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Occurrence of wheat leaf rust (*Puccinia triticina*) races and virulence changes in Slovakia in 1994–2004

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Abstract: In 1995–2004 we investigated leaf rust virulence in Slovakia on Thatcher near isogenic lines (NILs) with genes *Lr1, Lr2a, Lr2b, Lr2c, Lr3a, Lr9, Lr10, Lr11, Lr15, Lr17, Lr19, Lr21, Lr23, Lr24, Lr26* and *Lr28*. According to reaction of leaf rust isolates resistance genes *Lr9* and *Lr19* were completely effective to all examined pathotypes in all years. The resistance genes *Lr24* and *Lr28* were also completely effective to all examined pathotypes till the year 2001. In the year 2001 we detected 20% and 10% virulent isolates on NILs *Lr24* and *Lr28,* respectively. According to the reaction of investigated isolates from the territory of Slovakia on NILs, resistance genes *Lr2c, Lr3a, Lr11, Lr17, Lr21, Lr23* and *Lr26* were mostly ineffective.

During the 1994–2004 period we detected 16 races of leaf rust (races 2, 2SaBa, 6, 6SaBa, 12, 12SaBa, 14, 14SaBa, 57, 57SaBa, 61, 61SaBa, 62SaBa, 77, 77SaBa, 77/57SaBa). The most frequently determined races were 61SaBa and 77SaBa, which occurred in all years. Among frequently determined races we can assign race 12SaBa as well.

According to the field tests in 2001–2004 good resistance to leaf rust was displayed by the cvs *Arida* (*Lr13, Lru*), *Eva* (*Lr3, Lru*) and *Solara* (*Lru*).

Key words: leaf rust; wheat; *Lr* genes; virulence; races; Slovakia

Introduction

The key objective in the agricultural production is better use of genetical potential of grown plants and prevention from pollution of environment by crop management. By the breeding for disease resistance and growing resistant cultivars risk of pollution of the environment and food products is decreased because the application of fungicides can be substantially reduced. In Slovakia among the most important diseases of wheat belong rusts and powdery mildew. Wheat leaf rust at present with the highest harmfulness is causing considerable yield losses particularly when the pathogen appears early and the weather during wheat ripening is hot and dry (Chester 1946). In the resistance breeding of wheat to rusts the specific and also non specific genetic factors were utilised. For the success of the disease resistance breeding it is necessary to study virulence and changes of virulence in the pathogen population. This is particularly true for pathogens with such a high variability like rusts and powdery mildews. The pathogen of wheat leaf rust in conditions of Slovakia can hibernate as a dikaryotic mycelium of urediospore stage, either on volunteer or on winter wheat.

Material and methods

Samples of leaf rust originated from variety trials of the Institute for Supervision and Testing in Agriculture or from wheat fields from different parts of Slovakia (Fig. 1). The susceptible cv. *Diana* was inoculated with each field sample, single pustule isolates were taken and increased on the same cultivar and tested on the set of NILs. The 16 near-isogenic lines of the cv. Thatcher possessing the *Lr* genes listed in Table 3, were obtained by courtesy of Dr. J. Kolmer, Agriculture and Agrifood Canada, Central Research Centre, Winnipeg. Tests of virulence of the isolates were carried out with a suspension of urediospores at the seedling growth stage 12 according to Zadoks et al. (1974). The inoculated seedling plants were kept in closed glass cylinders to provide high air humidity for 24–48 h and than in open glass cylinders at 18–22 °C in the greenhouse with suplemental (18 h/d) illumination with fluorescent tubes. Infection types were evaluated 10–14 days after inoculation according to Stakman et al. (1962) and the race numbers were assigned according to Johnston & Browder (1966). Virulence on *Lr26* (cv. *Salzmünder Bartweizen*) is designated by suffix SaBa.

Field resistance to leaf rust under natural infection was evaluated in 2001–2004 at 14 Experimental Variety Testing Stations. The disease severity was evaluated in 4 replications in a 1–9 point assessment scale, where point 9 is without symptoms (resistance) and point 1 means maximum attack (susceptibility).

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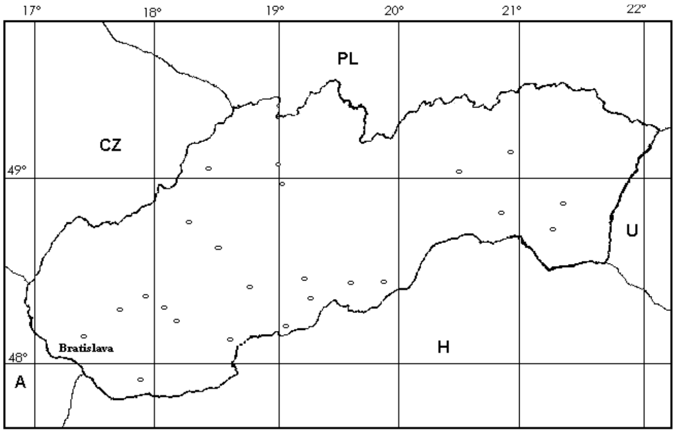

Fig. 1. Localities for sampling of leaf rust isolates in 2001–2004 in Slovakia.

Table 1. Geographic origin of leaf rust samples tested in 2001, 2003 and 2004.

Determined reactions on NILs correspond to races								
2001			2003			2004		
Locality	Cultivar	Race	Locality	Cultivar	Race	Locality	Cultivar	Race
Nýrovce	Brea	14 SaBa	Rimavská Sobota	SG-U-8069	2	Vrakuňa	Ilona	61 SaBa*
	Astella	61 SaBa*		Ilona, isol.2	61 SaBa*		Ilka	61 SaBa
	isol.1	61 SaBa*		Ilona, isol.3	77 SaBa		Torysa, isol.3	77
Veľký Meder	isol.1	12 SaBa*	Vranov nad Topľou	Elpa, isol.1	2		Torysa, isol.4	61 SaBa*
	isol.2	61 SaBa*		Elpa, isol.2	77 SaBa	Báhoň	Arida	57 SaBa*
	isol.3	61 SaBa*		Vanda, isol.3	2	Veľký Meder	Torysa, isol.1	77 SaBa
Víglaš	Hana	77 SaBa		Vanda, isol.4	14*		Torysa, isol.2	61 SaBa*
	Velta	61 SaBa		Malvina, isol.5	12 SaBa		Torysa, isol.3	57 SaBa
	BR-794	61 SaBa		Malvina, isol.6	77 SaBa*	Želiezovce	Mladka, isol.1	12 SaBa*
Jakubovany	Torysa	2		Malvina, isol.7	57		Mladka, isol.2	2
Vrakuňa	SK-38–1	2	Vrakuňa	Nic 92–3533A	12 SaBa		Vanda, isol.3	61 SaBa
Spišské Vlachy	Torysa	61 SaBa		Nic 88–3297A	57	Víglaš	Velta, isol.1	12 SaBa
	isol.1	61 SaBa	Báhoň	Axis	57 SaBa		Velta, isol.2	61 SaBa
Bodorová	GK-Zugoly	61 SaBa		Cebeco 9802	2		Arida, isol.3	61 SaBa
	P 9407	2		Atrium	61 SaBa*		Arida, isol.4	2 SaBa*
	BU-3	14 SaBa	Veľký Meder	Astella, isol.1	12 SaBa*		Rheia, isol.5	57 SaBa*
	Ilona	2 SaBa		Astella, isol.2	12 SaBa*	Beluša	Petrana, isol.1	12
Želiezovce	isol.1	61 SaBa		Velta	6 SaBa*		Istar, isol.2	61 SaBa*
	Šárka	61 SaBa	Veľké Ripňany	Ilona, isol.1	61 SaBa*		Istar, isol.3	61SaBa
	Arida	2 SaBa		Ilona, isol.2	12 SaBa	Bodorová	BU-67–3	12 SaBa*
				Astella, isol.3	12		SG-S-1393	57 SaBa
				Astella, isol.4	61 SaBa*		BU-67–1	61 SaBa*
				Astella, isol.5	14	Spišská Belá	SK-48	61 SaBa
				Astella, isol.6	12		SO-232	61
						Spišské Vlachy	Arida, isol.1	12 SaBa
							Arida, isol.2	77 SaBa
							Bruta, isol.3	61 SaBa

* small differences in reaction from the designated race

Results and discussion

During the last three years (2001, 2003 and 2004) we detected 14 races of leaf rust (Table 1). In 2002 the urediospores from the field samples lost the vitality during the storage. The geographic distribution of the determined races does not show any regional specialization of certain races. Some isolates show small differences from the designated race. Further differentiation of these rust isolates is possible on the NILs according to the virulence/avirulence on *Lr15, Lr23* or *Lr17*.

In 1994–2004 (Table 2) the most frequently determined isolates conformed to race 61SaBa (62–100%, except the year 2003 only with 16%), followed by race 77SaBa (5–33%) and by race 12SaBa (9–67%). The races 61SaBa and 77SaBa occurred in all years during the investigation period. The race 12SaBa we determined since1998 regularly. In the last three years also the race 2 (12–50%) was frequent. The lower occurrence of race 61SaBa (16%) in 2003 was probably caused by the low quantity of field samples tested in that year.

In the neighbouring countries Hungary and Czech Republic similar race occurrence was recorded (Bartoš et al. 2001). Manninger (2000) described races 12,

Table 2. Incidence of leaf rust races in relation to the total number of localities from where the rust samples originated in 1994–2004 (in %).

Race	1994	1995	1996	1997	1998	1999	2000	2001	2003	2004
2	0	0	0	0	0	0	0	38	50	12
2SaBa	0	0	12	28	0	0	6	25	0	13
6	0	0	0	0	6	0	12	0	0	0
6SaBa	0	0	0	0	6	9	31	0	16	0
12	0	0	0	0	0	0	0	0	16	12
12SaBa	0	20	0	0	12	9	31	13	67	50
14	0	5	31	0	6	0	0	0	33	0
14SaBa	0	0	6	0	0	0	0	25	0	0
57	0	0	0	0	0	0	0	0	16	0
57SaBa	4	0	0	0	0	9	31	0	16	50
61	0	0	12	0	0	9	0	0	0	0
61SaBa	96	100	94	78	75	100	62	75	16	100
62SaBa	0	0	0	0	6	0	0	0	0	0
77	4	0	12	0	12	0	0	0	0	13
77SaBa	11	5	25	28	31	27	12	13	33	15
77/57SaBa	0	0	0	21	0	0	0	0	0	0

Table 3. Virulence of leaf rust isolates on *Lr*-NILs (%) in years 1995–2004.

NIL	1995	1996	1997	1998	1999	2000	2001	2003	2004
Lr1	16	27	33	27	11	22	15	16	10
Lr2a	16	27	33	9	14	24	5	23	27
Lr2b	37	27	33	36	17	36	10	67	46
Lr2c	100	91	80	100	100	98	70	66	79
Lr3	83	82	100	91	100	100	95	80	100
Lr9	0	0	0	0	0	0	0	0	0
Lr10	66	–	–	–	–	–	40	100	90
Lr11	100	100	100	100	100	100	65	83	72
Lr15	50	45	77	73	100	64	30	35	90
Lr17	83	73	100	91	100	100	100	–	–
Lr19	0	0	0	0	0	0	0	0	0
Lr21	100	100	100	100	100	100	65	90	96
Lr23	100	100	30	100	80	53	100	75	87
Lr24	0	0	0	0	0	0	20	0	0
Lr26	83	64	100	73	97	96	90	80	73
Lr28	0	0	0	0	0	0	10	0	0

61 and 77 as predominant in Hungary. In the Czech Republic, race 61 SaBa was predominant, and races 57SaBa, 12SaBa and 77SaBa also belonged to relatively frequently determined races (Bartoš et al. 2001b).

Virulence of leaf rust isolates on near-isogenic lines (NILs) in the years 1995–2004 is recorded in Table 3. Near-isogenic lines (NILs) with resistance genes *Lr9, Lr19* were completely resistant to all examined pathotypes in all years. The resistance genes *Lr24* and *Lr28* were also completely effective to all examined pathotypes except the year 2001 when 20% virulence on NIL *Lr24* and 10% on NIL *Lr28* was detected. According to the reaction of investigated isolates from the territory of Slovakia on NILs, the resistance genes *Lr2c, Lr3a*, *Lr11, Lr17, Lr21, Lr23* and *Lr26* were ineffective. We have recorded high virulence to the *Lr3a* and *Lr26* genes of resistance in Slovakia already for a longer time (Bartoš & Huszár 1996, 1998, Bartoš et al. 1999, 2001, Huszár et al. 2001, 2004). The high virulence to *Lr3a* and *Lr26* evidently is the result of higher percentage of grown cultivars with these genes of resistance. Percentage of grown cultivars with gene *Lr3a* was 52% in 2001, in 2005 still 35%.

Virulence on 26 near-isogenic lines with different *Lr* genes in an international ring test comprising France, Germany, Italy, Czech Republic, Slovakia, Spain, Hungary, Poland, Bulgaria and Romania in 1998 was recorded by Mesterházy et al. (2000). Near isogenic lines carrying *Lr9, Lr19* were effective in all trials.

Leaf rust infection on *Lr24* was observed only in Bulgaria, Romania and Germany, virulence on *Lr28* appeared in Italy, Spain, Poland, Bulgaria and Romania. Disease severity on *Lr3a* was high in most countries and so was it also on *Lr26,* except Spain.

In Canada *Lr9, Lr19* and *Lr24* were relatively effective (McCallum & Seto-Goh, 2001) whereas in the USA virulence to *Lr9* was common (Kolmer et al. 2004). No virulence to *Lr9, Lr19* and *Lr24* was recorded by Yang-Wen Xiang et al. (2004) in China and in Peninsular India (Hasabnis et al. 2002).

Results of resistance scoring of recommended winter wheat cultivars carried out in Slovakia in 2001–2004 are given in Table 4. The disease severity in the years 2001 and 2002 was higher than in the years 2003 and 2004. The resistance assessment of cultivars tested in all State Variety Trials in the period 2001–2004 accord-

Table 4. Assessment of leaf rust severity on recomended winter wheat cultivars carried out in Slovakia in 2001–2004.

Cultivar	Registration in SK/CZ	Postulated *Lr* gene	Disease severity* 2001	2002	2003	2004	Average
Alka	1997/1995	*Lr10, Lr13*	5.5	5.8	–	–	5.7
Armelis	2002/ –		–	6.1	6.4	6.4	6.3
Astella	1995/1995	*Lr3a*	5.6	4.9	5.6	5.8	5.5
Arida	2001/ –	*Lr3a, Lru*	5.8	6.1	7.2	6.4	6.4
Axis	2003/ –		–	7.4	7.5	–	7.5
Bety	1999/ –	*Lru*	5.9	5.5	–	–	5.7
Bonita	2003/ –		–	6.8	6.0	–	6.4
Charger	2003/ –		–	7.3	6.8	–	7.1
Eva	2001/ –	*Lr3a, Lru*	6.2	6.0	6.2	6.7	6.3
Ilona	1989/1989	*none*	5.1	4.5	5.0	5.6	5.1
Klea	1998/ –	*Lr3a*	6.5	6.4	–	–	6.5
Malvina	1998/ –	*Lr26*	5.5	4.3	6.0	5.5	5.4
Malyska	2001/ –	*Lr3a*	4.3	4.1	–	–	4.2
Mladka	2003/2002	*Lru*	–	–	6.0	5.4	5.7
Petrana	2002/ –		–	6.6	7.1	7.1	6.9
Rada	1995/ –	*Lr3a*	6.0	5.9	–	–	5.9
Solara	1998/1998	*Lr u*	6.2	6.5	7.2	7.5	6.9
Šárka	2000/1997	*Lr u*	4.4	4.4	6.5	5.8	5.3
Torysa	1992/1992	*Lr u*	4.6	4.4	5.5	5.5	5.0
Vanda	2001/ –	*none*	4.7	4.0	5.5	4.6	4.7
Velta	2001/ –	*Lr3a*	5.4	5.2	5.8	–	5.5
Zerda	1995/ –	*Lr3a*	5.5	5.0	–	–	5.3
Venistar	2002/ –		–	6.8	7.5	7.3	7.2
Average			5.5	5.4	6.4	6.2	

*1 – high disease severity (susceptible), 9 – low disease severity (resistant)

ing to average leaf rust severity indicates good resistance to leaf rust in the field of the cvs. *Arida*, *Eva* and *Solara*. The highest resistance to leaf rust in the field was displayed by the cv. *Venistar* (without specific *Lr* genes) tested in 2002–2004 and cvs *Axis* and *Charger* tested only in 2002 and 2003. Cultivar *Solara* showed good resistance to leaf rust also in the period 1998–2000 (Huszár et al. 2004). Despite prevailing virulence in the leaf rust population on *Lr3a,* some cultivars possessing this gene showed a relatively good resistance in the field. These cultivars have cv. *Viginta* in their pedigrees. Hence they may possess the partial resistance of that cultivar in addition to *Lr3a*.

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