Resistance of Triticale to Wheat Leaf Rust (*Puccinia triticina*)

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Abstract: Reactions of winter triticale cultivars mostly from central Europe to recent and old leaf rust isolates were tested in the greenhouse. In one trial 20 cultivars were tested with 8 leaf rust isolates, collected recently from official wheat and triticale trials in the Czech Republic and Slovakia. In another trial 15 cultivars were tested with 6 old leaf rust isolates, used to identify leaf rust resistance genes in wheat. The cultivars Cando, Hortenso and Tricolor, registered in the Czech Republic, were resistant to the majority of the recent isolates. The Hungarian cultivar Tatra was resistant to all the recent isolates. The old leaf rust isolates were virulent only to a few of the triticale cultivars. Randomly selected isolates from wheat and triticale were tested on triticale cultivars and on Thatcher near isogenic lines with different *Lr* genes. On average, leaf rust isolates from triticale were virulent to a higher number of triticale cultivars than isolates collected from wheat and vice versa.

Keywords: *Puccinia triticina*; triticale; variety resistance; wheat leaf rust

Triticale is a cereal crop adapted to less favourable soil conditions. It is suitable for low input farming because of lower demands on pesticides application. It can be used for feeding, in distillery industry or human nutrition. Recently it became an important crop for ethanol production. Disease resistance is particularly important for farming with limited or no use of pesticides (e.g., organic farming). Triticale as a hybrid of wheat and rye may possess disease resistance derived both from wheat and rye. The leaf rust isolated from triticale in the field is usually wheat leaf rust *Puccinia triticina* (syn. *Puccinia recondita* f.sp. *tritici*) and triticale is usually resistant to leaf rust of rye (syn. *P. tritici* f.sp. *secalis*). In the Czech Republic Stuchlíková and Bartoš (1980) obtained no infection when leaf rust from rye was applied for inoculation of triticale cultivars. They used wheat leaf rust in the tests for triticale resistance. Quinones *et al.* (1972) expressed opinion, that resistance in triticale was conferred only by genes derived from the wheat parent. The above mentioned data suggest that triticale cultivars usually suffer from pathogens attacking wheat and resistant cultivars usually also possess resistance derived from wheat. However, we are short on data indicating differences between *Puccinia triticina* isolates collected from wheat and those from triticale. E.g., Manninger (2006) analyzed 82 isolates from wheat and triticale on 15 Thatcher near isogenic lines with different *Lr* genes. More than 50% of isolates were virulent to *Lr2b*, *Lr2c*, *Lr3*, *Lr11*, *Lr17*, *Lr21* and *Lr*26. On the other hand of 12 analyzed leaf rust isolates from triticale 9 were virulent only to *Lr2b* and *Lr2c* and other 3 isolates from triticale were virulent only to *Lr2b*, *Lr2c* and *Lr11*.

The aim of our work was to study resistance of triticale to wheat leaf rust and analyze whether specific differences in virulence exist between wheat leaf rust isolates attacking wheat and isolates attacking triticale.

MATERIAL AND METHODS

Two greenhouse tests for resistance were carried out. In the first test 20 triticale cultivars were tested with selected 8 leaf rust isolates from samples collected in 2008 and described on Table 2. In the second test 15 cultivars were tested with 6 isolates originated from various locations and years from the last century (Hanzalová 2010). They were used because of their ability to differentiate leaf rust resistance genes in wheat cultivars. Samples of wheat leaf rust were obtained on leaves from different triticale and wheat cultivars mainly from the variety trials of the Central Institute for Supervising and Testing in Agriculture in the Czech Republic and the Central Controlling and Testing Institute in Agriculture in Slovakia. Rust samples from wheat originated from 14 places (Blížkovice, Břeclav, Drákovice, Hradec nad Svitavou, Chrastava, Chrlice, Lípa, Němčice, Praha-Ruzyně, Pusté Jakartice, Svitavy, Trutnov, Úhřetice, Věrovany), rust samples from triticale from 12 places (Beluša, Chrastava, Chrlice, Janov, Lípa, Oldříškovice, Praha-Ruzyně, Pusté Jakartice, Radošiná, Spišská Belá, Velké Ripňany, Víglaš), five places of them being the same for samples from the both cereals. On the average 2–3 samples were analyzed from each location. Rust samples were increased on susceptible cultivars Michigan Amber (wheat) or cv. Kargo (spring triticale). When flecks appeared on inoculated leaves, leaf segments with one developing uredinium were transferred to Petri dishes with water and kept in the greenhouse until urediospores have developed. Single pustule isolates were increased on cv. Michigan Amber or cv. Kargo for tests on differentials. All tests were performed with single pustule isolates. Inoculation of seedlings was carried out with water suspension of urediospores. Inoculated plants were kept in closed glass cylinders to provide high air humidity for 24 h.

Table 1. Reactions of triticale cultivars to 8 wheat leaf rust isolates

Cultivar	Country of origin	Rust-field*	Provenience of rust/infection type**							
			Ruzyně	Lípa	Chrlice 1	Chrlice 2	Beluša	Oldříškovice	Radošiná	V. Ripňany
			A	B	C	D	E	F	G	H
Kinerit	CZ	–, –, –, –	3	3	;1	1;	;	;	;1	;2
Kolor	CZ	–, –, –, –	3	3	3	;	;2	3	;2	;2
Nazaret	CZ	–, –, –, –	2–3	3	3	;2N	3	;2	;1	;2
Benetto	PL	–, –, –, –	3	3	;1	1;	;	;	;1	;1
Dinaro	PL	–, –, –, –	3	3	3	;2	0	;2	;1	;1
Pawo⁺	PL	–, 7, 7, –	3	3	3	3	;2	;1	;	;
Todan⁺	PL	–, 7, 7, –	3	3	3	;1	3	;2	;N	;1
Hortenso⁺	PL	–, 7, 7, 7	3	3	;2N	;2	;1	;2	;2	–
Kitaro⁺	PL	4, 5, –, –	3	3	3	;	3	;2	;1	;1
Gutek⁺	PL	5, 5, –, –	3	3	3	3	3	;	;1	;2
Ticino⁺	DE	8, 8, –, 7	3	3	3	3	;	;1	;	;2
Mungis⁺	DE	–, 8, 8, 8	3	3	3	0	3	;1	;2	;
Cando⁺	DE	–, 7, 7, –	3	3	–	;	;	;1	;1	;1
SW Talentro⁺	DE	6, 6.5, 6, 6	0	3	3	3	0	;2	;1	;
Triamant⁺	DE	7, 8, 8, –	3	3	3	;2	3	3	3	3
Lupus⁺	DE	6, 7, 7, –	3	3	3	;	;2	3	;2	3
Inpetto⁺	DE	6, 6, 6, 5	3	3	3	;1	;2	;2	;2	3
Modus⁺	DE	–, –, –, –	3	3	3	;	3	3	;	;2
Tricolor⁺	FR	7, –, –, –	2–3	3	;2N	;	;2	;2	;2	;2
Tatra	HU	–, –, –, –	;2	;2N	;2N	;	;1	;1	;	;1

*Leaf rust severity in cultivars tested in the official trials of the Central Institute for Supervising and Testing in Agriculture variety trials (2007, 2008, 2009, 2010, respectively), scale: 9 – resistant, 1 – susceptible; – not evaluated in the field
**Infection types: ;, ;1, 2 – resistant, 2–3, 3 – susceptible, N – necrosis; ⁺Registered in the Czech Republic

Table 2. Reactions of isolates A–H (Table 1) on 17 NILs with different *Lr* genes

Locality	Thatcher NILs with *Lr**																
	1	2a	2b	2c	3a	9	10	11	13	15	17	19	21	23	24	26	28
A – Ruzyně (CZ)	;2	3	3	3	;	0	3	3	3	;2	;2	0;	3	;2	;1	3	0
B – Lípa (CZ)	0;	;2N	3	2	;1	0	3	3	3	;2	;2	0	3	3	0;	3	0;
C – Chrlice 1 (CZ)	;1	;2	3	;2	;1	0	3	3	3	;2	;2	0;	3	;2N	0;	3	0
D – Chrlice 2 (CZ)	3	0	;	;	3	0	3	3	3	3	3	0;	3	;2	0	0	0
E – Beluša (SK)	3	0	;2	3	3	0	3	3	3	3	3	0	3	3	0;	;2	3
F – Oldříškovice (CZ)	;1	3	3	3	3	;	3	3	3	3	;2	0;	3	3	0;	3	0;
G – Radošiná (SK)	;	;	;2	;1	3	0	3	3	3	3	3	3	3	3	;	3	0;
H – V. Ripňany 3 (SK)	3	;2	;2	;2	;1	3	3	3	3	3	3	0	3	3	;	;2	0

*Infection types: ;, ;1, 2 – resistant, 2–3, 3 – susceptible, N – necrosis

Randomly selected isolates from different localities and cultivars were further analyzed. Infection types were basically evaluated according to Stakman *et al.* (1962) 10–14 days after inoculation when plants were kept in a greenhouse at 18–22°C. Avirulence/resistance was characterized by infection types ; 0–2, virulence/susceptibility by infection types 2–3 and 3, necrosis by N. Basically Thatcher near isogenic lines (NILs) with single *Lr* genes approved as leaf rust differentials by participants in the international COST 817 Action (Mesterházy *et al.* 2000) were used in the tests. Seed of the NILs was supplied by Dr. J. Kolmer to the Cereal Research Non-Profit Company in Szeged, Hungary, and was subsequently increased for the participants of COST Action 817. Pedigree of NILs is described in the paper by Mesterházy *et al.* (2000). Seed of the registered cultivars was obtained from the Central Institute for Supervising and Testing in Agriculture in the Czech Republic and Selgen – Plant Breeding Station, Úhřetice.

RESULTS

Results of the tests for leaf rust resistance of triticale cultivars with 8 wheat leaf rust samples from the Czech Republic (6 samples) and Slovakia (2 samples) are summarized in Table 1. The results show distinct differences in reactions of the cultivars to the applied isolates on the one hand as well as distinct differences in virulence of the isolates on the other hand. This suggests a rather complex genetic background of leaf rust resistance. Three of the applied rust isolates were virulent to almost all tested triticale cultivars, in other isolates avirulence prevailed. Data on leaf rust severity in the variety trials of the Central Institute for Supervising and Testing in Agriculture indicate relatively high resistance in the field of the most triticale cultivars, except cvs Kitaro, Gutek and Inpetto. At the seedling stage these cultivars were susceptible to 4–5 isolates out of 8 isolates. However, also cultivars that had only a low disease severity in the field were susceptible at the seedling stage, e.g., cv. Triamant was suscep-

Table 3. Reaction of triticale to 6 wheat leaf rust isolates

Cultivar	Rust isolate*/infection type					
	4332	333	347/6	4332/3	4003/4	628
Ticino	0;	0;	0;	0	0	0
Kitaro	0	0	0;	0;	0;	0
Mungis	0;	0;	0	0;	0;	0
Todan	0	0;	0;	0;	0;	0
Tricolor	0;	0;	0;	0;	0;	0;
Hortenso	0	0;	0;	0;	3–	0
SW Talentro	0;	0;	0	0	0;	0
Triamant	3	3	3	3	3	3
Lupus	3	3–	3	3	3	3
Inpetto	0;	0	0;	0;	0;	0
Gutek	3	;2+	3–	3–	3	3
Doublet	0	0;	0	0	0;	0
Lamberto	0;	0;	0	0	0;	0;
Marko	3	3	3	3	3	3
Tornado	3	3	3	3–	3–	3–

For description of isolates see Hanzalová (2010)

Table 4. Reactions of leaf rust isolates from triticale ([tr]) and wheat ([w]) on 15 Thatcher *Lr* NILs and 7 triticale cultivars

Locality	Cultivar	Thatcher NIL with *Lr*															Cultivar						
		1	2a	2b	2c	3a	9	11	15	17	19	21	23	24	26	28	Gutek	Talentro	Agrano	Lupus	Modus	Inpetto	Kitaro
Chrastava	Lupus[tr]	0;	;2	3	;2	;1	0;	3	;2	;2N	;	3	;2	;1N	3	0;	3	3	3	0;	0;	3	3
	Aranka[w]	3	3	3	3	3	;	3	3	3	;	3	3	;	3	;2	3	;1N	;1	3	;2	;2	;1
Lípa	Hortenso[tr]	0	;2	;2	2	;1	0	3	;2	;2	0	3	;2	;1N	3	0;	3	3	3	3	3	3	3
	LP 53304[w]	3	0;	;1	;	3	;	3	3	3	;	3	;2–3	;1	3	3	3	0;	;1	3	;1	;1	;1
Pusté Jakartice	Inpetto[tr]	0;	;2N	3	3	;1–2	0;	3	3	3	0;	2–3	3	;	3	0	3	3	3	0;	;1–2	3	3
	Barryton[w]	3	0	0(3)	;2	0;	3	3	;2	3	;	3	3	;2	2-3	3	3	3	;1	;2N	3	;1	;2
Chrlice	Inpetto[tr]	0;	;2	3	2	;2	0	3	;2N	1–2	0;	3	;2	;1	2	0;	3	3	3	0	3	3	0;
	Samanta[w]	;	3	3	3	3	0;	3	3	3	;	3	3	;2	3	;1	3	3	;2	;3N	3	;2	;1

Table 5. Virulence on 15 Thatcher *Lr* NILs (% of virulent isolates from the tested isolates)

Isolates from	No. of rust isolates	Thatcher NILs with *Lr*														
		1	2a	2b	2c	3a	9	11	15	17	19	21	23	24	26	28
Triticale	36	5	10	18	16	10	4	36	20	18	0	34	24	0	28	5
Wheat	36	34	13	14	16	27	1	35	31	36	0	36	31	2	23	11

Table 6. Virulence on 7 triticale cultivars (% of virulent isolates from the tested isolates)

Isolates from	No. of rust isolates	Cultivar						
		Gutek	Talentro	Agrano	Lupus	Modus	Inpetto	Kitaro
Triticale	36	20	18	18	18	18	18	17
Wheat	36	26	0	0	31	1	1	0

tible to 7 rust isolates. Of the cultivars not tested in the variety trials of the Central Institute for Supervising and Testing in Agriculture cv. Tatra was resistant to all tested rust isolates, followed by cvs Kinerit, Benetto and Dinaro, resistant to 5–6 out of 8 tested isolates. Another test of resistance, carried out with older leaf rust isolates, comprised 11 cultivars that were included also in the first test summarized in Table 1, and 5 additional cultivars (Table 3). Older leaf rust isolates had a narrower spectrum of virulence than recently obtained isolates. Unlike in the first test in the second test the majority of triticale cultivars were resistant to all rust isolates. Susceptible reactions to all or most rust isolates in cvs Triamant, Lupus and Gutek in the second test is in agreement with the results of the first test. All these three cultivars were susceptible in these tests to the majority of the applied isolates. In the second test in addition to the above mentioned cultivars also cvs Marko and Tornado were susceptible. These two cultivars were not included in the first test.

Data on seedling resistance (Tables 1 and 3) have only a limited value for the estimation of field (adult plant) resistance as was shown by the comparison of the results of seedling tests with data on disease severity in the field. They rather indicate diversity in the genetic background of resistance of the tested cultivars.

In one trial (Table 4) rust samples originating both from wheat and triticale from the same localities were tested on 15 Thatcher NILs with different *Lr* genes and on 7 triticale cultivars. Samples from the same localities from wheat and triticale differed in their reactions on *Lr* NILs as well as on triticale. The results do not allow any conclusion on possible correlation between rust virulence/avirulence to any *Lr* NIL and virulence/avirulence to the tested triticale cultivars. Nevertheless isolates from wheat were virulent to a higher number of *Lr* NILs than from triticale. Vice versa isolates from triticale were virulent to a higher number of the tested triticale cultivars than isolates from wheat.

The same number (36) of rust isolates from triticale and wheat was tested on 15 Thatcher *Lr* NILs (Table 5). Virulence to all tested *Lr* NILs was registered among the samples from triticale except *Lr19* and *Lr24* as well as from wheat except *Lr19*. On the average, lower number of samples from triticale were virulent to the tested *Lr* NILs than of samples from wheat. The same isolates were tested on 7 triticale cultivars (Table 6). On the average a higher number of isolates from triticale than from wheat was virulent on triticale. A higher number of rust isolates from wheat than from triticale was virulent only on cultivars Gutek and Lupus. None of 36 rust isolates from wheat was virulent on cvs Talentro, Agrano and Kitaro and only one isolate was virulent on cvs Modus and Inpetto. In Table 7 virulence combinations of 36 leaf rust isolates from triticale and 36 leaf rust isolates from wheat on 7 triticale cultivars are summarized. Of the isolates from triticale 13 were avirulent to all seven triticale cultivars whereas 11 were virulent to all triticale cultivars. The remaining 12 isolates displayed various combinations of virulence/avirulence. Of the isolates from wheat 23 isolates were virulent only to 2 triticale cultivars (Gutek and Lupus), 5 only to one cultivar, 3 avirulent to all triticale cultivars and 5 remaining isolates displayed various combinations of

Table 7. Virulence combinations of leaf rust isolates on 7 triticale cultivars (R – resistant, S – susceptible)

Isolates from	No. of rust isolates	Cultivar						
		Gutek	Talentro	Agrano	Lupus	Modus	Inpetto	Kitaro
Triticale	13	R	R	R	R	R	R	R
	11	S	S	S	S	S	S	S
	3	S	R	R	S	R	R	R
	2	S	S	S	R	R	S	S
	7	other combinations of reactions than described above						
Wheat	23	S	R	R	S	R	R	R
	5	R	R	R	S	R	R	R
	3	R	R	R	R	R	R	R
	5	other combinations of reactions than described above						

virulence/avirulence. Unexpected was avirulence of 13 leaf rust isolates from triticale to all 7 tested triticale cultivars.

Though the number of randomly selected and tested isolates was too low to allow general conclusions, obtained results indicate a higher affinity of rust isolates from triticale to triticale than to wheat. Similarly isolates from wheat displayed a higher affinity to wheat (Thatcher near isogenic lines with different *Lr* genes) than to triticale.

Though no genetic analysis of triticale resistance was carried out by us, differences in reaction patterns of triticale cultivars observed in resistance tests indicate that tested triticale possess different genes for leaf rust resistance.

DISCUSSION

Many data exist on resistance of triticale cultivars to leaf rust. Hexaploid and octoploid triticale are generally resistant or moderately resistant to leaf rust although highly susceptible cultivars may be also found (McIntosh *et al.* 1995). In Russia Tyryshkin *et al.* (2008) tested 471 triticale accessions from the VIR's collection and found only 24 highly resistant accessions at the seedling stage. Seventy seven accessions were highly resistant at the VIR's Dagestan Experimental Station. Resistance derived from *Triticum timopheevi* or *Secale montanum* seemed to be of special importance in triticale resistance breeding. Mikhailova *et al.* (2009) selected 17 leaf rust resistant triticale accessions out of 416 tested triticale from the Vavilov All-Russian Research Institute of Plant Industry. In Hungary Manninger (2006) tested eight winter triticale both at seedling and at adult stage. Cultivars Presto, Tricolor, Disco, GK Bogo, Kitaro, Pongo were resistant at the seedling stage to three pathotypes of wheat leaf rust and susceptible only to one pathotype. However, only cultivars Presto and Tricolor were resistant at adult stage at two locations. Other above mentioned triticale cultivars though they were resistant to three pathotypes at the seedling stage, they were susceptible at adult stage. Manninger (2006) found distinct differences in the virulence of leaf rust isolates from triticale compared to virulence of isolates from wheat. In our experiments virulence to all tested *Lr* NILs except *Lr19* was observed in isolates from wheat and in triticale except *Lr19* and *Lr24*. We carried out resistance tests with recently collected leaf rust isolates as well as with older leaf rust isolates. Older isolates showed avirulence to a higher number of cultivars than recent isolates. Low virulence of the same older isolates was recorded already earlier (Hanzalová 2010). This situation agrees with the common experience that resistant cultivars "lose" resistance in the course of their prolonged cultivation; i.e. virulent pathotypes of pathogens appear and spread.

Genetics of leaf rust resistance in triticale was studied by several authors. Quinones *et al.* (1972) reported monogenic resistances in five triticale cultivars. Singh and McIntosh (1990) identified a resistance gene denominated as *LrSatu* frequent in CIMMYT triticale. They located *LrSatu* in a rye chromosome. The gene *SrSatu* is closely linked with stem rust resistance genes *Sr27* (*Coorong* gene). Singh and Saari (1990) postulated 4 resistance genes in three genotypes and at least two additional genes in triticale in Mexico. Wilson and Shaner (1989) described genes for hypersensitive resistance as well as slow rusting in triticale.

In Poland Grzesik and Strzembicka (2003) analyzed leaf rust resistance in triticale cultivars Presto, Vero and Ugo and concluded that the resistance of these cultivars was controlled by the same genetic action. In cv. Presto resistance was postulated to have been transfered from D-genome. Origin of resistance was studied by means of addition lines (Wos & Strzembicka 2005). Leaf rust resistance of triticale (line TM 16) derived from *Triticum monococcum* was located on the short arm of *T. monoccoccum* chromosome $2A^m$. An additional gene on chromosome $6A^m$ had complementary effect enhancing resistance governed by the gene on chromosome $2A^m$ (Sodkiewicz *et al.* 2008).

In the Czech Republic Stuchlíková and Bartoš (1980) studied genetics of leaf rust resistance in five triticale strains/cultivars in F_2 and F_3 progenies of crosses. Five different genes for leaf rust resistance were postulated; in one triticale two dominant genes were revealed. Resistance genes in three triticale strains were effective only at adult plant stage.

As selected data from the literature cited in the discussion indicate, there is much less known about resistance genes in triticale than in wheat. Specialization of wheat leaf rust on triticale, i.e. specific differences between leaf rust from triticale and from wheat need further investigations. Our paper should contribute to that topic.

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References

Grzesik R.H., Strzembicka A (2003): Resistance of some winter triticale varieties to leaf rust (*Puccinia recondita* f.sp. *tritici*). Biuletyn Instytutu Hodowli i Aklimatyzacji Rostlin, **230**: 171–175.

Hanzalová A. (2010): Physiologic specialization of wheat leaf rust (*Puccinia triticina* Eriks.) in the Czech Republic in 2005–2008. Cereal Research Communications, **38**: 366–374.

Manninger K. (2006): Physiological specialization of *Puccinia triticina* on wheat and triticale in Hungary in 2004. Acta Phytopathologica et Entomologica Hungarica, **41**: 93–100.

McIntosh R.A., Wellings C.R., Park R.F. (1995): Wheat Rusts. An Atlas of Resistance Genes. CSIRO, East Melbourne.

Mesterházy A., Bartoš P., Goyeau H., Niks R., Csösz M., Andersen O., Casulli F., Ittu M., Jones E., Manisterski J., Manninger K., Pasquini M., Rubiales D., Schachermayr G., Strzembicka A., Szunics L., Todorova M., Unger O., Vančo B., Vida G., Walther U. (2000): European virulence survey for leaf rust in wheat. Agronomie, **20**: 793–804.

Mikhailova L.A., Merezhko A.F., Funtikova E.Yu. (2009): Triticale diversity in leaf rust resistance. Russian Agricultural Science, **35**: 320–323.

Quinones M.A., Larter E. N., Samborski D.J. (1972): The inheritance of resistance to *Puccinia recondita* in hexaploid triticale. Canadian Journal of Genetics and Cytology, **14**: 495–505.

Singh R.P., McIntosh R.A. (1990): Linkage and expression of genes for resistance to leaf rust and stem rust in triticale. Genome, **33**: 115–116.

Singh R.P., Saari E.E. (1990): Biotic stresses in triticale. In: Proc. 2nd Int. Triticale Symposium. CIMMYT, Mexico, 171–181.

Sodkiewicz W., Strzembicka A., Apolinarska B. (2008): Chromosomal location in triticale of leaf rust resistance genes introduced from *Triticum monococcum*. Plant Breeding, **127**: 364–367.

Stakman E.C., Stewart P.M., Loegering W.O. (1962): Identification of Physiologic Races of *Puccinia graminis* var. *tritici*. Agricultural Research Service E617. United States Department of Agriculture: Washington DC.

Stuchlíková E., Bartoš P. (1980): Genetic analysis of leaf rust resistance in triticale. Genetika a Šlechtění, **16**: 171–180. (in Czech)

Tyryshkin L.G., Kurbanova P.M., Kurkiev K.U., Sarukhanov I.G., Kurkiev U.K. (2008): Effective juvenile resistance to brown rust in hexaploid triticale. Zaščita i Karantin Rastenij, **10**: 25.

Wilson J., Shaner G. (1989): Inheritance of the leaf rust resistance in four triticale cultivars. Phytopathology, **79**: 731–736.

Wos H., Strembicka A. (2005): Resistance to leaf rust (*Puccinia recondita* f.sp. *tritici*) at the seedling stage among single D-genome substitution line of triticale Presto. Plant Breeding and Seed Science, **51**: 473–47.

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