Virulence Analyses of the Populations of *Blumeria graminis* f. sp. *tritici* in the Slovak Republic 1996–1998

JOZEF HUSZÁR

Slovak Agricultural University in Nitra, Faculty of Agronomy – Department of Plant Protection, Nitra, Slovak Republic

Abstract

HUSZÁR J. (1999): **Virulence analyses of the populations of** *Blumeria graminis* f. sp. *tritici* **in the Slovak Republic 1996–1998**. Plant Protect. Sci., **38**: 53–56.

In 1996–1998, according to virulence analyses of populations of *Blumeria graminis* f. sp. *tritici,* the effective resistance genes in wheat were *Pm4a* and *Pm1+2+9*. The gene combination *Pm2+6* was effective only against isolates from western Slovakia. Ineffective were the genes *Pm2, Pm3a, Pm3b, Pm3c, Pm3f, pm5, Pm7* and *Pm8*. Gene *Pm4b* was partly effective only in eastern Slovakia. The number of virulence genes in the collected isolates ranged from 9 to 13; most frequent were isolates with 10 or 11 genes of virulence. The isolates with the lowest complexity were found in eastern Slovakia.

Key words: wheat, *Blumeria graminis* f. sp. *tritici*; virulence

Triticum aestivum L. is host for many pathogens, of which powdery mildew, rusts, septorioses, fusarioses and the diseases of stem bases are the most important for resistance breeding. Of the obligate parasites, powdery mildew and the rusts are remarkable for high intraspecific variability because of the appearance of new races or pathotypes. Resistance breeding in Slovakia uses race-specific resistance against such pathogens, although non-specific resistance is used as well. For production, slow rusting and slow mildewing genotypes are also important.

The pathogen for powdery mildew is *Blumeria graminis* DC. f. sp. *tritici* Marchal. GOLOVIN (1958) and SREER (1975) separeted the species *Erysiphe graminis* DC. from the genus *Erysiphe* into the new genus namely *Blumeria* with one species *Blumeria graminis* (DC.) SPEER. The reason for this were morphological differences in its vegetative organs and in the structure of cleistothecia, which are quite different from other species of the genus *Blumeria*.

From the territory of Slovakia, 21 races of *B. graminis* were described in the period 1981–1987 (HUSZÁR 1996; KOLLÁR 1985) by using seven differentials (NOVER 1957). In wheat 24–25 numbered major genes of resistance to powdery mildew were described; they are effective either individually or in gene combinations (BARTOŠ 1991). Race-specific breeding for resistance is used against wheat powdery mildew world-wide. For effective use of the resistance genes, the observations of pathogen variability are very important because the prevailing virulence factors of the race spectrum that are characteristic for an area become known, and we can also find effective genes for resistance. We report here the virulence observations of wheat powdery mildew of the years 1996–1998 in Slovakia.

MATERIALS AND METHODS

From regions of western Slovakia we collected 20 samples of powdery mildew from five localities, from central Slovakia 24 samples from 10 localities, and from eastern Slovakia 15 samples from five localities (Fig. 1). Single pustule isolates were obtained from the samples and mul-

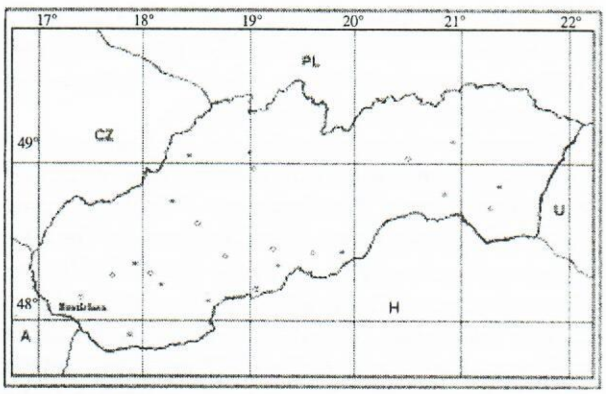

Fig. 1. Localities for sampling of isolates in 1996–1998 in Slovakia

tiplied on Carsten V, a cultivar with no gene of resistance. Tests on the virulence of the isolates were carried out at growth stage 12 (seedling stage) according to ZADOKS *et al.* (1974). In 1996 we inoculated intact plants, while from 1997 on the tests were done on leaf segments on agar medium with benzimidazole. From each cultivar we tested 10 leaf segments, each coming from a different plant. Sixteen differential cultivars were used, and Carsten V as check cultivar.

Cultivar	Gene of resistance	Cultivar	Gene of resistance
Axminster	*Pm1*	Weihenstephan M1	*Pm4b*
Ulka	*Pm2*	Hope	*pm5*
Asosan	*Pm3a*	Transec	*Pm7*
Chul	*Pm3b*	Salzmünder 14-44	*Pm8*
Sonora*	*Pm3c*	Amigo	*Pm17*
Colibri	*Pm3d*	Kenya Civet	*Pm2+6*
Michigan Amber	*Pm3f*	Halle 13471	*Mld+mlha*
Khapli/8	*Pm4a*	Normandie	*Pm1+2+9*

*used as differential cultivar from 1997 on

The reaction of a differential was evaluated by a scale of 0–5 (MAINS & DIETZ 1930), where degrees 0, 1 and 2 refer to resistance, whereas 3 and 4 refer to susceptibility:
0 – highly resistant (leaves without disease symptoms, or tiny chlorotic or necrotic spots);
1 – resistant (large chlorotic or necrotic spots on leaves, weak development of mycelia and conidia);
2 – weakly resistant (less evident chlorotic spots without necrotisation, conidia formation is moderate);
3 – susceptible (evident conidia formation);
4 – highly susceptible (vigorous fructification).

From the results we calculated the virulence of isolates against 16 resistance genes and the complexity of virulence.

RESULTS AND DISCUSSION

The results of virulence analyses from the regions of Slovakia, and the ratio of virulence against the resistance genes of the differentials are given in Table 1. Cultivar Khapli/8 with gene resistance *Pm4a,* and cv. Normandie with gene combination *Pm1+2+9* were resistant against all isolates collected in Slovakia. The gene combination of Kenya Civet (*Pm2+6*) was effective only against the isolates collected from western Slovakia.

The number of virulence genes in the isolates ranged from 9 to 13, but isolates with 10 or 11 genes of virulence were most frequent. The frequency of virulence against gene *Pm1* decreased towards eastern Slovakia. The effectiveness of resistance genes *Pm3d* and *Mld+mlha* was similar throughout Slovakia (33–42% for *Pm3d* and 7.0 to 30% for *Mld+mlha*). According to our results we can consider genes *Pm2*, *Pm3a*, *Pm3c*, *Pm3f*, *pm5*, *Pm7* and *Pm8* to be ineffective. The resistance of cv. Weihenstephan M1 with *Pm4b* was effective only in western Slovakia, while in the other regions it was completely ineffective. High virulence against gene *Pm17* was also detected. The appearance of virulence against the gene combination *Pm2+6* in eastern Slovakia is probably caused by races from Hungary, where cultivars with that gene combination are widely grown (SZUNICS & SZUNICS 1996). The resistance genes *Pm2+6* are not very frequent in cultivars grown in Slovakia at present. In Hungary, cultivation of varieties with resistance genes *Pm8* and *Pm2+Pm6* accelerated the evolution processes in the *Blumeria graminis* population, leading to an increased number of races virulent to these genes and consequently to loss of the resistance (SZUNICS & SZUNICS 1993).

The results of analyses of the complexity of the isolates are given in Tables 2 and 3. The coefficient of complexity in western Slovakia was 0.70. A similar value (0.71) was found also in isolates from central Slovakia. Isolates from eastern Slovakia had the lowest complexity (0.67). It is interesting to note that the isolates with lowest complexity came from cv. Torysa with the genes for resistance *Pm2+6*.

The results of the complexity of the isolates *Blumeria graminis* f. sp. *tritici* originated from the single locality (Table 3) suggested, that the virulence is higher at the isolates originated from the trials of Variety Testing Station than at the isolates originated from production wheat fields. It is probably caused by higher genotype variability in the trials of Variety Testing Station.

Table 1. Frequency [%] of *Blumeria graminis* f. sp. *tritici* virulence genes in the years 1996–1998 in Slovakia

Differential cultivar	Gene of resistance	Slovakia		
		West	Central	East
Axminster	*Pm1*	95.0	70.8	53.3
Ulka	*Pm2*	100.0	100.0	93.3
Asosan	*Pm3a*	100.0	100.0	100.0
Chul	*Pm3b*	100.0	100.0	100.0
Sonora	*Pm3c*	95.0	–	93.3
Colibri	*Pm3d*	35.0	42.8	33.3
Michigan Amber	*Pm3f*	100.0	100.0	100.0
Khapli/8	*Pm4a*	0	0	0
Weihenstephan M1	*Pm4b*	100.0	100.0	53.3
Hope	*pm5*	100.0	100.0	100.0
Transec	*Pm7*	100.0	100.0	100.0
Salzmunder 14/44	*Pm8*	100.0	100.0	100.0
Amigo	*Pm17*	75.0	66.7	93.3
Kenya Civet	*Pm2+6*	0	41.6	66.7
Halle 13471	*Mld+mlha*	30.0	29.2	6.7
Normandie	*Pm1+2+9*	0	0	0
Carsten V (control)	none	100.0	100.0	100.0

Table 2. Complexity of virulence in isolates of *Blumeria graminis* f. sp. *tritici* in Slovakia in 1996–1998 (according to origin of isolates)

Regions (No. of analyses)	Origin of isolates	Genes of resistance	Complexity of isolates
West Slovakia (320)	Astella	none	0.75
	Blava	none	0.68
	Ilona	*pm5*	0.75
	Torysa	*Pm2+6*	0.65
Total complexity in West Slovakia			0.70
Central Slovakia (343)	Astella	none	0.75
	Blava	none	0.85
	Ilona	*pm5*	0.85
	Torysa	*Pm2+6*	0.70
	Hana	none	0.71
	Samanta	none	0.79
Total complexity in Central Slovakia			0.71
East Slovakia (240)	Astella	none	0.69
	Blava	none	0.72
	Ilona	*pm5*	0.69
	Torysa	*Pm2+6*	0.60
Total complexity in East Slovakia			0.68

For the testing of horizontal resistance we found out lower complexity coefficients of virulence in isolates of powdry mildew at the Variety Testing Stations Trebišov and Haniska. The highest complexity of virulence was found at the locality Víglaš.

Our results are compared with the results within the framework of COST 817 project Population studies of air & borne pathogens on cereals as a means of improving strategies for disease control. All countries of central and western Europe are included in this framework. The cooperation within COST 817 was valuable for forecasting changes in virulence of powdery mildew and rusts (BARTOŠ & WALTER 1997; SCHACHERMAYR & WINZELER 1997).

In the Czech Republic, the virulence analyses for 1997 included cultivars with the genes of resistance *Pm2, Pm4b, pm5, Pm2+6* and *Pm1+2+9,* and in 1996 also *Pm17* (KLEM & TVARŮŽEK 1997). They found virulence against all these genes. Least frequent was virulence against the gene combination *Pm1+2+9*. The present analyses found no virulence against that gene combination in Slovakia. Against the gene combination *Pm2+6* we found virulent isolates mostly in eastern Slovakia and fewer in central Slovakia, but before 1996 some virulent isolates were also found in western Slovakia (HUSZÁR 1992, 1996; HUSZÁR & KRAIC 1997). In contrast to the Czech Republic, all isolates from throughout Slovakia were virulent against resistance genes *Pm2*, *Pm4b* and *pm5*, except for *Pm4b* to which only 53% of the isolates from eastern Slovakia were

Table 3. Complexity of virulence in isolates of *Blumeria graminis* f. sp. *tritici* in 1996–1998 (according to locality)

Regions	Locality	No. of analyses	Complexity of isolates
West Slovakia	Piešťany[1]	64	0.67
	V. Ripňany[2]	64	0.70
	Báhoň[2]	64	0.75
	V. Meder[2]	64	0.69
	Želiezovce[2]	64	0.72
Central Slovakia	R. Sobota[2]	70	0.74
	Víglaš[2]	57	0.79
	Bodorová[2]	70	0.74
	Beluša[2]	30	0.70
	Žiar n/Hronom[3]	30	0.60
	Balog n/Ipľom[3]	15	0.67
	V. Krtíš[3]	14	0.64
	Lučenec[3]	15	0.67
	Trenčín[3]	14	0.57
	Prievidza[3]	15	0.73
East Slovakia	Trebišov[2]	64	0.66
	M. Šariš[2]	64	0.70
	Haniska[2]	64	0.66
	Michalovce[2]	32	0.75
	Oborín[3]	16	0.69

[1]Research Institute of Crop Production; [2]Variety Testing Station; [3]production wheat fields

virulent. A relatively high virulence frequency in powdery mildew populations against all the most often used resistence genes and their combinations in Europe was observed in Poland (STRZEMBICKA & LAZARSKA 1996). In that country the frequencies of virulence to *Pm1, Pm2, pm5, Pm7* and *Pm8* were similar to those of the population of powdery mildew of wheat in Slovakia.

Acknowledgement

The author thanks Mrs. T. KLEIMANOVÁ and J. KLČOVÁ for their assistance during experiments at the Research Institute of Plant Production, Piešťany.

References

BARTOŠ P. (1991): Odolnost zemědělských rostlin k chorobám. VŠZ Praha: 119.

BARTOŠ P., WALTER U. (1997): The work of leaf rust of wheat and barley subgroup of WG1 of COST 817. In: Proc. Conf. Approaches to improving disease resistance to meet future needs: Airborne pathogens of wheat and barley. Prague, COST 817: 91–92.

GOLOVIN P. N. (1958): Obsor rodov semejstva *Erysiphaceae*. Sbor. Rabot prikl. Zool. i Fitopatol., **5**: 101–139.

HUSZÁR J. (1992): The variability of *Erysiphe graminis* f. sp. *tritici* in west Slovakia in 1989–1990. Ochr. Rostl., **28**: 171–176.

HUSZÁR J. (1996): Virulence analysis of *Erysiphe graminis* f. sp. *tritici* of wheat in Slovakia. In: COST 817 Integrated control of Cereal mildews and rusts. Towards coordination of research across Europe: 97–100.

HUSZÁR J., KRAIC J. (1997): Virulence survey data of *Erysiphe graminis* f. sp. *tritici* in 1995 and 1996 in the Slovak Republic. In: Proc. Conf. Approaches to improving disease resistance to meet future needs: Airborne pathogens of wheat and barley. Prague, COST 817: 117–118.

KLEM K., TVARŮŽEK L. (1997): Virulence frequencies in wheat mildew (*Erysiphe graminis* f. sp. *tritici*) in the Czech Republic. In: Proc. Conf. Approaches to improving disease resistance to meet future needs: Airborne pathogens of wheat and barley. Prague, COST 817: 119–120.

KOLLÁR V. (1985): Fyziologická špecializácia huby *Erysiphe graminis* DC. f. sp. *tritici* Marchal na pšenici v podmienkach Slovenska. Poľnohospodárstvo (Agriculture), **2**: 109–116.

MAINS E. B., DIETZ S. M. (1930): Physiologic forms of barley mildew *Erysiphe graminis hordei* Marchal. Phytopathology, **20**: 229–239.

NOVER I. (1957): Sechsjährige Beobachtungen über die physiologishe Spezialisierung des echten Mehltaus (*Erysiphe graminis* DC.) von Weizen und Gerste in Deutschland. Phytopath. Z., **31**: 85–107.

SCHACHERMAYR G., WINZELER M. (1997): Virulence surveys: the basis to implement breeding strategies in the Swiss wheat breeding program. In: Proc. Conf. Aproaches to improving disease resistance to meet future needs: Airborne pathogens of wheat and barley. Prague, COST 817: 119–120.

SREER E. O. (1975): Untersuchungen zur Morphologie und Systematik der *Erysiphaceae*. I. Die Gattung *Blumeria* Golovin und ihre Typies Art *Erysiphe graminis* DC. Sydowia, **27**: 127–130.

STRZEMBICKA A., LAZARSKA B. (1996): Virulence structure of wheat powdery mildew population (*Erysiphe graminis* f. sp. *tritici*) in Poland. In: Proc. 9[th] Eur. Medit. Cereal Rusts & Powdery Mildews Conf. 2–6 Sept., Lunteren, Netherlands: 147.

SZUNICS L., SZUNICS LU. (1993): Virulence of wheat powdery mildew in Hungary during 1970–1992. Poľnohospodárstvo (Agriculture), **4**: 299–303.

SZUNICS L., SZUNICS LU. (1996): Race composition and virulence of wheat powdery mildew in Hungary. In: COST 817 Integrated control of Cereal mildews and rusts. Towards coordination of research across Europe: 103–106.

ZADOKS J. C., CHANG T. T., KONZAK C. F. (1974): A decimal code for the growth stages of cereals. Weed Res., **14**: 415–421.

Received for publication September 2, 1999
Accepted for publication November 20, 1999

Súhrn

HUSZÁR J. (2000): **Virulenčná analýza** *Blumeria graminis* f. sp. *tritici* **v rokoch 1996–1998 na Slovensku.** Plant Protect. Sci., **36**: 53–56.

Na základe virulenčnej analýzy *Blumeria graminis* f. sp. *tritici* boli v rokoch 1996–1998 na Slovensku efektívne gény rezistencie *Pm4a* a *Pm1+2+9*. Génová kombinácia *Pm2+6* bola účinná iba proti izolátom zo západoslovenského regionu. Neúčinné boli gény rezistencie *Pm2, Pm3a, Pm3b, Pm3c, Pm3f, pm5, Pm7* a *Pm8*. Gén *Pm4b* bol čiatočne účinný iba proti niektorým izolátom z východoslovenského regionu. Najfrekventovanejšie boli izoláty s 10, resp. 11 génmi virulencie.

Klúčové slová: pšenica; *Blumeria graminis* f. sp. *tritici*; virulencia

Corresponding author:

Doc. Ing. JOZEF HUSZÁR, DrSc., Slovenská poľnohospodárska univerzita v Nitre, Katedra ochrany rastlín, Tr. A. Hlinku 2, 94976 Nitra, Slovenská republika, tel.: + 421 87 60 12 56, fax: + 421 87 41 14 51, e-mail: huszar@uniag.sk