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EVALUATION OF WHEAT GERMPLASM FOR RESISTANCE TO RUSTS

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ABSTRACT

Wheat is the most important food grain in Georgia. Rusts are major threat to wheat production all over the world including Georgia. Wheat sown area (46.5kg/ha) and yield (2.1t/ha) are much lower than in other countries. Unfortunately, wheat produced in Georgia meets only 10-15% of local demand. To improve the wheat productivity, CIMMYT in the frame of the International Winter Wheat Improvement Program distributes different international nurseries globally. Since 2000, this network has been providing the Georgian national breeding program with numerous nurseries comprising high yielding advanced breeding lines. As a result of regional testing of these nurseries, seven varieties with broad adaptation to range location have been released in Georgia. The objective of this study was to evaluate the sources of resistance to all three rusts in 85 wheat entries of IN-20RUST-SET under natural and artificial infections. Testing of IN-20RUST-SET germplasm obtained from CIMMYT was conducted at the research field of Institute of P&B during 2020-2021. The results of greenhouse assessment of wheat entries at the seedling stage under artificial infection revealed that 21entries were resistant, 30 and 27 entries were moderately resistant, 26 and 20 - moderately susceptible and five entries- susceptible to leaf rust and stem rust, respectively. The results of field assessment under natural infection of rusts showed that the majority of the genotypes were moderately resistant to leaf rust and stem rust. Natural infection of stripe rust was very low in the research years. Assessment of genotypes with resistant reaction will be continued under heavy infection of rusts.

Keywords: *Wheat, genotypes, leaf rust, stem rust, resistance.*

INTRODUCTION

Wheat plays very a important role in global food security. Wheat has historically been the major food crop in Georgia, and it is a major cash crop and has no practicable alternative in crop rotations, especially in the dryland areas in East Georgia (Lashkhi et al., 2014). Unfortunately, wheat sown area and yield over the past 5 years averages 46.5 thousand hectares and 2.1 t/ha, respectively, and wheat

produced in Georgia meets only 10-15% of local demand that threats food security of the nation. Wheat diseases are the most important constraints to wheat production (GeoStat, 2021). Therefore, identification and promotion of improved resistant varieties is one of the most efficient means to strengthen grain production in the country, which is the main internal priority of the Georgian agricultural sector. To improve the productivity of winter wheat, the International Maize and Wheat Improvement Center (CIMMYT) in the frame of the International Winter Wheat Improvement Program (IWWIP) develop and distribute the different International Nurseries globally to over collaborators in different countries (including Georgia). Since 2000, this network has provided the national breeding program with numerous nurseries comprising high yielding advanced breeding lines. As a result of the regional testing of these nurseries seven genotypes as varieties with broad adaptation to a range location have been released in Georgia (Morgounov et al., 2019]. The most distributed and harmful among wheat diseases are wheat rusts in Georgia. Protection of wheat from rust diseases has very special significance for the Caucasus, which is one of the origins of wheat and its pathogens having evolved together (Zhukovsky, 1973). Presence of alternate host-plants, wild cereals – infection reserves, and optimal climatic conditions provide for stable development of rusts and consequently, severe crop losses.

The objective of this study was to evaluate and identify sources of resistance to all three rusts in 85 winter wheat genotypes of IN-20RUST-SET.

MATERIALS AND METHODS

Field trials. The field trials were carried out at the experimental plot of Institute of Phytopathology and Biodiversity (5 m above sea level) during two (2019-2020 and 2020-2021) growing seasons. The tested International Wheat Rust Nursery (IN-20RUST-SET) consisted of 85 wheat genotypes originating from different country's breeding programs was obtained from the IWWIP, CIMMYT. The tested genotypes were hand-planted in 3 rows with one-meter length spaced 20 cm apart at a rate 120 seeds per meter, (Singh, 2006). Two rows of standard variety - Bezostaya 1 and universal susceptible variety Morocco were planted within the screening material after every 20^{th} entry to enhance inoculum pressure. Measurement of rusts incidence and severity in wheat genotypes under natural conditions during each of the two growing seasons was conducted according to international methodology. Observation on host response was recorded according to Roelfs et al. (1992) and the severity of disease was recorded using the international scales specified for rusts as % of rust infection on the plants according to the modified Cobb's Scale (Peterson et al., 1948). The host plant response(TR) to the rusts was assessed using the following grades: 'R' to indicate resistance or miniature uredinia;'MR' to indicate moderate resistance, expressed as small uredinia; "MS' to indicate moderate susceptible, expressed as moderate size uredinia somewhat smaller than the fully compatible type, and "S' to indicate full susceptibility. Severity (%) was estimated for whole plants, based on the proportion of the flag leaf surface area infected by rust. The incidence of the rusts

was assessed as the proportion of infected plants versus total plants assessed. Incidence and severity of rusts were recorded three times 7-10-day intervals after the appearance of the first disease symptoms. Disease severity and host response data were combined in a single value called the coefficient of infection (C.I.) what was calculated by multiplying the disease severity and a constant value for host response. These values of host response were: for immune = 0.0, R = 0.2, MR = 0.4, MS = 0.8, MR- MS = 0.6 and S = 1.0 (Stubbs et al., 1986).

Greenhouse seedling tests. Assessment of genotypes at the seedling stage was conducted in 2020-2021under artificial inoculation by using prevailed races of leaf rust (LR) and stem rust (SR). Wheat genotypes were sown into 9 cm diameter plastic pots in three replications and grown in the greenhouse conditions at 20-22 ^{0}C. Urediniospores of LR and SR were multiplied by using the susceptible cultivars Morocco and Thatcher. 3-8 days seedlings (at 1-2 leaf stage) of the tested genotypes were inoculated with water-spore suspensions by spraying of each single pustule isolate and placed in a dew chamber overnight. After 24hour infected seedlings were transferred to the greenhouse under temperature within the range of 20^{0}C - 28^{0}C. Twelve to fourteen days after inoculation, plant reactions (TR) were scored using the (0-4) Mains scale (Long, Kolmer, 1989; Jin et al., 2008).

RESULTS AND DISCUSSION

Observation of the experimental field showed that the first symptoms of stripe rust appeared on several genotypes (Morocco, Bezostaya and Seri) during the last week of May, the rest of the entries were free from stripe rust. In mid-June leaf rust and stem rust pustules with infection types “3” were episodically found on the forty and fourteen genotypes, respectively. The next records were done in the end of June and in the mid of July. Rust incidence and severity in both years were low: the severity of leaf rust and stem rust were between 1MS-30MS excluding the genotype N47 which showed susceptible reactions with high severity (60S). Also, relatively high severity (40S-60MS) of leaf rust and stem rust was indicated on varieties: Morocco (susceptible check), Bezostaya and Seri in both years.

The results of field assessment revealed that the main parts of tested genotypes had resistant and moderately resistant reaction to all three rusts. Particularly, fifteen and fourteen entries showed resistance, thirty-two and forty-three entries showed moderate resistance to leaf rust and stem rust, respectively. The moderately susceptible reaction to leaf rust and stem rust was scored on thirty-nine and thirteen genotypes, respectively. Only one genotype VEE#8//JUP/BJY/3/ F3.71/TRM/4/2* (N47) showed susceptibility to leaf rust in the field and one entry had combined MR-MS reaction to leaf rust. Nearly all of resistant entries had very low values of CI (0.2-0.5) and AUPDC (less than 10.0) are the best genotypes with very high levels of resistance, CI of susceptible genotypes varied between 0.8- 48, only one genotype had high CI - 48 (Table 1).

In accordance with the results of the seedling tests, eighteen and eleven genotypes were resistant (R), twenty-three and twenty-one genotypes were moderately resistant and twenty-seven and thirty-three genotypes were moderately susceptible

to leaf rust and stem rust, respectively. Only three entries (N17, N66, N76) had susceptible reaction to leaf rust at the seedling stage (Table 1).

Table 1. The host plant reaction of wheat genotypes to leaf rust and stem rust at the seedling and adult plant stages

N	Name of genotypes	Origin	Leaf rust		Stem rust	
			TR in seedlings	TR and CI in adult plants	TR in Seedlings	TR and CI in adult plants
1	BEZOSTAYA	RUS	MS	30 MS/24	MS	10 MS/8
2	SERI	MEX	MS	5MS/4	MS	5MS/4
3	**MOROCCO**		S	20MS/16	MS	20MS/16
4	NACIBEY	TCI-ESK	MS	5MS/4	MRMS	1MS/0.8
5	DI09016	FR	MS	1MS/0.8	MSS	1MS/0.8
6	RE08030	FR	MS	5MR/2	MS	5MR/2
7	MV NEMERE	HUN	R	R	R	R
8	KRAJCAR	HUN	R	R	MR	R
9	MV-PANTALIKA	HUN	R	R	MS	R
10	GRK79/KKTS	MEX	MR	5MR/2	MR	5MR/2
11	KUPAVA/CHAPIO	MEX	MS	1MS/0.8	MS	5MR/2
12	INTENSIVNAYA/KUKUNA	MEX	MR	5MR/2	MRMS	5MR/2
13	DORADE-5/3/SUNCO.6/FRAME//PASTOR/4/	MX-TCI	MR	5MR/2	MR	5MR/2
14	MERC/4/BJY/COC//PRL/BOW/3/FRTL/	MX-TCI	MS	5MR/2	MR	5MR/2
15	MT.DESC.1E-308WM97-98/TUKURU	MX-TCI	MR	5MR/2	R	5MR/2
16	DORADE-5/11/CROC_1/AE.SQUARROSA	MX-TCI	MR	10MS/8	R	10MS/8
17	ALPU01/4/338-K1-1//ANB/BUC/3/KIRGIZ	MX-TCI	S	5MR/2	MS	5MR/2
18	FGMUT213	ROM	MR	1MR/0.4	MS	1MR/0.4
19	AJVINA	RUS	MR	1MR/0.4	MR	1MR/0.4
21	SARVAR	TAJ	R	R	MR	5MR/2
22	BLUEGIL-2/BUCUR//SIRENA	TCI	MS	1MS/0.8	MR	1MS/0.8
23	AU/3MINN//HK/38MA..9-18-3/HBF0435//2180	TCI	R	R	MR	R
24	STAR/BWD//ATAY/GALVEZ87	TCI	MR	5MR/2	MR	5MR/2
25	8229/OK81306/8/AGRI/BJY//VEE/6....	TCI	R	5MR/2	MR	5MR/2
26	TREGO/JGR 8W//DORADE-6	TCI	MS	10MS/8	MS	1MS/0.8
27	ES14/SITTA//AGRI/NAC/5/TRAP#1	TCI	MR	5MR/2	MR	5MR/2
28	ND643/2*WAXWING/4/TAM200/	TCI	MR	5MR/2	MR	5MR/2
29	AGRI/NAC//KAUZ/3/CH75479/SAR	TCI	MR	5MS/4	MR	1MR/0.4
30	ST.ERYHTR894-07/3/KIRITATI//	TCI	MR	5MR/2	MR	1MR/0.4
31	PYN*2/CO725052/3/KAUZ*2/YACO	TCI	MS	5MS/4	MS	1MR/0.4
32	PYN/BAU//ATTILA/4/ID800994.W/VEE//	TCI	MS	5MS/4	MS	1MR/0.4
33	PANTHEON/BLUEGIL-2/5/AGRI/BJY//	TCI	MS	1MS/0.8	MS	1MR/0.4
34	HEILO/4/CROC_1/AE.SQUARROSA....	TCI	MR	5MR/2	MR	1MR/0.4
35	ZNAKHIDKA/EKIZ	TCI	MS	1MS/0.8	MS	1MS/0.8
36	MV-BERES/EKIZ	TCI	MR	5MR/2	MR	5MR/2
37	F498U1-1021 / BOEMA/3/KS96HW94//	TCI	MR	5MR/2	MR	1MR/0.4
38	ZIYABEY 98/4/KS90175-1-2/CM112793//..	TCI	MR	5MR/2	MR	5MR/2
39	CRINA/BONITO-37	TCI	MR	10MS-MR	MR	10MR/4
41	T98-9//VORONA/HD2402/5/AGRI/BJY//	TCI	MR	1MS/0.8	MR	1MR/0.4
42	BLOYKA/3/AGRI/NAC//KAUZ	TCI	MR	5MR/2	MR	5MR/2
43	CHEN/AE.SQUARROSA(TAUS)//	TCI	MR	5MR/2	MR	1MR/0.4
44	TJB368.251/BUC//WEAVER/3/	TCI	MS	1MS/0.8	MS	1MS/0.8
45	ESPADA/KARAHAN	TCI	MR	5MR/2	MR	5MR/2
46	KIRITATI/4/2*SERI.1B*2/3/KAUZ*2/	TCI	MR	5MR/2	MR	1MR/0.4
47	VEE#8//JUP/BJY/3/F3.71/TRM/4/2*	TCI	MS	60MS/48	MR	1MR/0.4

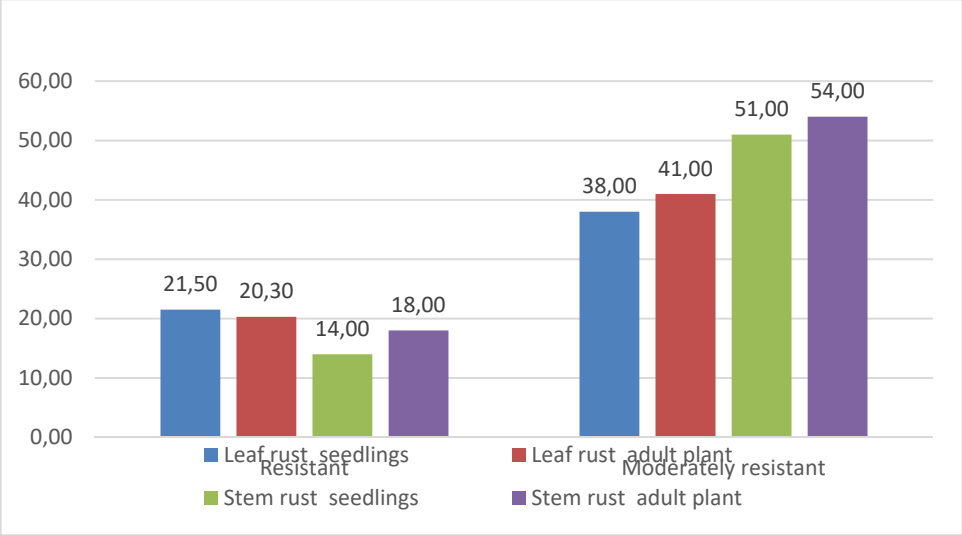
48	WBLL1*2/KIRITATI//BILLING(N566	TCI	MR	1MS/0.8	MR	1MR/0.4
49	DRAGANA/KINACI97	TCI	MS	1MS/0.8	MS	1MS/0.8
50	GONDVANA/6/53/3/ABL/1113//K92/	TCI	MR	10MR/4	MR	1MR/0.4
51	FRTL//AGRI/NAC/3/BONITO-36/4/	TCI	MS	1MS/0.8	MR	1MR/0.4
52	105/3/NE70654/BBY//BOW"S"/4/	TCI	MR	5MR/2	MR	1MR/0.4
53	338-K1-1//ANB/BUC/3/GS50A/4/059E//	TCI	MS	5MR/2	MS	5MS/4
54	ZNAKHIDKA/EKIZ	TCI	MR	5MR/2	MR	5MR/2
55	VORONA/HD2402/3/RSK/CA8055//	TCI	MR	10MR/4	MR	1MR/0.4
56	VORONA/OPATA//PYN/BAU/5/AGRI	TCI	R	R	R	R
57	87-461 A 63-555//SAULESKU #26/	TCI	MS	10MS/8	MS	1MS/0.8
58	OBRII/DNESTREANCA25//ILICIOVCA	TCI	MS	1MS/0.8	MS	1MS/0.8
59	ERITR 9945/DORADE-6/3/NEMURA/	TCI	MS	1MS/0.8	MS	1MS/0.8
61	PICAFLOR/3/KS82W409/SPN//TAM	TCI	MS	1MS/0.8	MS	1MS/0.8
62	MINO/5/REH/HARE//2*BCN/3/CROC	TCI	MS	5MR/2	MS	5MR/2
63	DANPHE #1/6/CA8055/4/ROMTAST	TCI	1MSMR	5MR/2	MR	5MR/2
64	TREGO/BTY SIB/4/338-K1-1//ANB	TCI	R	R	MR	R
65	KROSHKA/GONDVANA	TCI	MS	20MS/16	MS	5MS/4
66	AGRI/NAC//ATTILA/3/DORADE-6	TCI	S	20MS/16	MR	5MR/2
67	KUV/LJILN//ORACLE/PEHLIVAN	TCI	MS	1MS/0.8	MR	1MS/0.8
68	9852.1//ERYT1554.90/PEHLIVAN	TCI	MR	5MR/2	MR	5MR/2
69	**9852.1//ERYT1554.90/PEHLIVAN**	TCI	MR	5MR/2	MR	5MR/2
70	BILLING(N566/OK94P597)	USA	R	R	R	R
71	CO07 W245	USA CO	MS	1MS/0.8	MS	1MS/0.8
72	KS970187-1-10/KS031027-FHB~	USA-KS	R	R	R	R
73	FARMEC/KS990160-4-~5	USA-KS	MS	1MS/0.8	MS	1MS/0.8
74	KS980191-1-7/W04-417//ARMOUR	USA-KS	R	R	R	R
75	KS980554-12-~9/KS020363WM~	USA-KS	R	R	R	R
76	MNCH/ATTILA//TAM 400/3/N87V106/	USA-OK-TCI	S	5MS/4	MS	5MS/4
77	ATTILA*2/PASTOR//OK95553/OK92403..	USA-OK-TCI	R	R	R	R
78	KAMB1*2/KIRITATI//BIG DAWG/	USA-OK-TCI	R	R	MR	R
79	WBLL1*2/KIRITATI/5/T67/JGR 'S'//	USA-OK-TCI	R	R	MR	R
81	PFAU/MILAN/3/SKAUZ/KS94U215//	USA-OK-TCI	R	R	R	R
82	WBLL1*2/TUKURU//BILLINGS	USA-OK-TCI	R	R	R	R
83	PVN//CAR422/ANA/5/BOW/CROW//...	USA-OK-TCI	MR	5MR/2	MR	1MR/0.4
84	**NI12702W**	USA-UNL	-	-	-	-
85	SERI	MX	MS	10MS/8	MS	5MS/4

Thus, assessments of introduced wheat germplasm to rusts under natural and artificial infection showed that 21.5% and 14% of the tested entries were resistant, 38% and 51% - moderately resistant to leaf rust and stem rust, respectively, at the seedling stage, 20.3% and 18% of the entries were resistant and 41% and 54% -

moderately resistant to leaf rust and stem rust, respectively, at the adult plant stage (Figure 1).

All IWWIP wheat germplasm are evaluated under leaf rust, stem rust and stripe rust natural epidemic conditions and artificial rusts infection before being distributed to wheat breeding communities. According to results obtained in Izmir research station, 50% of tested genotypes of this nursery were resistant and moderately resistant to leaf rust, stripe rust and stem rust, 35% of genotypes showed MS and S reaction and 10-15% - intermediate reaction in 2017-2019 field tests (unpublished data). These data are in agreement with our research results.

Figure 1. Resistance of wheat genotypes to leaf rust and stem rust



Forty genotypes from this nursery were evaluated to stripe rust under artificial infection at the seedling and adult plant stages in Iran (Koc et al. 2023) and like our results, the majority of entries were also resistant and moderately resistant to pathogen in both stages. Over the last 20 years, numerous breeding nurseries comprising high-yielding advanced breeding lines introduced from CIMMYT and ICARDA were evaluated under diverse environments of Georgia and several varieties were selected. (Natsarishvili et. al., 2016; Sikharulidze et. al., 2015; 2013).

CONCLUSION

Thus, 59.5% and 65% of the tested entries of introduced wheat germplasm were resistant to leaf rust and stem rust, respectively, at the seedling stage. 61.3%, 72.1% and 94% of the entries were resistant to leaf rust, stem rust and stripe rust, respectively, at the adult plant stage. These lines and cultivars can be included in national breeding programs for further ecological and agronomic assessment.

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