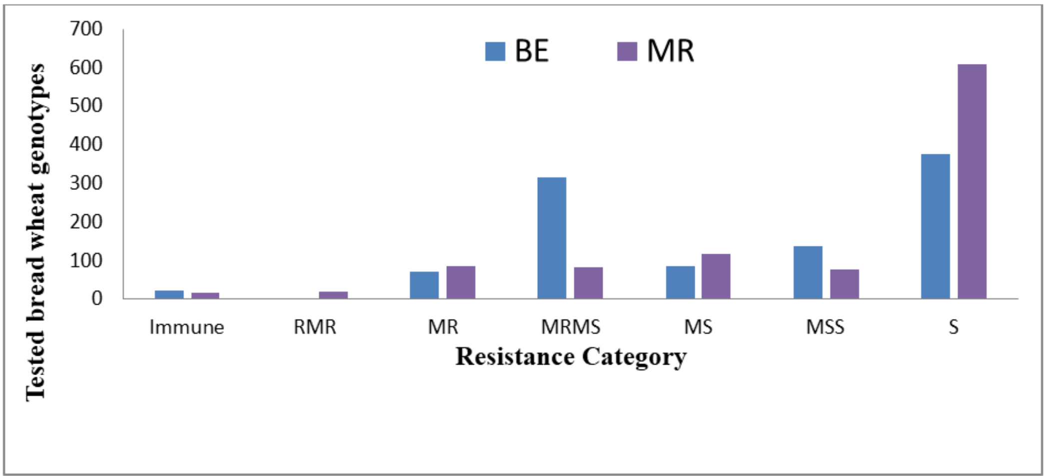

Fig. 1. Response of bread wheat genotypes to yellow rust at Bekoji and Meraro in 2022.

Despite highest yellow rust epidemics at Bekoji and Meraro 55 genotypes selected which 50 of them exhibiting final rust severities ranging from 5 to 20% with compatible RMR and MR disease reaction, are great importance to attain current breeding for long-lasting resistance (Parlevliet, JE., 1988), whereas five genotypes showed immune type response with zero disease severity (Table 1). On the other hand sixty two genotypes were also selected which showed intermediate response to yellow rust at both locations (Table 2).

The available resistant genes in these selected genotypes overcome yellow rust virulence in the field and led to statistically low yellow rust severities in spite of well-suited host pathogen reactions (Nzuve, FM, et al.,). According to van der Plank's (1968) and Robinson's (1979) attempts, Horizontal, uniform, race-non-specific or stable resistance can be distinguished from vertical, differential, race-specific or unstable resistance by a test in which a number of host genotypes are tested against a number of pathogen genotypes. Horizontal resistance should be built up in crops as a primary objective and as the foundation of disease management, with vertical plant pathology resistance being added as necessary, along with cultural control measures and targeted use of pesticides, as part of an IPM strategy. So Van der Plank's test for horizontal resistance appears to be a simple and sound way to test for polygenic inheritance of resistance (Parlevliet, JE., 1976) (Tables 1-3).

Table 1. Response of selected to 55 wheat genotypes showed best sources of resistance to yellow rust at in 2022.

Genotypes	Meraro		Bekoji		Genotypes	Meraro		Bekoji	
	Sev (%)	Rxn	Sev (%)	rxn		Sev (%)	rxn	Sev (%)	Rxn
EBW160002	10	MR	5	MR	EBW202479	20	MR	20	MR
EBW160009	5	MR	5	MR	EBW202610	0	0	0	0
EBW160017	10	MR	5	MR	EBW204020	10	MR	5	RMR

EBW160037	20	MR	10	MR	EBW204023	0	0	0	0
EBW160038	0	0	20	MR	EBW212106	5	MR	5	MR
EBW160056	5	MR	5	MR	EBW212229	20	MR	5	RMR
EBW160058	20	MR	10	MR	EBW212274	5	MR	10	MR
EBW160063	0	0	5	RMR	EBW212275	5	MR	0	0
EBW160065	5	MR	10	MR	EBW212318	5	MR	10	MR
EBW160066	5	MR	5	MR	EBW212354	5	MR	5	MR
EBW160067	20	MR	0	0	EBW212371	0	0	0	0
EBW160118	0	0	5	MR	EBW212448	5	MR	5	RMR
EBW182463	0	0	5	RMR	EBW212570	0	0	0	0
EBW192154	0	0	5	MR	EBW212571	0	0	5	MR
EBW192255	5	MR	10	RMR	EBW212572	0	0	0	0
EBW192345	5	MR	5	RMR	EBW212573	5	MR	5	MR
EBW192347	5	MR	5	RMR	EBW212574	10	MR	0	0
EBW192800	5	MR	5	MR	EBW212575	0	0	0	0
EBW202005	5	MR	10	MR	EBW212576	5	MR	0	0
EBW202056	5	MR	10	RMR	EBW212577	0	0	0	0
EBW202211	5	MR	10	MR	EBW212578	10	MR	0	0
EBW202213	20	MR	20	MR	EBW212789	5	MR	10	MR
EBW202216	5	MR	5	RMR	EBW213196	0	0	5	MR
EBW202245	10	MR	10	MR	EBW214009	5	MR	5	MR
EBW202370	10	MR	5	MR	EBW214029	0	0	5	MR
EBW202379	0	0	0	0	EBW214031	5	MR	20	MR
EBW202471	5	MR	10	RMR	EBW214162	5	MR	5	MR
EBW202473	10	MR	5	RMR					

Sev (%), percent severity, rxn, genotype response to yellow rust.

Table 2. Wheat genotypes showed intermediate resistance to yellow rust at Bekoji and Meraro.

Genotypes	Sev	Rexn	Sev	rxn	Genotypes	sev	Rexn	sev	Rxn
EBW160001	20	MRMS	20	MRMS	EBW202508	20	MRMS	30	MRMS
EBW160015	30	MRMS	30	MRMS	EBW202518	20	MRMS	20	MRMS
EBW160113	10	MRMS	30	MRMS	EBW202519	30	MRMS	20	MRMS
EBW160122	30	MRMS	30	MRMS	EBW204066	20	MRMS	20	MRMS
EBW192156	5	MRMS	30	MRMS	EBW212096	30	MRMS	30	MRMS
EBW192387	30	MRMS	20	MRMS	EBW212178	30	MRMS	30	MRMS
EBW193027	30	MRMS	30	MRMS	EBW212245	10	MRMS	20	MRMS
EBW193155	20	MRMS	20	MRMS	EBW212248	30	MRMS	20	MRMS
EBW202033	10	MRMS	20	MRMS	EBW212251	30	MRMS	20	MRMS
EBW202034	30	MRMS	30	MRMS	EBW212252	20	MRMS	20	MRMS
EBW202066	30	MRMS	20	MRMS	EBW212253	10	MRMS	20	MRMS
EBW202084	30	MRMS	30	MRMS	EBW212266	5	MRMS	20	MRMS
EBW202101	20	MRMS	40	MRMS	EBW212284	30	MRMS	30	MRMS
EBW202127	20	MRMS	30	MRMS	EBW212301	20	MRMS	30	MRMS
EBW202130	5	MRMS	20	MRMS	EBW212323	30	MRMS	20	MRMS
EBW202156	10	MRMS	20	MRMS	EBW212389	30	MRMS	20	MRMS
EBW202172	30	MRMS	20	MRMS	EBW212424	20	MRMS	20	MRMS

EBW202185	30	MRMS	30	MRMS	EBW212516	30	MRMS	20	MRMS
EBW202207	30	MRMS	20	MRMS	EBW212518	30	MRMS	30	MRMS
EBW202217	20	MRMS	20	MRMS	EBW212616	20	MRMS	10	MRMS
EBW202252	30	MRMS	20	MRMS	EBW212664	20	MRMS	20	MRMS
EBW202253	20	MRMS	30	MRMS	EBW212723	5	MRMS	20	MRMS
EBW202257	5	MRMS	20	MRMS	EBW212724	20	MRMS	10	MRMS
EBW202267	20	MRMS	10	MRMS	EBW212746	30	MRMS	20	MRMS
EBW202362	10	MRMS	20	MRMS	EBW212778	10	MRMS	20	MRMS
EBW202401	40	MRMS	20	MRMS	EBW212779	20	MRMS	20	MRMS
EBW202414	30	MRMS	30	MRMS	EBW212984	5	MRMS	5	MRMS
EBW202429	20	MRMS	20	MRMS	EBW213037	30	MRMS	30	MRMS
EBW202434	30	MRMS	10	MRMS	EBW213072	20	MRMS	20	MRMS
EBW202436	20	MRMS	5	MRMS	EBW214064	30	MRMS	30	MRMS
EBW202488	30	MRMS	20	MRMS	EBW223021	30	MRMS	20	MRMS

Sev (%), percent severity, rxn, genotype response to yellow rust.

Table 3. Response of check varieties to yellow rust at both locations.

	Bekoji		**Meraro**	
Variety	**Yr Severity**	**Disease reaction**	**Yr Severity**	**Disease reaction**
Alidoro	60	S	60	S
Balcha	10	MR	10	MR
Boru	40	MSS	50	MS
Daka	30	MRMS	60	MSS
Danda'a	40	MRMS	40	MSS
Hidase	60	S	70	S
King bird	60	S	80	S
MOROCCO	80	S	90	S
Ogolcho	70	S	70	S
Pavon-76	60	S	80	S
PBW343	80	S	90	S

Conclusion

Forecasting of upcoming transformations and developing an operational research tactics with use of new breeding tackles, needs a corresponding strength in creating communication net-works and teamwork's. Timely monitoring and information exchange between stake holders, creating new capacities and skills in ministries and extension services to develop effective management tactics, and continued research in searching of durable resistant genotypes to virulent races, planning to rapidly deliver appropriate improved seeds and fungicides to halt spread of wheat rust should be strategies to address the current existing problems of wheat rust disease management. Out of 1004 tested genotypes only 5.5% genotypes exhibited 1.2%, 0.7% and 3.6% exhibiting having RMR and MR field response, local cross, ICARDA and CIMMYT introductions performed best and selected to yellow rust resistance respectively, While 6.2% identified genotypes also showed intermediate (MRMS) field response, could be suggested to for further breeding purpose.

Acknowledgement

Accelerating Genetic Gain in wheat and Bill and Melinda Gates Foundation (BMGF), projects are genuinely acknowledged for technical and financial support of the Experiment. Ethiopian Institute of Agricultural Research is recognized for accommodating the field research. The all-round provision by the wheat research team of kulumsa Agricultural research Center of Ethiopia is greatly valued.

Conflict of Interest

The authors declare no conflict of interest.

References

Tadesse, W., Zegeye, H., Debele, T., Kassa, D., Shiferaw, W., Solomon, T., Assefa, S. (2022). Wheat production and breeding in ethiopia: retrospect and prospects. Crop Breeding, Genetics and Genomics, 4:e220003.

Grote, U., Fasse, A., Nguyen, T.T., Erenstein, O. (2021). Food security and the dynamics of wheat and maize value chains in Africa and Asia. Frontiers in Sustainable Food Systems, 4:617009.

Central Statistics Agency for Ethiopia. (2021). Agricultural sample survey of area and production of major crops.

Dixon, J., Braun, H.J., Kosina, P., Crouch, J.H. (Eds.). (2009). Wheat facts and futures 2009. Cimmyt.

Badebo, A., Bayu, W. (1991). The importance of stripe rust in the major bread wheat producing regions of Ethiopia during 1988-90. In The Seventh Regional Wheat Workshop, p:196.

Solh, M., Nazari, K., Tadesse, W., Wellings, C.R. (2012). The growing threat of stripe rust worldwide. In Borlaug Global Rust Initiative (BGRI) Conference, Beijing, China, pp:1-4.

Nazari, K., Wellings, C.R., Park, R.F. (2008). Characterisation of seedling resistance to rust diseases in wheat cultivars from Central Asia and the Caucasus. International Journal of Plant Breeding, 2:52-63.

Peterson, R.F., Campbell, A.B., Hannah, A.E. (1948). A diagrammatic scale for estimating rust intensity on leaves and stems of cereals. Canadian Journal of Research, 26:496-500.

Roelfs, A.P. (1992). Rust diseases of wheat: concepts and methods of disease management. Cimmyt.

Saari, E.E., Wilcoxson, R.D. (1974). Plant disease situation of high-yielding dwarf wheats in Asia and Africa. Annual Review of Phytopathology, 12:49-68.

Parlevliet, J.E. (1985). Resistance of the non-race-specific type. In Diseases, Distribution, Epidemiology, and Control, Academic Press, pp:501-525.

Nzuve, F.M., Bhavani, S., Tusiime, G., Njau, P., Wanyera, R. (2012). Evaluation of bread wheat for both seedling and adult plant resistance to stem rust.

Plank, J.V.D. (1968). Disease resistance in plants.

Robinson, R.A. (1979). Permanent and impermanent resistance to crop parasites. A re-examination of the pathosystem concept with special reference to rice blast. Zeitschrift fur Pflanzenzuchtung.

Parlevliet, J.E., Zadoks, J.C. (1977). The integrated concept of disease resistance: a new view including horizontal and vertical resistance in plants. Euphytica, 26:5-21.

Citation:

Ayele, A., Muche, G., Kassa, D., Negash, T. (2023). Examining Ethiopian bread wheat genotypes for the novel sources of resistance to strip rust (*Puccinia striformis* f.sp.*Tritici*). *Ukrainian Journal of Ecology.* 13:44-49.