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Assessment of Resistance of Local and Introduced Varieties and Breeding Lines to Georgian Population of Wheat Stripe Rust

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ABSTRACT: Stripe rust, caused by *Puccinia striiformis* f. sp. *tritici*, is an important fungal disease of wheat causing significant grain yeild and quality losses in many regions of the world. It has become a serious constraint to wheat production in Georgia in the past years. Growing resistant cultivars is the most effective method of disease control. The goal of this study was to determine levels of resistance in wheat species, old Georgian cultivars, breeding lines and introduced cultivars and to develop a panel of cultivars that can be utilized in future. The responses of fifty two wheat genotypes including wheat species, domestic landraces and introduced entries from different international nurseries to stripe rust Georgian population at seedlings and adult plant stages were studied. High level of juvenile and adult plant resistance to the disease was detected in nearly all tested species and subspecies. Three old domestic varieties Khulugo, Lagodekhis grzeltavtava and Tetri ipkli showed resistance. Varieties Korboulis doli and Almasi were moderately resistant and the rest varieties showed moderate susceptibility with low severity. Resistant reaction both in the seedling and adult plant stages was confirmed in ten advanced breeding lines and eleven introduced Austrian varieties.

Keywords: Breeding Lines, *Puccinia striiformis*, Georgian cultivars, Korboulis doli and Almasi

INTRODUCTION

Stripe rust, caused by *Puccinia striiformis* f. sp. *tritici*, is an important fungal disease of wheat causing significant grain yeild and quality losses in many regions of the world. The disease is more common in cooler environments and is spread in Europe, North America, China, India and the Middle East, Australia and New Zealand. Although stripe rust has been present in the South Caucasus for long time (the Caucasus is considered as the center of its origin by some authors (Zhukovsky, 1965; Stubbs, 1985), it has become a serious constraint to wheat production in Georgia in the past 15 years, which is reflected in the increased occurrence of stripe rust epidemics in Central Asia and South Caucasus (Ziyaev *et al*, 2011). The increased importance of stripe rust in Central Asia and the Caucasus could be explained by introduction of new pathotypes of stripe rust into Central Asia and the Caucasus, or changes in aggressiveness or virulence of the prevalent pathotypes (Hovmoller, *et al.*, 2008). Because of the evolution of new virulent pathotypes of stripe rust, deployed resistance genes are often overcome by the pathogen; therefore, new genes for resistance are needed to develop new improved varieties.

Growing of susceptible varieties is another potential reason explaining the stripe rust outbreaks in the region (Sharma *et al.,* 2012). The average wheat yield in Central Asia and the Caucasus for the last decade is about 1.5 ton/ha, which is lower than in neighboring regions (e.g. West Asia). The lower yields in the country are attributable to poor crop management practices and biotic and abiotic stresses. Stripe rust is the most important and most common biotic stress factor. The losses due to the disease could reach 100% in very susceptible wheat cultivars (Chen, 2005). Growing resistant cultivars is the most effective, economical, and environmentally friendly method of disease control.

The goal of this study was to determine levels of resistance in wheat species, old Georgian cultivars, breeding lines and commercial and introduced cultivars. The research was based primarily on plot trials and should allow subsequent selection of the most promising genotypes. The aim was also to develop a panel of cultivars that can be utilized in future.

MATERIALS AND METHODS

A. Plant materials

The plant materials used in the present research was presented by 12 wheat species and subspecies, 10 old Georgian varieties, 17 introduced varieties with different origin and 11 promised breeding lines from ICARDA (International Center Agricultural Research for Dry Areas). Russian variety Bezostaya 1 was used as control because it has produced in Georgia many years. The variety Morocco was planted as universal susceptible check.

B. Field trials

The trials aimed to screening different wheat genotypes for resistance against to stripe rust were conducted at the greenhouse and filed plot of Phytopathology and Biodiversity Institute during 12014-2015. A total of 52 entries were sown in October. Each entry was planted in 3 rows with 1 meter length spaced 20 cm apart at a rate 120 seeds per meter. Two rows of standard variety -Bezostaya 1 and universal susceptible Morocco were planted within the screening material after every 20th entry to enhance inoculums pressure. In early May, 2014 and 2015 artificial inoculation was carried out at the flag leaf stage of plants with mixture of Georgian races of stripe rust by spraying spore-water suspension. Inoculated plants were covered by polyethylene film for creation of the moist chamber. 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.

To assess the resistance of the seedlings in greenhouse conditions eight to ten plants per selected accessions was raised in 9 cm diameter pots in a coarse potting mix comprising compost and sand. Seven-day-old seedlings were inoculated in the first leaf stage with the water-spores mixture (approximately 3-5mg of freshly collected spores per 1ml of distilled water suspension added 1 drop of Tween 20) and incubated during 24 hours in a dew chamber in dark condition at 15-20°C and 100% humidity. After that the plants were transferred to a growth room where the temperature varied within the range of 18-22°C and relative humidity was 60-70% (Roelfs *et al*, 1992).

C. Assessment of disease reaction

The response of wheat varieties at seedling stage was recorded using the 0-4 scale according to Gassner and Straib (1932) where ITs "0" to 2- were regarded as low IT and ITs "3" and "4" as a high IT. Infection types of adult plants were recorded four times at a 7-8-day interval starting about three weeks after inoculation, according to the 0-9 scale (0-3 considered is resistant, 4-6 considered is intermediate, 7-9 considered is susceptible) described by Line and Qayoum (1992). 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). Severity (%) was estimated for whole plants, based on the proportion of the flag leaf surface area infected by rust. The host plant resistance level 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.

D. 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):

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

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/susceptible AUDPC

RESULTS AND DISCUSSION

The responses of fifty two wheat genotypes including wheat species, domestic landraces and introduced entries from different international nurseries to stripe rust Georgian population at seedlings and adult plant stages were studied. High level (R, MR) of juvenile and adult resistance to the disease was detected in nearly all tested species and subspecies: *Triticum monoccoccum (v*ar. *laetissimum* Korn*), Triticum timopheevi (v*ar. *tipicum* Zhuk-var.*viticulosum* Zhuk*), Triticum dicoccum* (var. *farrum), Triticum carthlicum Men(*var. *fuliginosum Zhuk), Triticum carthlicum Men (v*ar. *stramineum Zhuk), Triticum macha* Dek et Men *(*var. *megrelicum* Men*), Triticum macha* Dek et Men *(*var.*colchicum), Triticum macha* Dek et Men *(*var. *palaeo-imereticum), Triticum spelta* (var. *dekaprelevichi* Dorof.*) Triticum durum* Desf. and *Triticum compactum* Host (var. *icterinum).*

Exception was *Triticum georgicum (*var.*chvamlicum* Supat*)*, which showed the susceptibility (10MS) at seedling stage. The Georgian wheat landraces have been widely used in breeding of wheat as they represent rich sources of genes conferring resistance to diseases. Over the years, breeding for rust resistance has been based on Georgian endemic wheat species: *Triticum timopheevi*, *Triticum zhukovski*, *Triticum carthlicum* in the world (Tyryshkin *et al*., 2011; Knott and Zang, 1990; Dekaprelevich, 1961) *Triticum carthlicum* was found to have also resistance to leaf and stripe rusts (Dekaprelevitch and Naskidashvili, 1976).

As shown in Table 1 three old domestic varieties Khulugo, Lagodekhis grzeltavtava and Tetri ipkli showed resistance (R). Varieties Korboulis doli (5MR) and Almasi (10MR) were moderately resistant and the rest varieties showed moderate susceptibility. The highest severity 90S) was recorded on Tbilisuri 15. Accordingly, the highest value of AUPDC (1120) has Tbilisuri 15. Notwithstanding high infection type (ITs 7-8) of cultivars: Vardzia, Akhaltsikhis tsiteli doli, Dolis puri 35/4, Zedazeni, Kartuli 21, Megobroba, Mukhrani and Aisi those had low severity (≤ 30 %) in the field tests at adult-plant stage and they can be considered as slow-rusting (SR) genotypes. According to different references many old local varieties are known as valuable sources of resistance to the main fungal diseases, which have been incorporated into some improved varieties. For instance, Georgian varieties:Vardzia, Bagrationi, Deda, Mukhrani, Motsinave were developed from local landraces: Dika, Khulugo, Dolis puri (Naskidashvili *et al.*, 1983; Menabde,1948).

Table 1: Characteristics of resistance of Georgian wheat varieties to stripe rust artificial infection.

S. No.	Entry	Disease Reaction	Coefficient of Infection(CI)	AUPDC	rAUDPC
1	Vardzia	30MS	24.0	520	25
2	Tblisuri 15	90S	90.0	1120	54.9
3	KKhulugo	R	0.2	22.0	1.1
4	Lagodekhis grzeltavtava	R	0.2	22.0	1.1
5	Korboulis doli	5MR	2.0	55.0	1.1
6	Akhaltsikhis tsiteli doli	30MS	24.0	121.0	5.9
7	Tetri ipkli	R	0.2	22.0	1.1
8	Almasi	10MR	4.0	110.0	5.4
9	Dolis puri 35/4	20MS	16.0	158.5	7.8
10	Tbilisuri 5	30MS	24.0	520	25
11	Zedazeni	10MS	8.0	221.0	10.8
12	Kartuli 21	20MS	16.0	172.5	8.4
13	Megobroba	5MS	4.0	98.5	4.8
14	Mukhrani	20MS	16.0	150.0	7.3
15	Aisi	20MS	16.0	112.5	5.5
16	Lomtagora 123	50MS	40.0	367.5	18.0
17	Sauli 9	80S	80	1002	49.1

The varieties Sauli 9, and Lomtagora 123 which were selected from international nurseries developed by ICARDA and CIMMYT during years and accepted for release in Georgia five years ago as resistant varieties (Sikharulizde *et. al*, 2014) showed susceptible reaction and high severity in our study.

Over last 15 years new wheat cultivars were introduced into the country via different ways including genotypes developed by international breeding programs. In this case, it is necessary to evaluate them to the existing in Georgia stripe rust population. The field tests for evaluating of resistance level of advanced breeding lines selected from ICARDA's different nurseries showed that a resistant reaction both in the seedling and adult plant stages was confirmed in ten advanced breeding lines out of eleven: Attila*2/P8 -20HRWYT-5, Kinaci-97, 17IWWYT-IR-9803, Tacupeto-F2001/6/CNDO, 20HRWYT-225, Tacupeto-F2001/6/CNDO, 20HRWYT-225, Amsel/TUI//…LG-44, 17IWWYT-IR-9803; HBK0935W-24, KR-11 -9043, KR-11 -003, KR-11 -014, KR-11 -015 and shafag 2. Only one line 19FAWWON-SA-79 showed susceptible reaction with low severity (10%) and low AUPDC (220)(Table 2).

Assessment of eighteen bread wheat varieties introduced from Russia, Austria, France and German showed that all Russian varieties: Krasnodrskaya 99, Tanya, Sila, Mirleben and German variety Diego were susceptible (S) and moderate susceptible (MS), respectively. Severity of these varieties was very high (60-80%), accordingly, coefficient of infection (48-90) and AUPDC (750-1230) were also high (Table 3.).

Table 2: Reaction of breeding lines to stripe rust artificial infection.

S. No.	Entry	Origin	Disease Reaction	Coefficient of Infection(CI)	AUPDC
1.	19FAWWON-SA-79	ICARDA	10MS	8	220
2.	Attila*2/P8 -20HRWYT-5	ICARDA	5MR	2	130
3.	Kinaci-97, 17IWWYT-IR-9803	ICARDA	20MR	8	385
4.	Tacupeto-F2001/6/CNDO, 20HRWYT-225	ICARDA	R	0.2	22
5.	Amsel/TUI//… LG-44	ICARDA	R	0.2	22
6.	17IWWYT-IR-9803; HBK0935W-24	ICARDA	R	0.2	22
7.	KR-11 -9043	ICARDA	5MR	2.0	42
8.	KR11-003	ICARDA	R	0.2	22
9.	KR11-014	ICARDA	R	0.2	22
10.	KR11-015	ICARDA	5MR	2.0	42
11.	Shafag 2	ICARDA	R	0.2	22

Table 3: Response of introduced wheat varieties to stripe rust artificial infection.

S. No.	Entry	Origin	Disease Reaction	Coefficient of Infection(CI)	AUPDC	rAUDPC
1.	Bezostaya 1	Russian	90S	90	1335	65.4
2.	Krasnodrskaya 99	Russian	80S	80	1225	60.0
3.	Tanya	Russian	80S	80	1230	60.3
4.	Sila	Russian	80S	80	1050	51.5
5.	Mirleben	Russian	60S	60	860	42.2
6.	Diego	German	60MS	48	750	36.8
7.	Amandus	France	R	0.2	22	1.1
9.	Amicus	Austrian	R	0.2	22	1.1
10.	Balitus	Austrian	R	0.2	22	1.1
11.	Gallus	Austrian	0	0	0	0
12.	Fidelius	Austrian	0	0	0	0
13.	Lukullus	Austrian	0	0	0	0
14.	Lupus	Austrian	R	0.2	22	1.1
15.	Urbanus	Austrian	0	0	0	0
16.	Amebelo	Austrian	0	0	0	0
17.	Asano	Austrian	0	0	0	0
18.	Premio	Austrian	R	0.2	22	1.1

Thus, the results of our study showed that a majority of tested accessions (66%) had high and moderate resistance to Georgian population of stripe rust. The results of this study also support the fact, that nowadays the wild relatives could be valuable sources of resistance to the stripe rust races in our country. This research results could be useful for the national and international breeding programs in either further evaluation the stripe rust resistant lines for varietal identification or using them as parents in the crossing.

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