# Effectiveness of leaf rust resistance genes and resistance of registered winter wheat cultivars to leaf rust and yellow rust in Slovakia

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According to the experience average losses of crops caused by diseases and pests vary between 5 and 40% according to the crop management and depend also on the diseases resistance of the grown cultivars. Growing resistant cultivars reduced the risk of pollution of the environment and food products because the application of fungicides can be substantially reduced. This can also lead to favourable changes in the biocenosis of the crop stand.

Success of the disease resistance breeding depends upon many factors. One of them is the need to cope with the variability of the pathogen. For this reason 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. In the resistance breeding of wheat to rusts the specific and also non specific genetic factors were utilised. In the wheat growing in Slovakia to the most important diseases belong leaf rust, powdery mildew, septorioses and fusarioses. Wheat leaf rust is causing considerable yield losses particularly when the pathogen appears early and the weather during ripening is hot and dry.

### **Material and Methods**

From different regions of Slovakia we collected 259 samples of wheat leaf rust in the years 1995 - 2000, originated mostly from the Experimental Variety Testing Stations (*Figure 1*), (BARTOŠ & HUSZÁR 1996, 1998, BARTOŠ et al. 1999, 2001).

One to three single pustule isolates were obtained from the samples and multiplied on the susceptible cultivar Diana. Tests of virulence of the isolates were carried out at the growth stage 12 accor-

ding to ZADOKS et al. (1974) (seedling stage) or on segments of the first leaf on agar medium with benzimidazole. Leaf rust isolates were tested on 15 near isogenic Thatcher lines (NILs) possessing Lr genes listed in *Table 2* and on 8 standard differentials (JOHNSON & BROWDER 1966). Reactions of differentials and NILs to leaf rust were tested in the greenhouse at 18-22 °C with supplemental (18 h/d) illumination with fluorescent tubes. Infection types were evaluated 14 days after inoculation according to STAKMAN et al. (1962).

Race numbers were assigned according to JOHNSON & BROWDER (1966). Virulence on Lr26 (cv. Salzmünder Bartwiezen) is designated by the suffix SaBa. We used the term "race" when standard differentials were applied, whereas the term "pathotype" when the set of 15 NILs was used as differentials. Both terms characterise the same category of the specialisation of the pathogen.

Field resistance to leaf rust and yellow rust under natural infection was evaluated in 1998 - 2001 at 14 Experimental Variety Testing Stations. The disease severity was evaluated in four replication in a 9 point assessment scale, where point 9 was without symptoms of attack and point 1 means maximum attack.

## Results and discussion

The data on occurrence of leaf rust races in the years 1995 - 2000 in Slovakia are given in Table 1. During the investigation period we detected 12 races of leaf rust. The most frequently determined isolates conformed to race 61SaBa (43 - 86 %), followed by race 77SaBa (2 - 20 %). Both races occurred in all years. To the less frequently determined races belong 14SaBa, 62SaBa, 2SaBa, 77, 61, 6 and race 14. The races 57SaBa, 12SaBa and 6SaBa were more frequent in the last years. The geographic distribution of the determined races does not show any regional specialisation of certain races or pathotypes. If we compare the data on leaf rust races from Slovakia with those from the neighbouring coun-

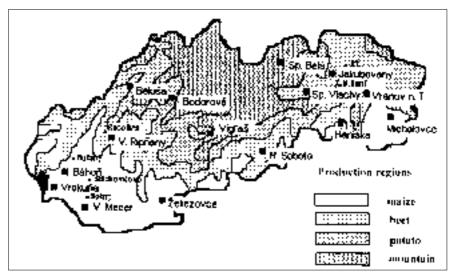


Figure 1: Testing Stations's map of winter wheat in Slovakia

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tries Hungary and the Czech Republic we find many similarities. For year 1999, MANNINGER (2000) described races 12, 61 and 77 as predominant in Hungary. In the Czech Republic, race 61 SaBa predominated in 1999-2000, and races 57SaBa, 12SaBa and 77SaBa also belonged to relatively frequently determined races. Neither in Slovakia nor in the Czech Republic in 1999-2000 (BARTOŠ et al. 2001) and Hungary in 1999 (MANNINGER, 2000) virulence on Lr9, Lr19, Lr24 and Lr 28 was detected.

The effectiveness of resistance genes to the isolates of leaf rust in the years 1997 - 2000 in Slovakia are given in *Table 2*. Near-isogenic lines (NILs) with resistance genes Lr9, Lr19, Lr24 and Lr28 were completely resistant to all examined pathotypes in all years. High effectiveness against the leaf rust population was found in the genes Lr1, Lr2a and Lr2b. Virulence on Lr3, that is present in several registered cultivars, was common. Similarly, most samples were virulent on Lr26, also present in several registered cultivars. Resistance genes Lr11 and Lr21 were completely ineffective.

Results of the test of registered cultivars with the most common races are given in Table 3. Resistance genes Lr3 and Lr26 prevail in our registered cultivars. These genes are not effective to the most widespread race 61SaBa. Cvs. Arida, Astella, Balada, Barbara, Brea, Eva, Hana, Klea, Malyska, Rada, Regia, Solida, Velta, Viginta and Zerda possess gene Lr3, cv. Samanta Lr3+Lr13, cv. Vlada Lr1+Lr3+Lr13, cv. Blava Lr3ka, cvs. Livia, Malvina and Sana gene Lr26, cv. Alka genes Lr10+Lr13. Undetermined Lr gene possess cvs. Alana, Bety, Elpa, Košútka, Sana, Solara, Šárka and Torysa.

Cultivars Estica and Torysa displayed different reactions to the isolates of race 61SaBa. 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 locality 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

Table 1: Occurrence of leaf rust races in 1995-2000 in Slovakia (in %)

				<u> </u>			
Year	Occurrence of races in %						
	< 10	10.1-20	20.1-40	>40			
1995	12SaBa 77SaBa 14	-	-	61SaBa			
1996	14SaBa 2SaBa 77 61	77SaBa	-	61SaBa			
1997	62SaBa 2SaBa 6SaBa 6	77SaBa 57SaBa	-	61SaBa			
1998	12SaBa 77 14	77SaBa	-	61SaBa			
1999	77SaBa 57SaBa 12SaBa 6SaBa 61	-	-	61SaBa			
2000	2SaBa 77SaBa 6	57SaBa 12SaBa 6SaBa	-	61SaBa			

localities there were differences in reaction of cvs. Torysa and Solida (infection types 2-3). Similar differences were also found in the Czech Republic in cvs. Asta, Blava, Danubia, Lívia and Samara (Bartoš et al. 1996). Cv. Estica belongs to the most resistant cultivars whereas cvs. Boka and Solara were susceptible to all applied rust isolates.

Futher differentiation of different rust isolates belonging to the same race was also possible on the NILs according the virulence/avirulence on Lr15, Lr23 or Lr17. The most widespread race 61SaBa comprised three pathotypes in 1966, four different pathotypes in 1997, two pathotypes in 1999 and four pathotypes in 2000. Race 77SaBa comprised two pa-

thotypes in 1966, two pathotypes in 1997 and also two pathotypes in 2000.

The results of leaf rust and yellow rust severity on recommended winter wheat varieties in Slovakia in 1998 - 2001 are given in Table 4. Currently we established the increasing leaf rust severity. The highest resistance to leaf rust in the field was displayed by the cvs Estica. The ranking of cultivars tested in all State Variety Trials in the period 1998-2001 according to average leaf rust severity also indicates good resistance to leaf rust in the field of the cvs Barbara, Rada, Viginta Klea and Solida (with Lr3) and Solara that has an undetermined Lr gene. Although virulence on Lr3 is prevailing in the leaf rust population, most culti-

Table 2: Virulence of leaf rust isolates on Lr-NILs (%) in years 1997 - 2000

NIL	1997	1998	1999	2000	
Lr1	16-33	27	11.4	22.2	
Lr2a	33	9	14.2	24.4	
Lr2b	33	36	17.1	35.5	
Lr2c	80	100	100	97.8	
Lr3	100 91 100		100	100	
Lr9	0	0	0	0	
Lr11	100	100	100	100	
Lr15	77	73	100	64.4	
Lr17	100	91	100	100	
Lr19	0	0	0	0	
Lr21	100	100	100	100	
Lr23	30	100	80	53	
Lr24	0	0	0	0	
Lr26	100	73	97.1	95.5	
Lr28	0	0	0	0	

Table 3: Postulated leaf rust resistance genes in registered cultivars in Slovakia in 2000

Cultivars	registered	postulated Lr gene	cultivars	registered	postulated Lr gene
1. Alana	1997	Lru*	18. Košútka	1981	Lru
<ol><li>Alka</li></ol>	1997	Lr10+Lr13	19. Lívia	1991	Lr26
<ol><li>Arida</li></ol>	2001	Lr3	20. Malyska	2001	Lr3
<ol><li>Astella</li></ol>	1995	Lr3	21. Malvina	1998	Lr26
5. Balada	1999	Lr3	22. Rada	1995	Lr3
6. Barbara	a 1993	Lr3	23. Regia	1994	Lr3
7. Bety	1999	Lru	24. Samanta	1993	Lr3+Lr13
8. Blava	1992	Lr3ka	25. Sana	1995	Lr26+Lru
9. Boka	1996	Lr13?	26. Solida	1995	Lr3
10. Brea	1998	Lr3	27. Solara	1998	Lru
11. Bruta	1994	none	28. Šárka	2000	Lru
12. Elpa	2001	Lru	29. Torysa	1992	Lru
13. Estica	1996	Lr13+Lr14a	30. Vanda	2001	none
14. Eva	2001	Lr3	31. Velta	2001	Lr3
15. Hana	1985	Lr3	32. Viginta	1984	Lr3
16. Ilona	1989	none	33. Vlada	1990	Lr1+Lr3+Lr13
17. Klea	1998	Lr3	34. Zerda	1999	Lr3

<sup>\*</sup> undetermined, note: genes Lrka, Lr13 and Lr14a were postulated by R.F. PARK.

Table 4: Assessment of leaf rust and yellow rust severity on recommended winter wheat varieties carried out in Slovakia in 1998 - 2001

	postulated		leaf	rust		y e l l o w	rust
Cultivars	Lr gene	1998	1999	2000	2001	2000	2001
Alana	Lr u*	6.9	5.8	-	-	-	-
Alka	Lr10+13	6.9	5.6	5.5	5.5	8.8	8.9
Arida	Lr3				5.8		8.5
Astella	Lr3	7.8	6.0	5.9	5.6	7.3	8.2
Barbara	Lr3	7.9	6.9	7.1	-	7.9	-
Balada	Lr3				6.9		8.0
Bety	Lru				5.9		8.0
Blava	Lr3ka	6.9	5.4	4.9	-	6.6	-
Boka	Lr13?	7.5	6.6	6.3	-	7.9	-
Brea	Lr3	7.2	6.1	4.9	4.8	7.6	8.1
Bruta	non	5.8	4.0	-	-	-	-
Estica	Lr 13+Lr14a?	7.9	8.1	-	-	-	-
Eva	Lr3				6.2		8.3
Hana	Lr3	6.0	3.9	4.2	-	7.8	-
llona	none	6.9	5.7	5.0	5.1	7.3	7.6
Klea	Lr3	-	6.7	6.2	6.5	7.9	8.6
Lívia	Lr26	6.2	4.6	-	-	-	-
Malvina	Lr26	6.1	5.1	5.3	5.5	6.4	6.7
Malyska	Lr3				4.3		7.7
Rada	Lr3	7.6	6.5	6.1	6.0	7.8	8.3
Regia	Lr3	7.5	6.6	-	-	-	-
Samanta	Lr3+Lr13	5.9	4.0	5.4	-	7.9	-
Sana	Lr26+Lr u	7.5	5.9	-	-	-	-
Šarka	Lru				4.4		8.7
Solida	Lr3	7.6	6.5	6.5	-	6.6	-
Solara	Lru	7.5	6.7	6.6	6.2	7.3	8.1
Torysa	Lru	6.7	5.1	4.9	4.6	7.7	8.3
Vanda	none				4.7		8.2
Velta	Lr3				5.4		7.0
Viginta	Lr3	7.3	6.4	6.2	-	7.9	-
Vlada	Lr1+Lr3+Lr13	7.9	6.9	-	-	-	-
Zerda	Lr3				5.5	-	8.6
average		7.1	5.9	5.7	5.5	7.5	8.1

<sup>9 -</sup> without attack, 1 - maximum attack, u - undetermined gene

vars 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. The highest susceptibility to leaf rust was displayed by cvs Hana (Lr3) and Samanta (Lr3+Lr13), by cv. Livia (with Lr26) and Bruta (without specific Lr genes).

After many years in 1999 we recognised the occurrence of yellow rust from natural inoculum. In 2000 and 2001 the occurrence of yellow rust was significant on all registered cultivars and advanced lines, but in 2000 the intensity of severity was higher than in 2001. In 2000 the beginning of intensive attack by yellow rust was earlier than in 2001 and was recognised also on the heads of susceptible cultivars. The highest field resistance to yellow rust was displayed by the cv. Alka. The field observation in 2000 - 2001 indicates also good resistance to yellow rust of cvs. Klea, Rada and Torysa.

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 probably contribute to the reduction of yield losses in some cultivars.

# Summary

In 1995 - 2000 we investigated the occurrence of leaf rust races in Slovakia. During this period we detected 12 races of leaf rust, the most frequently determined isolates conformed to race 61SaBa and 77SaBa. Both races occurred in all years. According to virulence of leaf rust isolates on near isogenic Thatcher lines (NILs) resistance genes Lr9, Lr19, Lr24 and Lr28 were completely resistant to all examined pathotypes in all years. High effectiveness against the leaf rust population was found in the genes Lr1, Lr2a and Lr2b. Virulence on Lr3, that is present in several registered cultivars, was common. Similarly, most samples were virulent on Lr26, also present in several registered cultivars. Resistance genes Lr11 and Lr21 were completely ineffective.

According the test of registered cultivars with the most common races, the resistance genes Lr3 and Lr26 prevail in our registered cultivars. These genes are not effective to the most widespread race 61SaBa. Some registered cultivars possess undetermined Lr genes (Alana, Bety, Elpa, Košútka, Sana, Solara, Šárka and Torysa). Estica and Torysa displayed different reactions to some isolates of race 61SaBa. Cultivars Torysa and

Solida displayed different reactions to three isolates of race 77SaBa. Variation of virulence was found also on NILs Lr15, Lr23 and Lr17.

The highest resistance to leaf rust in the field was displayed by the cvs Estica (Lr13). Also high field resistance was shown by cvs. Barbara, Rada, Viginta, Klea and Solida (with Lr3) and Solara that has an undetermined Lr gene.

In 2000 and 2001 the occurrence of yellow rust was significant on all registered cultivars and advanced lines. The highest field resistance to yellow rust was displayed by the cv. Alka. The field observation in 2000 - 2001 indicates also

good resistance to yellow rust of cvs. Klea, Rada and Torysa.

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