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Resistance Level of Introduced Germplasm of Wheat to Stem Rust in Georgia

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ABSTRACT. Stem rust (*Puccinia graminis* f. sp. *tritici)* is devastating wheat disease, causing significant yield losses in many regions of the world. The use of resistant varieties is the most efficient way to protect wheat crops from stem rust. In the present study, the levels of resistance to stem rust in entries of 4 nd IWWSRRN was determined. Resistance reaction was found in fifteen entries. Thirty nine entries showed moderate resistance. Based on the coefficient of infection and rAUDPC values more resistance against stem rust was determined and most of the lines had a great potential to be used as a source of resistance against stem rust.

Key words: wheat, stem rust, diseases severity, coefficient of infection, slow rusting

INTRODUCTION

The major airborne cereal diseases in most of the world cereal growing areas are rusts. Outbreaks of wheat rusts pose a threat to global food security. Aggressive new strains of wheat stem and stripe rusts have decimated up to 40% of farmers' wheat fields in recent harvests in North Africa, the Middle East, Central Asia and the Caucuses (Chen, 2002; Milus, 2009; Roelfs, 1986). Stem rust (*Puccinia graminis* f. sp. *tritici)* is one the most devastating diseases of wheat in many regions of the world (Wanuera, 2008). The emergence of a new stem rust strain Ug99 in Uganda in 1999 (Pretorius *et al.,* 2000) devastated crops and has spread to Kenya, Ethiopia, Sudan and Yemen, though has to reach the Iran. Georgia is under high risk of spread this race.

Considering the diverse ecology and type of wheats grown in the principal risk areas along the migration path of Ug99 and secondary risk areas of developing countries, the Wheat Rust Disease Global Program was created to manage the Ug99 epidemic and to prevent similar wheat rust threats in the future. The program covers 29 countries already affected by Ug99 or at risk of Ug99 and emphasizes regional and international cooperation and information sharing (Anonymous, 2008).

The objective of the cooperative between partner organizations (FAO, BGRI, ICARDA, CIMMYT) is to evaluate, identify and develop sources of resistance to stem rust in wheat. CIMMYT and ICARDA in collaboration with various National Programs conduct breeding and testing of wheat germplasm. International Winter Wheat Improvement Program (IWWIP) develops and distributes advanced winter wheat breeding lines and improved germplasm across Central Asian and the Caucasian countries. In the framework of collaboration with the IWWIP the 4nd Winter Wheat Stem Rust Resistant Nursery (IWWSRRN) was received from CIMMYT. In the present study, our objective was to determine the levels of resistance to stem rust in entries of 4rd IWWSRRN.

MATERIALS AND METHODS

Plant material. The wheat accessions for this study were selected by International Winter Wheat Improvement Program (IWWIP) representing winter wheat breeding programs in Turkey, Eastern Europe, West Asia and USA. 85 entries of the 4rd Winter Wheat Stem Rust Resistance Nursery combine different type of germplasm resistant to Stem Rust Ug99 population already tested in Kenya.

Field trial design and management. The wheat trials were conducted at experimental area of Institute of Phytopathology and Biodiversity during 2013-2014. 85 international varieties/cultivars/lines were sown in October. Each entry was planted in 3 rows with 2 meter length spaced 20 cm apart at a rate 130 seeds per meter. The trial was hand-planted to reduce the experimental error. 2 rows of standard variety -Bezostaya 1 and universal susceptible variety Morocco were planted within the screening material after every 20th entry to enhance inoculum pressure. Artificial inoculation was carried out with mixture of Georgian races by spraying spore-water suspension. Disease scoring was done 20 days after inoculation in three times with 7-8 days intervals.

The experiment fields were managed based on the practices that were recommended for the respective area. The fields were disk ploughed and then harrowed prior to planting. Mineral phosphorus fertilizer was applied at planting, while ammonium nitrate was applied at rate 90 kg/ha in early spring to promote tillering. Weeds were controlled by hand.

Assessment of disease reaction: Observation on 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 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 proportion of infected plants versus total plants assessed.

Statistical analysis of data. 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). Coefficient of Infection (CI) was used for estimating of Area Under Disease Progress Curve (AUDPC) derived by multiplying response value with the intensity of infection in percent.

To analyze of disease progress value of AUDPC was calculated for each varieties using the following formula (Wilcoxon *et al.*, 1975):

$$AUDPC = \sum_{n-1} 0.5(x_{i+1} + x_i)(t_{i+1} - t_1),$$

Where, x is terminal diseases severity expressed as a proportion at the i^{th} observation; t is the time (days after planting) at the i^{th} observation and n is total number of observations. Estimation of rAUDPC was performed by formula:

rAUDPC =entryAUDPCx100/susceptibleAUDPC

RESULTS AND DISCUSSION

The results of field assessment revealed that fifteen entries had resistance reaction, among them ten entries (T03/17, TAM-107/T21, SD92107-2/SD99W042 , KS95U522/TX95VA0011)F1/JAGGER, AR800-1-3-1/NW97S320, FL9547/NC00-14622, FL9547/TX00D1626, TAM 302/KS93U450, MCCORMİCK/TREGO, NC00-14622/2137) are of USA origin, four entries (TAM200/KAUZ// GOLDMARK/3/BETTY, KS920709-B-5-1-1/BURBOT-4, SOMNEZ, TAM200/KAUZ/4/BEZ/NAD //KZM (ES85.24)/3/F900K,) are of Turkey origin and one variety- AFINA is of Russia origin. Thirty nine entries showed moderate resistance and nearly all of tested entries having very low values of CI (0.2-0.5) and AUPDC (less then 10.0) are the best genotypes with very high levels of resistance (T07/08, T07/09, T08/02, T08/01, T08/02, T08/04, CAKET/PEHLIVAN, ID800994.W/VEE//PIOPIO/3/MNCH/4/FDL4/KAUZ, PBI1013.13.3/3233.35/3/STAR//KAUZ/STAR, DULGER-1//VORONA/BAU, ZANDER-17/3/YE2453/KA//1D13.1/MLT, 55-1744/7C//SU/RDL/3/ CROW/4/MILAN/5/ITOR, 1D13.1/MLT//TUI/3/S?NMEZ/4/ATAY/GALVEZ87, TAM107//ATAY/ GALVEZ87, HBF0290/ X84W063-9-39-2//ARH/3/LE2301, STAR/BWD/3/PRL/VEE#6//CLMS, FRTL//AGRI/NAC/3/KALYOZ-17, CV. RODİNA/AE.SPELTOİDES10 KR, TAM107//ATAY/ GALVEZ87, 06393GP1,). Fifteen entries had combined MR-MS reaction and the rest seventeen entries were moderate susceptible to pathogen.

Table 1. Resistance level of 4nd IWWSRRN entries to stem rust in Georgia.

Entry No	Cross	Origin (Country)	Final Respond	Mean of CI	AUDPC	rAUDPC
1	TAM-107/T21	US-Trio	R	0.2	3.0	0.5
2	SD92107-2/SD99W042	US-SDSU	R	0.2	3.1	0.5
3	KS95U522/TX95VA0011)F1/JAGGER	US-AgriPro South	R	0.2	2.3	0.4
4	AFINA	RUS	R	0.2	3.1	0.5
5	TAM200/KAUZ/4/BEZ/NAD//KZM (ES85.24)/3/F900K	TCI	R	1.4	18.3	3.2
6	AR800-1-3-1/NW97S320	US-NC	R	0.2	2.3	0.4
7	FL9547/NC00-14622	US-NC	R	0.2	2.7	0.5
8	FL9547/TX00D1626	US-NC	R	0.06	2.3	0.4
9	TAM 302/KS93U450	US-NC	R	0.06	2.3	0.4
10	MCCORMİCK/TREGO	US-NC	R	0.06	2.3	0.4
11	NC00-14622/2137	US-NC	R	0.06	2.3	0.4
12	SOMNEZ	TR	R	0.2	3.0	0.5
13	T03/17	SA	R	0.2	3.0	0.5
14	KS920709-B-5-1-1/BURBOT-4	TCI	R	0.3	4.2	0.8
15	TAM200/KAUZ//GOLDMARK/3/BETTY	TCI	R	1.8	19.0	3.4

16	REMESLINA	UKR-MIR	5MR	1.4	24.4	4.3
17	SERI	MX	15MR	3.5	55.4	9.8
18	T07/05	SA	10MR	4.1	63.1	11.2
19	T07/08	SA	5MR	0.2	10.2	1.8
20	T07/09	SA	5MR	0.3	5.3	1.0
21	T08/01	SA	5MR	0.3	5.3	1.0
22	T08/02	SA	5MR	0.5	6.8	1.2
23	T08/04	SA	5MR	0.3	5.3	1.0
24	T08/05	SA	MR	2.8	47.4	8.4
25	PYN/PARUS/3/VPM/MOS83-11-4-8//PEW/4/BLUEGİL	TCI	MR	0.2	3.9	0.7
26	ID800994.W/VEE//PIOPIO/3/MNCH/4/FDL4/KAUZ	TCI	MR	0.2	3.9	0.7
27	PBI1013.13.3/3233.35/3/STAR//KAUZ/STAR	MX-TCI	MR	0.2	3.9	0.7
28	LOV26/LFN/SDY(ES84-24)/3/SERI/4/FDL49../5/LAGOS-6	TCI	30MR	5.5	79.4	14.1
29	TAST/SPRW//BLL/3/NWT/4/55.1744/MEX67.1//NO57/3/ATTILA	TCI	30MR	5.3	78.0	0.9
30	DULGER-1//VORONA/BAU	TCI	MR	0.2	3.9	0.7
31	CAKET/PEHLIVAN	TCI	MR	0.2	2.3	0.5
32	55-1744/7C//SU/RDL/3/CROW/4/MILAN/5/ITOR	URG-TCI	MR	0.2	3.1	0.5
33	1D13.1/MLT//TUI/3/S?NMEZ/4/ATAY/GALVEZ87	TCI	MR	0.2	3.1	0.5
34	HBF0290/X84W063-9-39-2//ARH/3/LE 2301	URG-TCI	MR	0.2	3.9	0.5
35	DULGER-1//VORONA/BAU	TCI	MR	0.2	3.1	0.5
36	ABI 86*3414/X84W063-9-39-2//KARL92/3/CAMPION/4/BLUEGIL-13	TCI	10MR	2.1	32.4	0.5
37	CMH83.2517/6/CMH73.A.329//CMH72-428/MOROCCO/3/ BDFN/4/TEMU36-77/5/MAQUI/CANELO//MAITEN/PATAGUA INIA/7/CEP 27‘S“/CRDN//EMB 27	URG-TCI	5MR	0.9	11.7	0.9
38	KUKUNA/TAM200//PICAREL-1	TCI	20MR	2.9	36.1	0.5
39	LAGOS-11/ESKINA-3//ATAY/GALVEZ87	TCI	5MR	2.1	31.7	0.4
40	STAR/BWD/3/PRL/VEE#6//CLMS	URG-TCI	10MR	0.2	3.9	0.7
41	OK81306/MERCAN-2	TCI	90MR	12.1	147.0	26.1
42	ZANDER-17/3/YE2453/KA//1D13.1/MLT	TCI	5MR	0.2	2.3	0.2
43	OK81306/MERCAN-2	TCI	10MR	2.8	47.8	4.2
44	RINA-6/4/BEZ/NAD//KZM (ES85.24)/3/F900K	TCI	20MR	4.0	62.0	11.0
45	RINA-6/4/BEZ/NAD//KZM (ES85.24)/3/F900K	TCI	20MR	4.0	62.0	11.0
46	TRAKİA//MAGA74/MON/3/SHAHİ /4/EBVD99-1	IR	30MR	6.7	108.0	19.2
47	RINA-6/4/BEZ/NAD//KZM (ES85.24)/3/F900K	TCI	20MR	5.3	92.0	16.4
48	06393GP1	RO	MR	0.6	8.3	1.5
49	CV. RODİNA/AE.SPELTOİDES (10 KR)	RUS	MR	0.2	3.9	0.7
50	ETA/K-62905=ESTER	RUS	20MR	5.3	47.0	8.4
51	CV. RODİNA/AE.SPELTOİDES (10 KR)	RUS	50MR	8.7	117.0	20.8
52	CV. RODİNA/AE.SPELTOİDES (10 KR)	RUS	10MR	4.0	69.0	12.3
53	OR2060395	US-OR	30MR	4.1	49.5	8.8
54	OR2070182H	US-OR	10MR-5MS	2.7	39.0	6.9
55	OR2080156H	US-OR	10MR-1MS	1.4	18.3	3.3
56	CV. RODİNA/AE.SPELTOİDES (10 KR)	RUS	5MR-MS	2.2	36.6	6.5
57	CV. RODİNA/AE.SPELTOİDES (10 KR)	RUS	30MR-5MS	8.0	117.0	20.8
58	CV. RODİNA/AE.SPELTOİDES (10 KR)	RUS	20MR-5MS	4.7	63.0	11.2
59	CV. RODİNA/AE.SPELTOİDES (10 KR)	RUS	30MR-5MS	8.2	119.1	21.2
60	RINA-6/4/BEZ/NAD//KZM (ES85.24)/3/F900K	TCI	20MR-10MS	5.3	78.0	13.8
61	VORONA/HD2402//STEKLOVIDNAYA24	TCI	5MR-5MS	2.7	317.0	56.4
62	TAM107//ATAY/GALVEZ87	TCI	5MR-1MS	0.5	6.8	0.08

63	SERI.1B*2/3/KAUZ*2/BOW//KAUZ/4/BURBOT-4/5/BOEMA	TCI	20MR-1MS	6.9	110.8	1.2
64	X84W063-9-18/U1324-25-1-4-4//K92/3/LE 2301	URG-TCI	10MR-1MS	4.1	63.4	0.7
65	B 10/B. ARRİERO	URG-TCI	10MR-1MS	3.2	48.6	0.6
66	RANA96/GANSU-3	TCI	10MR-20MS	8.7	124.0	1.5
67	FRTL//AGRI/NAC/3/KALYOZ-17	TCI	5MR-MS	1.3	18.0	3.2
68	FRTL//AGRI/NAC/3/KALYOZ-17	TCI	5MR - 1MS	0.3	4.7	0.8
69	BEZOSTAYA	RUS	60MS	21.6	314.8	60.0
70	MOROCCO		80S	38.3	562.5	-
71	SULTAN	TR	70MS	32.3	496.0	88.1
72	VOLOSHKOVA	UKR-MIR	30MS	10.1	142.4	25.3
73	DASHENKA	UKR-MIR	40MS	12.3	160.8	28.6
74	EC - P	SA	40MS	12.3	157.5	28.0
75	FIORINA	SWITZ.	60MS	17.6	224.8	39.9
76	CH111.14422	SWITZ.	20MS	5.8	72.1	12.8
77	SIMANO	SWITZ.	70MS	21.5	260.9	46.3
78	KS920709-B-5-1-1/4/CHAM6//1D13.1/MLT/3/SHI4414/CROW	TCI	40MS	4.6	56.2	0.8
79	BLUEGIL-2/MV.MAGDALENA/3/TX96V2427	TCI	50MS	2.9	36.2	0.4
80	JCAM/EMU//DOVE/3/JGR/4/THK/5/BOEMA	TCI	30MS	10.9	158.8	28.2
81	SANTA	RUS-SAM	30MS	10.9	158.8	28.2
82	PH1B-MUTANT/AE.SPELTOİDES	RUS	50MS	20.0	294.0	52.3
83	PH1B-MUTANT/AE.SPELTOİDES	RUS	50MS	14.9	192.8	34.3
84	CV. LADA/ K-62903	RUS	60MS	34.7	548.0	97.4
85	CV. RODİNA/AE.SPELTOİDES (10 KR)	RUS	10MS	4.3	64.8	11.5
86	CV. RODİNA/AE.SPELTOİDES (10 KR)/S.CEREALE (1.0KR)	RUS	10MS	9.3	138.0	24.5

The final severity of disease on susceptible entries varied from 20% to 70%. Stem rust severity on susceptible check cultivar Morocco was 80% and on local check cultivar Bezostaya 1 was 60%. However, the majority of entries (80 entries) with average CI values of 0.2-20 and five entries with CI 21-40 were regarded as high and moderate level of adult plant resistance, respectively.

Based on the rAUDPC values, the majority of tested entries having rAUDPC values less than 30% of susceptible check Morocco were marked as better slow rusting genotypes. Only five entries (Bezostaya 1, Fiorina, Simano, PH1B-MUTANT/AE.SPELTOİDES, CV. LADA/ K-62903 had rAUDPC values up to 50% of Morocco (Table 1).

The entries of 4nd IWWSRR nursery evaluated to stem rust, especially to race Ug99 in many countries (Kenya, Ethiopia, Turkey etc) showed resistance in the most cases.

So, testing of new wheat germplasm developed by different International Centers and National Programs showed that the 4nd IWWSRR nursery consists of a large number of entries having high level of adult plant resistance to Georgian population of stem rust. These lines and cultivars can be used in future breeding in wheat improvement program or can then be promoted for release in Georgia. However, selected resistant entries should be assessed over years and different locations for determining other important desirable characters before release.

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