SHORT COMMUNICATION

Response of Susceptible, Partially Resistant and Resistant Winter Wheat Cultivars to *Blumeria graminis* f.sp. *tritici*

LUBOMÍR VĚCHET

Research Institute of Crop Production – Department of Genetics and Plant Breeding, Prague-Ruzyně, Czech Republic

Abstract

VĚCHET L. (2001): **Response of susceptible, partially resistant and resistant winter wheat cultivars to** *Blumeria graminis* f.sp. *tritici*. Plant Protect. Sci., **37**: 145–148.

Response of the susceptible cultivar Kanzler, the partially resistant cultivar Mikon and the resistant cultivar Asta (genes of resistance *Pm2*, *Pm6*) to powdery, were tested in two years small plot-experiments. Disease severity was influenced by weather conditions. There were highly significant differences in disease severity, infection type and number of diseased plants between the susceptible cultivar and the cultivars with partial resistance and specific resistance. Smaller differences were between the partially resistant cultivar and the resistant cultivar than between the cultivar with partial resistance and the susceptible cultivar. The most affected leaf was the third leaf from the top in all tested cultivars. Among these cultivars were differences in the highest development of disease in single growth stages.

Keywords: winter wheat; powdery mildew; disease severity; number of diseased plants; infection type

Powdery mildew on wheat *Blumeria graminis* DC. (syn. *Erysiphe graminis* DC. E.O.Speer) f.sp. *tritici* Em. Marchal (FRIEBE *et al.* 1996; HSAM *et al.* 1998; SHI *et al.* 1998) is one of the most destructive leaf diseases of wheat. Most genes used in present plant breeding are race specific single genes for which the pathogens seem to have the ability to develop virulence. Each virulence is like a switch allowing the pathogen to infect a certain set of host varieties with the corresponding resistance genes (DE VALLAVIEILLE-POPE *et al.* 1998). Most commercial cultivars are susceptible to many powdery mildew races. PARLEVLIET (1988) has defined partial resistance as resistance that results in reduced epidemic development despite a compatible (susceptible) infection type.

In this work we wanted to find out how the cultivar with partial resistance reduces epidemic development in relation to the susceptible and to the specific resistant cultivar.

MATERIALS AND METHODS

For two years small plot-experiments as models the cultivar Kanzler (Germany) susceptible to powdery mildew (as standard in ring tests 1997–1999 of COST 817, WG4), the cultivar Mikon (Germany) with partial resistance to the disease (standard in ring tests 1997–1999 of COST 817, WG4) and Asta (Czech Republic) with genes of resistance *Pm2* and *Pm6* were chosen. The cultivars were sown in three rows vertically to one row of the susceptible cultivar Kanzler. This spreader was artificially inoculated by a mixture of four powdery mildew races with representation of virulence against genes of resistance *Pm2*, *Pm3d*, *Pm18*, and medium or low representation against genes of resistance *Pm1*, *Pm3b*, *Pm3c*, *Pm3f*, *Pm4b*, *Pm5*, *Pm6*, *Pm2* and *6*, *Pm7*. The disease severity was scored by evaluation in four replicates on all live leaves on 15 plants of the tested cultivar by a 9 point as-

sessment scale (SAARI & PRESCOTT 1975). From the disease severity data the cumulative proportion of leaf area diseased – CPLAD was counted. Reaction of a cultivar to powdery mildew was expressed as the infection type – IT (MAINS & DIETZ 1930). In each evaluated cultivar a number of diseased plants – NDP was expressed. Analysis of variance was used to find out reliability of differences among cultivars. The growth stage was assessed using decimal code (ZADOKS *et al.* 1974).

RESULTS AND DISCUSSION

The disease severity was estimated on five sampling dates in 1999 and in four dates in 2000 (Table 1). The occurrence of powdery mildew was higher in 1999 than in 2000 year. Progress of daily temperatures shows Table 2. Averaged daily temperatures in 2000 were higher than 1999 but there were high differences in the number of days with maximum temperature higher than 25°C (1999 7 days; 2000 23 days) in May and June. Maximum temperatures 30°C occurred on five days in June in 2000 and in 1999 not so high temperatures were recorded.

Table 1. The sampling dates (SD) and the corresponding averaged Zadoks growth stage (GS) values for winter wheat cultivars tested in 1999 and 2000

Year	SD	GS
1999	SD1 (27.5.)	51
	SD2 (3.6.)	61
	SD3 (10.6.)	69
	SD4 (29.6.)	71
	SD5 (7.7.)	75
2000	SD1 (29.5.)	
	SD2 (10.6.)	55
	SD3 (16.6.)	65
	SD4 (28.6.)	69

Table 2. Averaged daily temperatures (ADT) and number of days with maximum temperature above 25°C (MT) for ten days (decade) in 1999 and 2000

Decade	1999		2000	
	ADT	MT	ADT	MT
May 1.	13.0	0	18.0	2
2.	13.4	0	16.5	4
3.	17.6	4	14.0	2
June 1.	17.2	1	19.3	6
2.	15.2	0	20.0	7
3.	16.0	2	16.3	2

Development of powdery mildew and reaction of cultivars in both years of experiments is shown in the Table 3. All leaves on the cultivar Kanzler were attacked from the beginning of evaluation, except 55 growth stage in 1999 when the first leaf was without powdery mildew yet. The third leaf from the top was most affected by the disease from evaluated leaves on the plants. The first leaf (flag leaf) was less affected. Infection type was 4 (plentiful sporulation and growth of mycelium). This cultivar had affected high number of plants (60–80%).

The cultivar Mikon had far less disease severity than the previous cultivar and its values approached to the cultivar Asta. This cultivar had higher differences between the disease severity in both years also. In the year 2000 when the disease severity was lower than in 1999 this cultivar had the first leaf from the top without powdery mildew. The most affected leaf on the plants was the third leaf again. Infection type was initially low (2 – middle resistant) lately higher (3 – middle sporulation, and plentiful growth of mycelium). The cultivar had affected small number of plants only.

The cultivar Asta had very low disease severity with higher differences between two years. In 1999 there was higher and in 2000 lower disease severity. This cultivar had never affected the first leaf from the top and in 2000 had not affected the second leaf from the top. The most diseased leaf from all leaves was the fourth in 1999 and in 2000 the same value as the fourth one had the third leaf. Infection type was low (in 1999 = 2; 2000 = 1). A number of diseased plants was also low (7–35%). The most disease development on the plant expressed as CPLAD in the susceptible cultivar Kanzler started in the beginning of the evaluation (1999: 51–61 growth stage; 2000: 55–65 stage) in the partially resistant cutivar Mikon it fluctuated (1999: 71–75 growth stage; 2000: 59–65 stage) in the resistant cultivar Asta it was in the middle of the evaluation (1999: 55–69 growth stage; 2000: 65–69 stage). The cultivar Asta had lower disease severity and higher number of diseased plants than the cultivar Mikon in 1999. Differences among cultivars were very significant in CPLAD and NDP for both years of experiments.

Occurrence of powdery mildew was likely influenced by different progress of daily temperatures in two years of experiments. The colder year 1999 had more suitable conditions for development of the disease. On the contrary the period of evaluation of the year 2000 was warmer but in May and June number of days with temperatures above 25°C was much higher than in the year 1999. KOCOUREK and VĚCHET (1984) found out that at temperature 24.5°C development of *E. graminis* f.sp. *tritici* has stopped. Several days in June 2000 reached even 30°C and these temperatures probably retarded powdery mildew epidemic. The most drop of the disease severity in the year 2000 against 1999 was recorded in the cultivar Asta with specific resistance to powdery mildew.

Table 3. The disease severity in each SD for each evaluated leaf (from the top, + dead leaf), cumulative proportion of leaf area diseased – CPLAD, infection type – IT and number of diseased plants – NDP

Cultivar	SD	1st leaf	2nd leaf	3rd leaf	4th leaf	5th leaf	CPLAD	IT	NDP
Kanzler 1999	1.	0	0.1	0.5	1.0	0.7	2.3	3	75.3
	2.	0.2	0.7	1.7	6.0	+	9.3	4	76.3
	3.	0.3	0.9	3.2	10.0	+	15.1	4	80.0
	4.	0.5	3.9	12.9	+	+	28.0	4	77.3
	5.	0.9	+	+	+	+	28.4	4	53.3
Mikon 1999	1.	0	0.01	0.01	0.04	0.08	0.14	2	6.7
	2.	0.03	0.01	0.04	0.15	+	0.31	2	11.4
	3.	0.02	0.08	0.04	0.2	+	0.42	3	18.3
	4.	0.03	0.2	1.3	+	+	1.81	3	23.3
	5.	0.07	0.35	+	+	+	2.0	3	13.3
Asta 1999	1.	0	0	0.05	0.25	0	0.3	2	18.5
	2.	0	0	0.08	0.3	+	0.38	2	20.0
	3.	0	0.1	0.1	0.7	+	0.9	2	20.0
	4.	0	0.1	0.15	1.2	+	1.45	2	35.0
	5.	0	0.1	+	+	+	1.45	2	15.4
F							10.56		111.84
Kanzler 2000	1	0.1	0.6	1.2	1.4	+	3.3	4	60.0
	2.	0.2	1.4	5.8	3.0	+	10.4	4	75.6
	3.	0.3	1.4	6.0	+	+	10.7	4	80.0
	4.	0.3	1.8	+	+	+	11.2	4	31.0
Mikon 2000	1.	0	0	0.1	0.1	+	0.2	2	10.0
	2.	0	0.1	0.2	+	+	0.4	3	13.3
	3.	0	0.2	0.3	+	+	0.6	3	15.0
	4	0	0.2	+	+	+	0.6	3	6.2
Asta 2000	1.	0	0	0	0.05	+	0.05	1	3.2
	2.	0	0	0.03	0.05	+	0.08	1	6.7
	3.	0	0	0.05	+	+	0.1	1	2.8
	4.	0	0	+	+	+	0.1	0	0
F							15.23		32.17

Analysis of variance ($F_{tab.}$ for cultivars 1999 $P = 0.05 = 4.5$; $P = 0.01 = 8.7$; 2000 $P = 0.05 = 5.1$; $P = 0.01 = 10.9$)

High significant differences in the disease severity of powdery mildew were found out between the three tested cultivars. But disparity between the disease severity of the partially resistant and resistant cultivars was not such broad like between the partial resistant and susceptible cultivars. It means that the disease severity of the partially resistant cultivar does not lie somewhere in the middle between the disease severity of susceptible and resistant cultivar but it is nearer to disease severity of the resistant cultivar despite its of intermediate susceptible infection type. Infection type of partial resistance cultivar can a little change according to growth stage of a plant. PARLEVLIET (1988) find out that infection type can be lower at more advanced development stage of a plant. The partial resistant cultivar Mikon had medium infection type at the beginning and end of the evaluation (SD1 and SD5 or SD4) and medium susceptible infection type in the remaining sampling dates. The highest infection type had the susceptible cultivar in both years it was the same. The resistant cultivar Asta had a low infection type but it varied in both years. This was higher in 1999 and lower in 2000. The hypothesis that partial resistance reduces epidemic development despite a susceptible infection type was confirmed by the present data. Disease severity on partial resistant cultivar will likely dependent on a level of partial resistance of that given cultivar. Differences in the occurrence on the flag leaf were among these cultivars too. The resistant cultivar had the first leaf from the top without the powdery mildew in both years, the partially resistant cultivar had in one year (1999) very low disease

severity and in the second year it was without disease and on the contrary the susceptible cultivar had the lowest disease severity from all leaves on the plant. In the susceptible and the partially resistant and resistant cultivar the third leaf from the top had the highest disease severity. It seems that the expression of partial resistance and mainly specific resistance can be in certain extent influenced by weather conditions. Outside conditions are very important in expression of major genes (PARLEVLIET 1988). Infection pressure strongly depends on the weather, and so weather exerts an influence on the resistance level of the individual cultivars (WALTHER 1988).

Susceptible cultivar had the highest number of diseased plants from the beginning of the epidemic. A number of diseased plants in partially resistant cultivar was substantially lower than in the susceptible cultivar, the resistant cultivar has low number of diseased plants. On the meaning of number of diseased plants as an epidemiological parameter was pointed out by VĚCHET (1997).

Model winter wheat cultivars with dissimilar susceptibility/resistance to powdery mildew demonstrated differences in the development of the disease, infection type and number of diseased plants.

References

DE VALLAVIEILLE-POPE C.C., LYNGKJAER M., ØSTERGÅRD H., PONS J., SACHE I., SHAW M. (1998): Epidemiological parameters. Airborne pathogens on cereals. Ann. Report 1998. COST Action, **817**: 142–150.

FRIEBE B., JIANG J., RAUPP W.J., MC INTOSH R.A., GILI B.S. (1996): Characterization of wheat-alien translocation conferring resistance to disease and pests: current status. Euphytica, **91**: 59–87.

HSAM S.L.K., HUANG X.Q., ERNST F. (1998): Chromosome location of genes for resistance to powdery mildew in common wheat (*Triticum aestivum* L. Em. Thell.). 5. Alleles at the Pm1 lokus. Theor. Appl. Genet., **96**: 1129–1134.

KOCOUREK F., VĚCHET L. (1984): Über ein temperaturabhängiges Model zur Vorhersage der Entwicklungsgeschwindikeit bei *Erysiphe graminis* f.sp. *tritici*. Anz. Schädlingskd. Pfl., **57**: 15–18.

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

PARLEVLIET J.E. (1988): Race-specific aspects of polygenic resistance of barley to leaf rust, *Puccinia hordei*. Neth. J. Plant. Pathol., **84**: 121–126.

SAARI E.E., PRESCOTT J.M. (1975): A scale for appraising the foliar intensity of winter diseases. Pl. Dis. Reptr., **595**: 337–380.

SHI A.N., LEATH S., MURPHY J.P. (1998): A major gene for powdery mildew resistance transferred to common wheat from wild Einkorn wheat. Phytopathology, **88**: 144–147.

VĚCHET L. (1997): Reaction of winter wheat cultivars and breeding lines from European countries to powdery mildew (*Blumeria graminis* f.sp. *tritici*). Scientia Agric. Bohemica, **37**: 1–12.

WALTHER U. (1988): Wie sicher ist die „Feldresistenz" – Erläutert an mehjähriger Prüfung von Sommergersten gegen *Puccinia hordei* Otth Tagungsber. 271, Teil II Schaderreger in der Getreideproduction. Akad. Lanwirt.-Wissens. DDR, Berlin, **271**: 243–246.

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 June 1, 2001
Accepted for publication December 13, 2001

Souhrn

VĚCHET L. (2001): **Reakce náchylné, částečně rezistentní a rezistentní odrůdy pšenice ozimé k** *Blumeria graminis* f.sp. *tritici*. Plant Protect. Sci., **37**: 145–148.

V maloparcelkových dvouletých pokusech byly sledovány reakce náchylné odrůdy pšenice ozimé Kamzler, částečně rezistentní odrůdy Mikon a rezistentní odrůdy Asta (geny rezistence *Pm2, Pm6*) k padlí travnímu. Síla choroby byla ovlivněna klimatickými podmínkami. Vysoce průkazné rozdíly byly v síle choroby, infekčním typu a počtu napadených rostlin mezi náchylnou odrůdou a odrůdami s částečnou rezistencí a specifickou rezistencí. Menší rozdíly byly mezi odrůdou částečně rezistentní a rezistentní než mezi odrůdou částečně rezistentní a náchylnou. U všech testovaných odrůd byl nejvíce napaden třetí list shora. Rozdíly mezi odrůdami v nejvyšším vývoji choroby byly v jednotlivých růstových fázích.

Klíčová slova: pšenice ozimá; padlí travní; síla choroby; počet napadených rostlin; infekční typ

Corresponding author:

Ing. LUBOMÍR VĚCHET, CSc., Výzkumný ústav rostlinné výroby, odbor genetiky a šlechtění, 161 06 Praha-Ruzyně, Česká republika
tel.: + 420 2 33 02 23 61, fax: + 420 2 33 02 22 86, e-mail: vechet@vurv.cz