Juvenile resistance to diseases in samples of *Triticum* L. species from VIR World Collection

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Summary

Seedling (juvenile) resistance to 3 foliar diseases was studied in 540 samples of 24 *Triticum* L. species from VIR World Collection. Samples of *T. timopheevii*, *T. militinae*, *T. zhukovskyi*, *T. timococcum* and 4 of *T. boeoticum* were highly resistant to complex population of leaf rust causal agent. Presence of *Puccinia recondita* clones virulent to samples of *T. miguschovae* and *T. kiharae* (synthetic hexaploids with genome A^bGD) indicates to partial suppression of resistance from species with A^bG genome by D genome of *Ae. tauschii*. Two samples of *T. araraticum* and one of *T. timopheevii* were resistant to dark-brown leaf spot blotch. Three samples of *T. araraticum* and two of *T. timopheevii* were classified as resistant after inoculation with mixture of 7 *Stagonospora nodorum* isolates. All 239 samples of 6 species studied were susceptible to common root rot. The causes of differences between our results and that obtained in other studies are discussed.

Index words: *Triticum*, leaf rust, dark-brown leaf spot blotch, *Septoria nodorum* blotch, common root rot, juvenile resistance.

Introduction

Bred wheat (*Triticum aestivum* L.) is one of the most important grain crops in the world. Diseases of wheat, mostly caused by fungal pathogens, are important production constraints in almost all wheat-growing environments. The cheapest and ecologically profitable method to control them is to breed and grow resistant varieties. This is generally limited by low number of donors of resistance protected by new earlier unemployed genes for resistance. Wheat samples from Vavilov Institute of Plant Industry (VIR) World Collection with effective juvenile resistance to leaf rust (*Puccinia recondita* Rob. ex Desm.) have only genes Lr 9, 19, 24, 41 now widely used in breeding (Tyryshkin et al., 2004b); no one genotype was found to be highly resistant to dark brown leaf spot blotch and common root rot (both caused by *Bipolaris sorokiniana* Shoem.) and septoria glume blotch (*Stagonospora nodorum* Berk.) (Tyryshkin and Tyryshkina, 2003).

One of the possible approaches to create new wheat donors is introgression of genes for resistance from wild and cultivated relatives, including species of *Triticum* genus as primary and secondary gene pools. At least 4 named genes for resistance to leaf rust were transferred to *T. aestivum* genome from another *Triticum* species: *Lr*18 from *T. timopheevii*, *Lr*23 from *T. durum*, *Lr*44 from *T. spelta* (McIntosh et al., 1998) and *Lr*50 from *T. timopheevii* subsp. *armeniacum* (= *T. araraticum*) (Brown-Guedira et al., 1997; Brown-Guedira et al., 2003).

VIR World Collection of wheats was extensively studied for juvenile and field resistance to fungal diseases including leaf rust (Berljand-Kozhevnicov et al., 1978; Krivchenko et al., 1984; Makarova et al., 1993; Gultyaeva et al., 2002), septoria glume blotch

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(Yamaleev et al., 1990) and dark-brown leaf spot blotch (Mikhailova et.al., 2004). Juvenile resistance usually was studied with use of so called "benzimidazole method": detached leaves of samples were placed on cotton-wool wetted with water solution of the chemical and inoculated with pathogens (Mikhailova and Kvitko, 1970; Mikhailova et al., 1982; Tyryshkin and Mikhailova, 1993).

Genotype-dependent induction of resistance to foliar diseases by this chemical was shown in wheat (Tyryshkin et al., 2005), barley (Tyryshkin and Solovieva, 2001) and *Aegilops* (Kolesova and Tyryshkin, 2004) so use of that technique could lead to mistaken description of some susceptible samples as resistant.

The purpose of present work is to evaluate juvenile resistance in samples of *Triticum* genus to three foliar diseases and common root rot and to identify genotypes with high level of the resistance expression.

Material and Methods

Seedling (juvenile) resistance to foliar diseases was studied in 538 samples of 24 *Triticum* L. species from VIR World Collection (Table). For analysis samples from different ecologo-geographical regions were taken, but in *T. aethiopicum*, *T. persicum*, *T. turgidum* only samples earlier described as highly resistant to leaf rust at seedling stage (Makarova et al., 1993) were evaluated. In this study classification in genus *Triticum* adopted in Russia (Dorofeev et al., 1979; Dorofeev et al., 1987) was used.

The seeds were sown in cuvettes on wet cotton wool and kept in the darkness. After seedling emergence cuvettes were placed in light room at 20-22 °C and constant illumination.

For inoculation complex population of *P. recondita* (mixture of isolates collected in North-West region, Leningradskaia oblast, and North Caucasus, Derbent district), aggressive isolate T of *B. sorokiniana* (Tyryshkin and Mikhailova, 1993) and mixture of 7 *S. nodorum* isolates were used. Population of leaf rust pathogen was virulent to *Lr* genes 1, 2, 3ka, 3bg, 10, 13, 14a, 15, 16, 17, 18, 20, 21, 23, 27+31, 30, 32, 33, 34, 35, 37, 42, 44, avirulent to Lr 9, 24, 41; on samples with *Lr* 19, 26 only rare pustules were recorded. *S. nodorum* isolates were kindly provided by Dr. A. Buloichik (Institute of Cytology and Genetics, National Academy of Sciences, Belarus).

Intact plants (1st leaf stage) were sprayed with water suspension of the pathogens spores, cuvettes were wrapped into polyethylene, kept in the darkness for 24 h. and placed in light room; polyethylene from cuvettes inoculated with *P. recondita* was removed. Concentrations of suspensions (spores/ml) were 3×10^4 for *P. recondita*, 5×10^4 for *B. sorokiniana* and 1×10^7 for *S. nodorum*.

Types of reaction were scored 10th day after inoculation with *P. recondita* according to scale of Mains and Jackson (1926); samples with types 0, 0;, 1, were classified as highly resistant. Disease ratings were scored 7 days after inoculation with *B. sorokiniana* or *S. nodorum* according to original scale (Tyryshkin et al., 2004b) from 0 (no symptoms) to 6 (death of leaf); samples with ratings 0 - 3 were classified as resistant.

Samples selected as resistant were reevaluated for reactions in at least 3 independent experiments with intact plants and in one experiment with leaf segments, placed on cotton-wool wetted with water (Tyryshkin, 2001).

Table: Species of genus *Ttriticum* L. being under study for resistance to fungal foliar diseases

Species	Number of chromosomes (2n)	Genome	Number of samples evaluated for resistance
	Subgenus *Triticum*		
T. urartu Thum. ex Gandil.	14	A^u	75
T. aethiopicum Jakubz.	28	A^uB	5
T. dicoccoides (Koern. ex Aschers. et Graenbn.) Schveinf.	28	A^uB	50
T .ispahanicum Helsot	28	A^uB	2
T. karamyschevii Nevskyi	28	A^uB	3
T. persicum Vav.	28	A^uB	13
T. turgidum L.	28	A^uB	30
T. erebuni Gandil.	28	A^uD	1
T. compactum Host	42	A^uBD	56
T. macha Dekapr. et Menabde	42	A^uBD	37
T. spelta L.	42	A^uBD	52
T. sphaerococcum Perciv.	42	A^uBD	27
	Subgenus *Boeoticum* Migush. et Dorof.		
T. boeoticum Boiss.	14	A^b	48
T. sinskajae Filat. et. Kurk	14	A^b	1
T. araraticum Thum. ex Gandil.	28	A^bG	84
T. timopheevii Zhuk.	28	A^bG	44
T. militinae Zhuk. et Migusch.	28	A^bG	2
T. zhukovskyi Menabde et Ericzjan.	42	A^bA^bG	1
T. palmovae Ivanov.	28	A^{bD}	1
T. timococcum Kost.	42	A^bA^bG	1
T. miguschovae Zhir.	42	A^bGD	1
T. kiharae Dorof. et Migusch.	42	A^bGD	1
T. fungicidum Zhuk.	56	A^uA^bBG	2
T. timonovum Helsot et Ferrary	56	A^bA^bGG	1

For reaction to common root rot, caused by *B. sorokiniana*, only samples of *T. urartu*, *T. dicoccoides*, *T. boeoticum*, *T. araraticum*, *T. timopheevii*, *T. militinae*, *T. miguschovae* and *T. timonovum* were screened. Germinated seeds were sown in sand infested with conidia of the pathogen isolate T (10^4 conidia/g). Disease ratings on roots and coleoptiles were scored 15 days after according to scale from 0 (absence of symptoms) to 6 (plant death) (Tyryshkin et al., 2004b).

Results

Most samples under study were susceptible to the diseases.

All samples of *T. timopheevii*, *T. militinae*, *T. zhukovskyi* and *T. timococcum*, 4 of *T. boeoticum* – kk-59171 (Azerbaijan), 59175 (Ukraine), 62490, 62492 (Bulgaria), were highly resistant to leaf rust. On leaves of *T. kiharae*, *T. miguschovae*, *T. timonovum* samples and *T. aethiopicum* sample k-19056 (Ethiopia) only single pustules were recorded.

To dark-brown leaf spot blotch high level of resistance was found only in 3 samples: ii-589766, 589727 (Iraq) of *T. araraticum* and k-29551 of *T. timopheevii* (Georgia).

High level of juvenile resistance to *S. nodorum* was found in samples ii-589754, 589756, 589770 of *T. araraticum*; kk-58666 and 29558 of *T. timopheevii*. In general samples of *T. timopheevii* classified as susceptible were less diseased (scores 4-5) than that of other species and *T. aestivum* checks (usually score 6).

Reaction to inoculation with *P. recondita* and *S. nodorum* of intact plants of selected highly resistant samples was the same as that of leaf segments; reaction to *B. sorokiniana* inoculation was slightly higher in the case of leaf segments.

All samples under study were susceptible to common root rot.

Discussion

Samples of wheats from Vavilov Institute of Plant Industry (VIR) World Collection were studied earlier for resistance to leaf rust, dark-brown leaf spot blotch and *S. nodorum* blotch.

Makarova et al. (1993) studying seedling resistance to leaf rust in 1331 samples of 9 *Triticum* species have identified 57 highly resistant genotypes in *T. dicoccodes*, *T. dicoccum*, *T. persicum*, *T. spelta*, *T. turgidum*, *T. urartu*. All of them were classified as susceptible in our study. Gultyaeva et al. (2002) found 4 samples of *T. spelta* resistant in seedling and adult stage to leaf rust; one of them k-21439 was in our work and showed high susceptibility; moreover Thatcher line with gene *Lr*44 was described as resistant but gave type of reaction 3 in present study. It should be noted that in 2 above mentioned investigations "benzimidazole method" was used to study resistance. There can be 2 explanations of differences between the data: 1. the pathogen population in our work consisted of much more *P. recondita* isolates with broader pattern of virulence; 2. as in wheat, barley and *Aegilops* benzimidazole induces resistance in some susceptible samples of *Triticum* species. In any case the samples described as resistant could not be assumed as possessing effective genes for juvenile resistance.

From 538 samples under study only that of 5 species possess very effective resistance to leaf rust. Resistance in *T. timopheevii* and spontaneous mutant from it *T. militinae* is well documented as in *T. zhukovskyi* (for example, Berljand-Kozhevnicov et al., 1978; Krivchenko et al., 1984). Among synthetic wheat forms *T. timococcum* (*T. timopheevii* × *T. monococcum*) was highly resistant. Surprisingly virulent clones to samples of *T. miguschovae* (*T. militinae* × *Ae. tauschii*), *T. kiharae* (*T. timopheevii* × *Ae. tauschii*) and *T. timonovum* (allodiploid of *T. timopheevii*) were found. In the first two cases it can likely be explained by partial suppression of resistance of *T. timopheevii* or *T. militinae* by D genome of *Ae. tauschii*. If it is so possibility of introgression of single highly effective seedling genes for leaf rust resistance from *T. timopheevii* to *T. aestivum* is questionable. Till now two mapped genes were introgressed from *T. timopheevii* *Lr*18 and *Lr*50. The first is not effective in seedlings against population of *P. recondita* from Russia (Tyryshkin, 2001); races virulent to *Lr*50 existed in USA before its commercial use (Brown-Guedira et al., 2003). Presence of virulent clones to *T. timonovum* is possibly connected with non authenticity of the sample in the Collection. No one gene was introgressed into bred wheat from *T. boeoticum* (McIntosh et al., 1998); so samples of the species with resistance to rust could be of big interest for breeding. Taking into account different origin of the samples we could suppose no identical genetic control of their resistance. Principal possibility of relatively easy transferring of *T. boeoticum* genes for resistance into *T. aestivum* was shown (Valkoun, 2001).

Unnamed genes for effective leaf rust resistance were reported to be successfully transferred to *T. aestivum* from *T. erebuni*, *T. palmovae*, *T. dicoccoides* (Babajants et al., 2001). All samples of these species were susceptible in our study; possibly they are protected in field by genes for adult resistance.

Studying juvenile resistance to 1 isolate of *Septoria nodorum* in 14 *Triticum* species Yamalleev et al. (1990) found *T. beoticum*, *T. zhukovskyi*, *T. kiharae* to be the most resistant, but no information on intraspecific variation for the traits was listed. Only 5 samples – 3 of *T. araraticum* and 2 of *T. timopheevii* – were classified as highly resistant in present study. It should be noted that we inoculated intact plants and leaf segments placed on water *versus* inoculation of leaf segments in benzimidazole in the cited work. Besides for inoculation we use higher concentration of pathogen spores and mixture of several aggressive isolates.

Among 19 *Triticum* species studied for reaction to dark brown leaf spot blotch the most resistant were samples of *T. urartu*, *T. monococcum*, *T. persicum*, *T. spelta*, *T. macha* and *T. vavilovii* (Mikhailova et al., 2004). No one sample of 4 species from them was resistant in present study; susceptibility of all *T. monococcum* samples from VIR Collection was shown in our previous work (Tyryshkin et al., 2004a). The reason of differences in resistance evaluation could be influence of benzimidazole to reaction expression, differences in aggressiveness of the pathogen isolates and inoculum pressures. Partial proof of more correctness of our data is report on high susceptibility of *T. urartu* samples to the disease (Dhalival et al., 1986). Only 3 samples were highly resistant to spot blotch; all of closely related species *T araraticum* and *T. timopheevii.*

Despite evident differences in the inoculums used in our and previous studies we suppose that primary reason of differences in results of the samples evaluation is induction of resistance by benzimidazole in leaf segments although we have not verified this hypothesis for species of genus *Triticum*. This induction was shown in 2 bred wheat varieties for resistance to stem rust (Forsyth, Samborski, 1958), in 2 wheat samples to dark brown leaf spot blotch (Hetzler, 1992), samples of barley (Tyryshkin and Solovieva, 2001), wheat (Tyryshkin, 2001; Tyryshkin et al, 2005) and *Aegilops* species (Kolesova. and Tyryshkin, 2004) to several foliar diseases. All samples identified in this study as resistant at intact plant level were resistant when leaf segments placed on cotton wool wetted with water were inoculated, so the last method could be recommended to study resistance to 3 foliar diseases in *Triticum* species.

Studying of genetics of resistance in selected samples is planned.

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