Virulence of Wheat Leaf Rust in Slovakia in 1997–1998

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Abstract

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In 1997–1998 virulence of the leaf rust population was studied on near isogenic Thatcher lines with the genes for resistance *Lr1, Lr2a, Lr2b, Lr2c, Lr3, Lr9, Lr11, Lr15, Lr17, Lr19, Lr21, Lr23, Lr24, Lr26* and *Lr28*, and on the standard differentials Malakoff, Carina, Brevit, Webster, Loros, Mediterranean, Hussar, Democrat and the supplemental cultivar Salzmünder Bartweizen. All 55 analyzed rust samples were avirulent on *Lr9, Lr19, Lr24* and *Lr28*. On the standard differentials, races 61SaBa, 77SaBa, 77/57SaBa, 2SaBa, 77, 12SaBa, 62SaBa, 6, 6SaBa and 14 were determined. Races 61SaBa and 77SaBa (77/57SaBa) prevailed in both years. Races 6 and 6SaBa were found for the first time. The effectiveness of leaf rust resistance genes in registered cultivars under field conditions in variety trials is discussed.

Key words: *Puccinia persistens* subsp. *triticina*, syn. *Puccinia recondita* f. sp. *tritici*; pathotypes; physiologic races; *Lr* genes; winter wheat; inscripted cultivars; Slovakia

Wheat leaf rust, caused by *Puccinia recondita* f. sp. *tritici*, is an economically important disease of wheat causing considerable yield losses. Resistant cultivars are endangered by new avirulent races of the pathogen. For this reason, analyses of virulence in the leaf rust populations (race surveys) are carried out in most European countries. To standardize this procedure, an international project was established within the European Cooperation of Scientific and Technical Research (EC-COST 817). This contribution contains results obtained in 1997 and 1998 race surveys. The set of differentials recommended in the COST 817 project in addition to the standard differentials was applied. This enables comparison with older data as well as with the results obtained in the same period in the Czech Republic (BARTOŠ & STUCHLÍKOVÁ 1999) and in other countries participating in the above mentioned action.

MATERIAL AND METHODS

To differentiate leaf rust pathotypes, 15 near-isogenic lines (NILs) of the cv. Thatcher possessing the *Lr* genes listed in Table 2, and the 8 standard differentials (JOHNSON & BROWDER 1966) supplemented with the cv. Salzmünder Bartweizen (*Lr26*) were used to test field samples of wheat leaf rust. Field samples of the rust were increased on the susceptible cv. Diana. Greenhouse tests were carried out on the first leaf of seedlings inoculated with rust urediospores. Temperatures in the greenhouse varied between 18–22°C. Infection types were evaluated 14 d after inoculation according to STAKMAN *et al.* (1962). Race numbers were assigned according to JOHNSON and BROWDER (1966). Virulence on *Lr26* (cv. Salzmünder Bartweizen) is designated by the suffix SaBa. Seed of the registered cultivars was obtained from the Central Institute for Supervision and Testing in Agriculture, Variety Testing Station Želiezovce. Data on leaf rust severity under natural infection in the field trials originate from the Research Institute of Crop Production, Piešťany and from 67 variety yield trials of the Central Institute for Supervision and Testing in Agriculture, Variety Testing Station Želiezovce carried out in the years 1996–1998. The terms "race" and "pathotype" characterize the same category of the specialization of the pathogen. We used the term "race" when standard differentials were applied, whereas the term "pathotype" when the set of 15 NILs was used as differentials.

RESULTS AND DISCUSSION

On the standard differentials, four races were determined in 30 rust samples coming from 14 localities in 1997, while in 1998 eight races were identified in 25 samples originating from 16 localities (Table 1). On the set of NILs,

Table 1. Leaf rust races determined in 1997 and 1998

Race	Number of samples	[%]	Number of localities	[%]
1997				
61SaBa	13	43	11	78
77SaBa	5	17	4	28
77/57SaBa	6	20	3	21
2SaBa	6	20	4	28
Total	30	100	14	–
1998				
61SaBa	12	48	12	75
77SaBa	5	20	5	31
77	2	8	2	12
12SaBa	2	8	2	12
62SaBa	1	4	1	6
6	1	4	1	6
6SaBa	1	4	1	6
14	1	4	1	6
Total	25	100	16	–

nine pathotypes were determined in 30 samples in 1997 (Table 2), whereas in 1998 six pathotypes were identified in 11 samples from different localities (Table 3). These results indicate that it was the higher number of localities rather than the higher number of rust samples that lead to the determination of a higher number of different races/pathotypes. This conclusion is also supported by the results of 1995 and 1996 when a much higher number of samples was analysed, but the number of determined races/pathotypes was similar to that from 1997 and 1998. In 1995 (BARTOŠ & HUSZÁR 1996) 4 races/6 pathotypes were determined when 59 samples from 20 localities were analyzed. In 1996 a total of 7 races/11 pathotypes was identified in 64 samples from 16 localities (BARTOŠ & HUSZÁR 1998). That more pathotypes than races were determined from the same number of rust samples is due to the higher number of NILs (15) compared to the number of standard differentials (8 + 1). In 1997 race 61SaBa comprised four different pathotypes, races 77SaBa and 2SaBa two pathotypes each.

Both in 1997 and 1998 race 61SaBa prevailed, followed by 77SaBa and 77/57SaBa. Isolates designated 77/57SaBa differed from 77SaBa by an intermediate variable reaction on cv. Malakoff (*Lr1*). Race 77SaBa, as the most virulent of the determined races, continues to represent an important part of the rust population. Other races were less frequent. New for Slovakia are races 6 and 6SaBa that differ from races 61 and 61SaBa only by virulence on cv. Malakoff (*Lr1*). Race 6SaBa may have originated by mutation from the most common race 61SaBa, and race 6 from race 61. Stepwise mutations like 61–6–6SaBa are another possible explanation for the origin of new races.

Both in 1997 and 1998, as in the two previous years (BARTOŠ & HUSZÁR 1996, 1998), all rust samples were avirulent on *Lr9*, *Lr19*, *Lr24* and *Lr28*, and most of them were avirulent also on *Lr1*, *Lr2a* and *Lr2b*. Virulence on *Lr26*, that is present in several registered cultivars, was

Table 2. Reactions of leaf rust isolates on *Lr*-NILs (1997)

NIL	Leaf rust pathotypes a	b	c	d	e	f	g	h	i	Virulence [%]
Lr1	R	R	R	R	S	S	S/R	R	R	16–33
Lr2a	R	R	R	R	S	S	S	R	R	33
Lr2b	R	R	R	R	S	S	S	R	R	33
Lr2c	S	S	S	S	S	S	S	R	R	80
Lr3	S	S	S	S	S	S	S	S	S	100
Lr9	R	R	R	R	R	R	R	R	R	0
Lr11	S	S	S	S	S	S	S	S	S	100
Lr15	R	S	S	R	S	S	S	S	R	77
Lr17	S	S	S	S	S	S	S	S	S	100
Lr19	R	R	R	R	R	R	R	R	R	0
Lr21	S	S	S	S	S	S	S	S	S	100
Lr23	S	S	R	R	S	R	R	S	R	30
Lr24	R	R	R	R	R	R	R	R	R	0
Lr26	S	S	S	S	S	S	S	S	S	100
Lr28	R	R	R	R	R	R	R	R	R	0
Number of isolates	2	1	9	2	3	2	5	3	3	Σ 30
Conformed to race	61SaBa				77SaBa		77/57SaBa	2SaBa		

Table 3. Reactions of leaf rust isolates on *Lr*-NILs (1998)

NIL	Leaf rust pathotypes						Virulence [%]
	a	b	c	d	e	f	
Lr1	R	R	S	S	S	R	27
Lr2a	R	R	S	R	R	R	9
Lr2b	R	S	S	R	R	R	36
Lr2c	S	S	S	S	S	S	100
Lr3	S	S	S	S	S	R	91
Lr9	R	R	R	R	R	R	0
Lr11	S	S	S	S	S	S	100
Lr15	S	S	S	R	R	R	73
Lr17	S	S	S	S	S	R	91
Lr19	R	R	R	R	R	R	0
Lr21	S	S	S	S	S	S	100
Lr23	S	S	S	S	S	S	100
Lr24	R	R	R	R	R	R	0
Lr26	S	S	R	R	S	R	73
Lr28	R	R	R	R	R	R	0
Number of isolates	4	3	1	1	1	1	Σ 11
Conformed to race	61SaBa	12SaBa	77	6	6SaBa	14	

common (100% in 1997, 73% in 1998). Similarly, all samples were virulent on *Lr3*. There was, however, a striking difference between the two years in the virulence frequency on *Lr23*. Whereas in 1997 only 30% of the isolates were virulent, in 1998 all of them were virulent. Classification of virulence on *Lr23* is difficult because all infection types between ; and 3 are considered as low infection types, i.e., are an expression of resistance (McINTOSH *et al.* 1995). Environmental variability is high because *Lr23* is more effective at temperatures above 20 °C (DYCK & JOHNSON 1983). This, rather than a change of virulence in the rust population, may have contributed to the discrepancy in our results of the two years.

The geographic distribution of the determined races (Table 4) does not show any regional specialization of certain races or pathotypes. The most important races 61SaBa and 77SaBa were found in various areas of the country.

The most common races in 1998 were used for inoculation of selected registered cultivars possessing specific resistance (Table 5). The objective was to determine whether the reactions of these cultivars to samples of the same race but collected at different localities were identical, or whether a race could be further differentiated through different reactions of the cultivars. Further differentiation was indeed possible. The sample of race 61SaBa from Bodorová differed by its low virulence on the cv. Estica (infection type 2) from the other samples of this race that were virulent on it. The sample of race 61SaBa from Šalgovce differed from other samples virulent on the cv. Torysa by its intermediate reaction (infection type 2–3) on this cultivar. Between samples of race 77SaBa from three localities there were differences in reactions of cvs. Torysa and Solida (infection types 2–3). Further differentiation was also possible on the NILs (Table 2) where four different pathotypes belonged to race 61SaBa, two pathotypes to race 77SaBa, and two to race 2SaBa.

Another objective of the test with the selected cultivars was to determine whether some of the leaf rust samples from 1998 can help to identify resistance genes other than those described earlier in the tested cultivars (BARTOŠ & HUSZÁR 1998). The trial did not allow to verify the postulated presence of *Lr3* in some cultivars, as all used rust samples were virulent on *Lr3*. The possibility of an additional gene to *Lr3* in the cv. Solida, partially effective to an isolate from Haniska, can be suggested. The reactions confirmed the presence of *Lr26* in cvs Livia, Sana and Malvina. Unlike in earlier experiments, the reactions to the rust samples do not show resistance in addition to that governed by *Lr26* in cv. Malvina. Additional resistance to *Lr26* can be postulated in cv. Sana, but has to be verified in further tests. It was confirmed that the genes for leaf rust resistance in the cvs Estica, Košútka and Torysa are different. An important conclusion regarding cv. Vlada is postulation of resistance gene *Lr1*. This confirms preliminary results by R. F. PARK (personal communication) that were obtained with Australian leaf rust races and indicated the possible presence of *Lr1* in cv. Vlada. The second gene postulated by R. F. PARK is *Lr3*. In our

Table 4. Geographic origin of analyzed leaf rust samples (1997 and 1998)

District	Locality	Cultivar	Race
1997			
Bratislava	Báhoň	Blava	77SaBa
		Hana	2SaBa
		Košútka	2SaBa
Dunajská Streda	Velký Meder	Blava	77SaBa
		Rada	77/57SaBa
Levice	Želiezovce	Blava	61SaBa, 77/57SaBa
		Rada	61SaBa
		undetermined	61SaBa, 77SaBa
Martin	Bodorová	BR 458	2SaBa
		Lívia	61SaBa
Nitra	Nitra	spelt wheat	61SaBa, 77/57SaBa
Piešťany	Piešťany	MV-21	61SaBa
		mixture	61SaBa, 77SaBa
Poprad	Spišská Belá	Torysa	61SaBa
Prešov	Malý Šariš	Hana	61SaBa
		Torysa	2SaBa
Rimavská Sobota	Rimavská Sobota	undetermined	61SaBa
Topoľčany	Velké Ripňany	Viginta	61SaBa
Zvolen	Víglaš	undetermined	2SaBa
	Pribilina	undetermined	61SaBa
	Štúrovo	undetermined	61SaBa
	Vrakuňa	Boka	61SaBa, 77SaBa
1998			
Piešťany	Piešťany	Simona	77
		Ritmo	77SaBa
Topoľčany	Velké Ripňany	Contra	61SaBa
Dunajská Streda	Velký Meder	Alana	61SaBa
Spišská Nová Ves	Spišské Vlachy	Solara	77SaBa
		Rada	6
Poprad	Spišská Belá	Brea	61SaBa
		Vlasta	77SaBa
Martin	Bodorová	Hana	61SaBa
		Šárka	61SaBa
Rimavská Sobota	Rimavská Sobota	Alka	61SaBa
		Bruta	62SaBa
Zvolen	Víglaš	Hana	71SaBa
		Brea	77
	Vrakuňa	Solara	12SaBa
		Hana	77SaBa
Považská Bystrica	Beluša	mixture	61SaBa
Nitra	Nitra	Malanta	12SaBa
		Viginta	61SaBa
Košice	Haniska	Soldur	14
		Samanta	77SaBa
Sabinov	Jakubovany	Bruta	6SaBa
Topoľčany	Šalgovce	Rada	61SaBa
Levice	Želiezovce	Nela (HE 3625)	61SaBa
Michalovce	Michalovce	Alka	61SaBa

Table 5. Reactions of leaf rust samples of 1998 on some inscripted cultivars that possess different *Lr* genes (*Lr u* = gene unknown)

Race and origin		Cultivar (resistance gene)													
Locality	cv.	Astella (*Lr3*)	Barbara (*Lr3*)	Blava (*Lr u*)	Estica (*Lr13*)	Košútka (*Lr u*)	Lívia (*Lr26*)	Regia (*Lr3*)	Solida (*Lr3*)	Torysa (*Lr u*)	Vlada (*Lr1, Lr3*)	Malvina (*Lr26*)	Sana (*Lr26*,+)	Alana (*Lr u*)	Alka (*Lr u*)
61SaBa															
Spišská Belá	Brea	4	4	4	4	4	4	4	4	4	;	4	4	4	4
Michalovce	Alka	4	4	4	4	4	4	4	4	4	;	4	4	4	4
Rimavská Sobota	Bruta	4	3	4	4	4	4	4	4	3CH	0;	4	4	4	3
Rimavská Sobota	Alka	4	4	4	4	4	4	4	4	4	;	4	4	4	4
Bodorová	Šárka	4	4	4	2	4	4	4	4	4	0;	4	2–3	4	4
Želiezovce	Nela	4	4	3CH	4	4	4	4	4	4	0	4	4	4	3CH
Nitra	Malanta	4	4	4	4	4	4	4	4	4	0	4	4	4	4
Víglaš	Brea	4	4	3	4	4	3CH	4	4	4	0	4	3CH	3	3CH
Velký Meder	Alana	4	4	4	4	4	4	4	4	4	0	4	4	4	4
Šalgovce	Rada	4	4	4	3	4	4	4	4	2–3	0;	4	4	4	3
77SaBa															
Spišské Vlachy	Solara	4	3	4	4	3	4	4	4	2–3	4	4	4	4	;+3
Haniska	Samanta	4	4	4	4	4	4	4	2–3	2–3	4	4	4	4	4
Piešťany	Ritmo	4	4	4	4	3CH	4	4	4	4	4	4	4	4	;+3
77															
Piešťany	Simona	4	3	4	2–3	4	0;	4	4	2–3	4	0	0	2–3	;1–2
6															
Spišské Vlachy	Rada	4	4	4	2–3	4	;	4	4	1–2	4	0;	0;	4	3CH
6 SaBa															
Jakubovany	Bruta	4	4	4	4	4	4	4	4	3	4	4	4	4	2–3

genetic study (BARTOŠ & STUCHLÍKOVÁ 1993) we found a segregation of 15R : 1S in the F_2 generation of crosses of cv. Vlada with the leaf rust susceptible cvs Regina and Zdar after inoculation with an isolate avirulent on both *Lr1* and *Lr3*. These results agree with postulation of the two above mentioned *Lr* genes in cv. Vlada.

Virulence on cv. Soldur carried by race 14 was found for the first time in 1995 (BARTOŠ & HUSZÁR 1996), and again in 1996 (BARTOŠ & HUSZÁR 1998). The sample of race 14 of the year 1998 originated also from the cv. Soldur. This indicates that in Slovakia race 14 may have virulence on Soldur as a characteristic feature.

The effectiveness of resistance genes in the grown cultivars under field conditions depends upon the frequency of corresponding virulence genes in the rust population. However, not only the determined resistance genes, but also other genetic factors contribute to the degree of resistance observed in the field. In the group of cultivars that carry *Lr3* (Viginta, Hana, Vega, Samanta, Barbara, Regia, Astella, Solida, Rada and Klea) (BARTOŠ & HUSZÁR 1998) considerable differences in field behaviour can be observed. Although virulence on *Lr3* is prevailing in the rust population, most cultivars with *Lr3*, particularly recently released cultivars, show a relatively good level of resistance. As some of them have the partially resistant cv. Viginta in their pedigree, they may possess this type of resistance in addition to *Lr3*. Cultivars Viginta (released in 1984) and Hana (released in 1985) sharply differ in their field reaction to leaf rust; cv. Viginta shows durable resistance, whereas cv. Hana became highly susceptible (Table 6). Obviously additional genetic factors contribute to the resistance of cv. Viginta. Very effective seems to be the combination of *Lr1* and *Lr3* in the cv. Vlada. This can be ascribed to gene *Lr1* to which avirulence prevails in the rust population. Similarly to cultivars with *Lr3*, cultivars possessing *Lr26* also differ in their resistance in the field. In 1996 at Piešťany, e.g., the cv. Iris was relatively resistant in the field trial, whereas cv. Lívia was highly susceptible. In 1995 only Lívia showed high susceptibility, whereas the other cultivars with *Lr26* had a lower disease severity. Of the cultivars possessing specific but so far undetermined resistance genes, cv. Blava shows relatively good resistance in the field. Both at Piešťany and in the State Variety Trials (Ta-

Table 6. Assessment of leaf rust severity on winter wheat cultivars in Piešťany in 1995–1996

Resistance gene	Cultivar	Registered in year	Disease severity* 1995	Disease severity* 1996	Average	Variation span
Lr3	Viginta	1984	8.5	7.0	7.7	1.5
	Hana	1985	1.0	2.0	1.5	1.0
	Samanta	1993	6.0	5.0	5.5	1.0
	Barbara	1993	8.5	8.0	8.2	0.5
	Regia	1994	8.0	5.0	6.5	3.0
	Astella	1995	7.0	6.0	6.5	1.0
	Solida	1995	8.0	6.5	7.2	1.5
	Rada	1995	8.5	7.0	7.7	1.5
Lr26	Iris	1983	7.0	7.0	7.0	0.0
	Lívia	1991	1.0	1.0	1.0	0.0
	Sofia (+ *Lr3*)	1990	7.0	–	–	–
	Sana (+ *Lr u*)	1995	8.0	4.0	6.0	4.0
Lr1	Vlada(+ *Lr3*)	1990	9.0	9.0	9.0	0.0
Lr u	Košútka	1981	–	7.0	–	–
	Blava	1992	9.0	9.0	9.0	0.0
	Torysa	1992	8.0	4.0	6.0	4.0
	Estica	1996	–	9.0	–	–
none	Zdar	1983	5.0	6.0	5.5	1.0
	Ilona	1989	1.0	2.0	1.5	1.0
	Simona	1991	–	1.0	–	–
	Bruta	1994	–	4.0	–	–

* 1 – high disease severity (susceptibility)
9 – low disease severity (resistance)
u – unknown

Table 7. Assessment of leaf rust severity on winter wheat cultivars from 67 State Varietal Trials carried out in Slovakia in 1996–1998

Ranking	Cultivar	Disease severity* (average)	Variation		Registered
			extreme values	span	
1	Estica	8.14	7.9–8.5	0.6	1996
2	Barbara	7.58	7.3–7.9	0.6	1993
3	Boka	7.20	7.0–7.5	0.5	1996
4	Regia	7.12	6.6–7.5	0.9	1994
5	Rada	6.98	6.1–7.6	1.5	1995
6	Solida	6.88	6.2–7.6	1.4	1995
7	Astella	6.88	5.9–7.8	1.9	1995
8	Blava	6.86	6.5–7.3	0.8	1992
9	Sana	6.54	5.1–7.5	2.4	1995

*1 – high disease severity (susceptibility)
9 – low disease severity (resistance)

ble 7) the highest resistance in the field was displayed by the cv. Estica, probably due to the gene for adult plant resistance *Lr13*, postulated in this cultivar by R. F. PARK (personal communication). The ranking of cultivars tested in all State Variety Trials in the period 1996–1998 according to average leaf rust severity also indicates good resistance to leaf rust in the field of the cv. Boka that has no specific *Lr* gene(s). However, it has partially resistant cultivar Viginta in the pedigree like almost all cultivars listed in Table 7, except cvs Estica and Sana.

If we consider the present virulence genes in the rust population, the resistance genes in the grown cultivars and the disease severity in the field together, we can conclude that both genes for specific resistance and genes for partial field resistance contribute to the reduction of yield losses to wheat leaf rust in Slovakia.

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Souhrn

BARTOŠ P., HUSZÁR J., HERZOVÁ E. (1999): **Virulence rzi pšeničné na Slovensku v letech 1997–1998**. Pl. Protect. Sci., **35**: 85–92.

V letech 1997–1998 jsme studovali virulenci rzi pšeničné na téměř izogenních liniích odrůdy Thatcher s geny *Lr1, Lr2a, Lr2b, Lr2c, Lr3, Lr9, Lr11, Lr15, Lr17, Lr19, Lr21, Lr23, Lr24, Lr26, Lr28* a na doplňkové odrůdě Salzmünder Bartweizen. Všech 55 analyzovaných vzorků bylo avirulentních na liniích s geny *Lr9, Lr19, Lr24* a *Lr28*. Na standardních diferenciačních odrůdách byly určeny rasy 61SaBa, 77SaBa, 77/57SaBa, 2SaBa, 77, 12SaBa, 62SaBa, 6, 6SaBa a 14. V obou letech byly nejrozšířenější rasy 61SaBa a 77SaBa. Poprvé byly zjištěny rasy 6 a 6SaBa. V práci se diskutuje o účinnosti genů rezistence ke rzi pšeničné v polních podmínkách v odrůdových pokusech.

Klíčová slova: *Puccinia persistens* subsp. *triticina;* syn. *Puccinia recondita* f. sp. *tritici*; patotypy; fyziologické rasy; *Lr* geny; pšenice ozimá; zapsané odrůdy; Slovensko

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