Development of powdery mildew and leaf rust epidemics in winter wheat cultivars

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ABSTRACT

Development of powdery mildew and leaf rust epidemics was examined on three winter wheat cultivars with different predispositions to powdery mildew in three-year experiments. The progress of powdery mildew and leaf rust on the same cultivar was conditioned by its dissimilar susceptibility to the respective disease. Fit temperature played an important role at the beginning of the particular disease and during its progress. Significant differences in the disease severity of powdery mildew and leaf rust were recorded on single leaves. Disease severity of leaf rust was higher on upper leaves while disease severity of powdery mildew was higher on lower leaves.

Keywords: winter wheat; powdery mildew; leaf rust; disease severity; temperature

The occurrence of one disease on a plant is obviously accompanied by other diseases. Out of the obligatory pathogens for example powdery mildew and leaf rust very often occur on winter wheat together. *Blumeria graminis* (syn. *Erysiphe graminis*) DC. Speer f.sp. *tritici* and *Puccinia recondita* Rob. ex Desm f.sp. *tritici* are probably the most important diseases of wheat throughout the world. Both diseases have different requirements at the beginning of the disease and during its progress. For example higher occurrences of leaf rust were presumably influenced by the highest temperatures in summer months in the last years but changes in the populations of this rust can also play their role (Bartoš et al. 1992). On the contrary, the same cultivar need not have the same susceptibility to both diseases.

The aim of these experiments was to compare disease severity of powdery mildew and leaf rust and their progress on winter wheat cultivars with different susceptibility to powdery mildew in three years.

MATERIAL AND METHODS

Both diseases were studied on three cultivars: Kanzler – susceptible standard to powdery mildew, Mikon – partially resistant standard to powdery mildew and Asta with specific genes of resistance Pm2 and Pm6 to powdery mildew. These cultivars were sown in three rows vertically to one row of the susceptible cultivar Kanzler. This spreader was artificially infected by a mixture of powdery mildew races with powerful representation of virulence against the genes of resistance Pm2, Pm3d, Pm18 and middle or low representation of virulence against the genes of resistance Pm1, Pm3B, Pm3c, Pm4b, Pm5, Pm6, Pm2.6, Pm7. The disease severity was scored by evaluation of all live leaves on 15 plants of the tested cultivars by a 9-point assessment scale (Saari and Prescott 1975).

In leaf rust natural infection was used with the predominance of race UN3-61SaBa (from adjacent experiments) that is a dominant race of this pathogen in the Czech Republic (Bartoš et al. 1992). Disease severity was expressed as percent leaf area diseased. The disease severity of the whole plant was expressed in the same way as in powdery mildew.

To express the disease progress AUDPC – area under disease progress curve (Shaner and Finney 1977) was used. The disease severity of the whole plant was expressed as the cumulative proportion of leaf area diseased – CPLAD (Věchet and Kocourek 1987, Brière et al. 1994). The number of diseased plants (NDP) was counted on each sampling date. The growth stage was assessed using Zadoks decimal code (Zadoks et al. 1974).

RESULTS

The disease severity was estimated on several sampling dates in both years (Table 1). Maximal values of disease severity of powdery mildew and leaf rust in the years of experiments are shown in Figure 1. Severity of powdery mildew was highest in 2001 while the highest severity of leaf rust was in 2000. The occurrence of leaf rust was higher in all years of experiments than that of powdery mildew.

Development of powdery mildew in 1999 (Figure 2) was more rapid up to growth stage 61 whereas development of leaf rust was more rapid from growth stage 65 to 73. But development of leaf rust on the cultivar Mikon was slower than development of powdery mildew in all growth stages except the growth from 55 to 61. Maximal rise of powdery mildew on the cultivar Kanzler from growth stage 61 to 65, on the cultivar Mikon it was from 73 to 75 and on the cultivar Asta it was from growth stage 59 to 65. In leaf rust maximal rise of the disease on the cultivars

Table 1. The sampling dates (SD) and the corresponding averaged Zadoks growth stage (GS) for winter wheat cultivars in 1999, 2000 and 2001

Year	SD	GS
1999	SD1 (27.5.)	49
	SD2 (4.6.)	55
	SD3 (10.6.)	61
	SD4 (24.6.)	65
	SD5 (1.7.)	73
2000	SD1 (25.5.)	51
	SD2 (7.6.)	61
	SD3 (14.6.)	69
	SD4 (28.6.)	73
2001	SD1 (25.5.)	49
	SD2 (13.6.)	55
	SD3 (26.6.)	65
	SD4 (10.7.)	75

Kanzler and Mikon was from growth stage 55 to 61 and on the cultivar Asta it was from 61 to 65. Development of leaf rust began later than of powdery mildew. Leaf rust appeared on the cultivars Kanzler and Mikon in growth stage 55 and on the cultivar Asta in growth stage 61.

Progress of powdery mildew in 2000 (Figure 3) was moderate and disease severity was weak. Maximal rise of powdery mildew was in the growth stage from 51 to 61 on the cultivars Kanzler, Mikon and Asta. Development of leaf rust began earlier (in growth stage 51) than in 1999 and disease severity was higher than in powdery mildew except the cultivar Mikon. Mainly in the growth stage from 69 to 75 a high increase of leaf rust occurred in all cultivars. Maximal rise of leaf rust on the cultivar Kanzler was from growth stage 51 to 61, on the cultivars Mikon and Asta it was from 61 to 69. Disease severity of leaf rust was the highest of all years.

Maximal rise of powdery mildew in 2001 (Figure 4) was on the cultivar Kanzler from growth stage 55 to 65 and on the cultivars Ramiro and Vlasta it was from phase 49 to 55. Disease severity of leaf rust was higher than that of powdery mildew although its disease severity was the highest of all years. On the cultivar Asta progress of leaf rust was higher than in powdery mildew in all growth stages. On the cultivar Ramiro it was from growth stage 55 to 65 and on the cultivar Kanzler it was from growth stage 65 to 75. Maximal rise of leaf rust was in the growth stage from 55 to 65.

Higher values of powdery mildew disease were on lower leaves (the third F3 and the fourth F4 leaves) in 2001. In the years 1999 and 2002 the flag (the first F1) leaf was not affected by powdery mildew and in 2000 the cultivar Kanzler was affected very little only. The cultivar Asta had the second (F2) and the third (F3) leaf less affected than the cultivar Mikon. Table 2 shows maximal values of powdery mildew and leaf rust incidence on single leaves. The highest incidence values of leaf rust were on the first (F1) leaf from the top and further on the second (F2) leaf. On the contrary, higher values of leaf rust were on upper leaves (F2 and F1) leaves in the cultivars Kanzler, Mikon and Asta in the year 2000.

Average daily temperatures in single decades (Table 3) in 2000 showed that a rapid increase in leaf rust in the period 14.6.–28.6. was probably conditioned by an increase in temperatures in the second and third decade of June and a high number of days with maximum temperature above 20°C.

DISCUSSION

Common occurrence of powdery mildew and leaf rust is very frequent. Both diseases have dissimilar conditions for successful development. According to Everts et al. (2001) powdery mildew is early-season and leaf rust is late-season. Different levels of powdery mildew and leaf rust developed on three winter wheat cultivars that varied in the levels of disease resistance, presence of seed treatment, and the presence and timing of foliar fungicide application. Browder and Eversmayer (1987) showed different requirements for high temperatures that can manifest either by susceptibility or resistance. Our experiments showed that the start of powdery mildew was earlier than that of leaf rust in most cases. On the contrary, leaf rust started progress quickly a little later than powdery mildew only when daily temperatures were higher. But in this period the progress of powdery mildew (for example in 2000) stopped in most cases. Kocourek and Věchet (1984) found out the optimum temperature for *E. graminis* f.sp. *tritici* 21.5°C. Covering of the leaf area by both diseases together on single leaves of cultivars did not reach more than 85%.

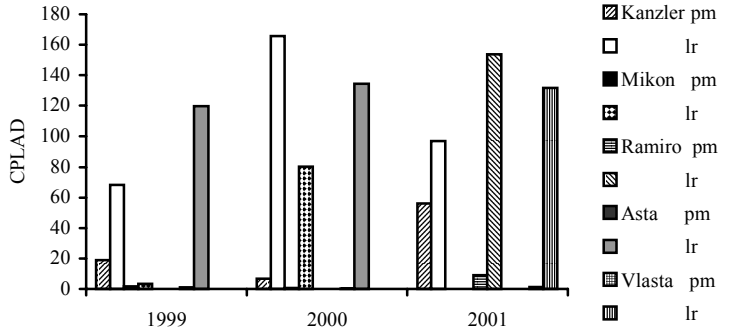


Figure 1. Disease severity (CPLAD) of powdery mildew (pm) and leaf rust (lr) on the whole plants (all live leaves) of tested cultivars in three years of experiments

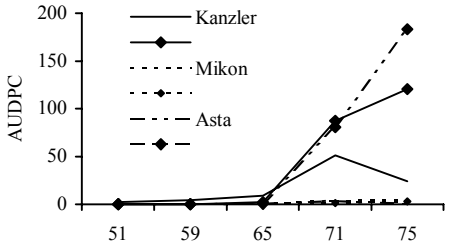
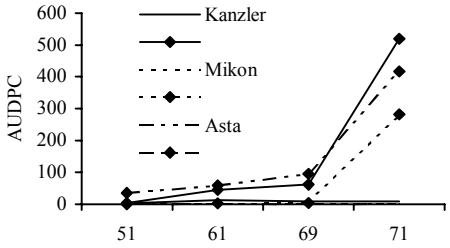


Figure 2. Progress of powdery mildew and leaf rust on the tested cultivars expressed as area under disease progress curve (AUDPC) in 1999



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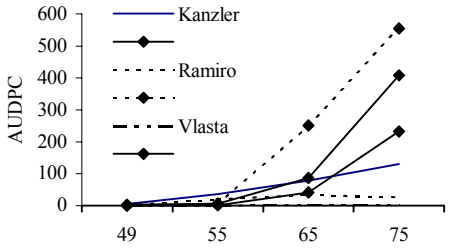

Figure 4. Progress of powdery mildew and leaf rust on the tested cultivars expressed as area under disease progress curve (AUDPC) in 2001

Differences were ascertained between the tested cultivars. The cultivar Kanzler, susceptible standard to powdery mildew, showed the highest disease severity in all years. Disease severity of the cultivar Mikon or Ramiro was always substantially lower than in Kanzler but a little higher than in the cultivars Asta or Vlasta, cultivars with specific genes of resistance (Pm2, Pm6). Parlevliet (1988) defined partial resistance as a reduced rate of epidemic development despite of a high or susceptible infection type. Disease severity of leaf rust was high in all cultivars, even in the cultivars with specific resistance to powdery mildew (Asta in the first year of experiments and Vlasta in the third year) was higher than in the cultivar Kanzler. The cultivar Mikon had lower disease severity of leaf rust than the cultivar Kanzler in two years of experiments. However, the cultivar Ramiro had higher disease severity of leaf rust than the cultivar Kanzler. Petrova et al. (2000) reported that 16 cultivars of common wheat showed resistance that differed from the response patterns of the powdery mildew major genes or gene combinations.

Differences in disease severity of powdery mildew and leaf rust were found on single leaves. Higher development of powdery mildew was on lower leaves from the top, the third and the fourth leaf. On the contrary, disease severity of leaf rust was highest on upper leaves, the second and the first leaf. It indicates the influence of higher temperatures on the development of leaf rust just in the month of June in comparison with May when temperatures were lower. And conspicuous is the highest disease severity of leaf rust in 2000, when average daily temperatures in the second and third decade of June were higher than in the other years.

The number of days with maximum temperatures above 25°C in the first and second decade of this year played its role.

The occurrence of powdery mildew and leaf rust on the same cultivar of winter wheat is different and it is conditioned by temperature in the period specific to favourable development of the disease.

Table 2. Maximal incidence of powdery mildew and leaf rust (percent of leaf area diseased) on single leaves of the tested cultivars expressed as values for powdery mildew (first number in round brackets) and leaf rust (second number) in all years of experiments

	1st leaf (F1)	2nd leaf (F2)	3rd leaf (F3)	4th leaf (F4)
		1999		
Kanzler	30.98 (0.68, 30.3)	37.18 (5.12, 32.06)	26.58 (9.68, 16.9)	4.06 (3.33, 0.73)
Mikon	0.13 (0.03, 0.11)	0.64 (0.19, 0.45)	1.45 (1.03, 0.42)	2.12 (0.33, 1.79)
Asta	28.00 (0, 28.0)	54.10 (0.1, 54.0)	29.40 (0.15, 29.25)	9.20 (0.7, 8.5)
		2000		
Kanzler	52.05 (0.05, 52.0)	74.85 (0.85, 74.0)	26.35 (2.65, 23.7)	19.00 (3.0, 16.0)
Mikon	12.50 (0, 12.5)	66.05 (0.05, 66.0)	2.00 (0.5, 1.5)	0.50 (0.2, 0.3)
Asta	29.25 (0, 29.25)	44.10 (0.1, 44.0)	49.03 (0.2, 48.83)	21.70 (0.2, 21.5)
		2001		
Kanzler	20.90 (0.9, 20.0)	67.20 (2.85, 42.0)	43.70 (25.2, 18.5)	17.73 (25.7, 16.4)
Ramiro	79.20 (0.2, 79.0)	42.55 (0.55, 42.0)	73.65 (1.65, 72.0)	6.80 (6.6, 0.2)
Vlasta	85.25 (0, 85.25)	9.70 (0.1, 9.6)	21.75 (0.55, 21.1)	22.18 (0.65, 21.57)

Table 3. Average daily temperatures (ADT °C) and the number of days with maximum temperature above 25°C (MT) in decades (ten days) in four years of experiments

Month	Decade	1999		2000		2001	
		ADT	MT	ADT	MT	ADT	MT
May	1.	13.0	0	14.2	2	12.2	3
	2.	13.4	0	16.0	4	13.8	0
	3.	17.6	4	15.6	2	14.9	1
June	1.	17.2	1	16.7	6	14.8	0
	2.	15.2	0	18.4	7	15.0	0
	3.	16.0	2	18.5	2	16.0	2
July	1.	21.1	6	18.3	0	17.8	4
	2.	19.5	6	16.1	0	18.0	1

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ABSTRAKT

Vývoj epidemie padlí travního a rzi pšeničné na vybraných odrůdách ozimé pšenice

V tříletých pokusech byl na třech odrůdách ozimé pšenice s odlišnou náchylností k padlí travnímu sledován vývoj epidemie padlí travního a rzi pšeničné. Postupný vývoj padlí a rzi pšeničné na té samé odrůdě byl podmíněn rozdílnou vnímavostí k určité chorobě. Důležitou úlohu v počátku konkrétní choroby a v jejím vývoji hrála vhodná teplota. Významné rozdíly mezi závažností padlí travního a rzi pšeničné byly zaznamenány na jednotlivých listech. Horní listy měly větší závažnost rzi pšeničné, zatímco dolní listy měly vysokou závažnost padlí travního.

Klíčová slova: ozimá pšenice; padlí travní; rez pšeničná; závažnost choroby; teplota

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