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VIRULENCE FREQUENCY OF *TILLETIA CARIES* AND THE OCCURRENCE OF COMMON BUNT ON 20 WINTER WHEAT CULTIVARS

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Abstract

During three vegetation seasons virulence frequency of *Tilletia caries* and common bunt occurrence on 20 winter wheat cultivars were assessed. *Tilletia caries* virulence frequency was calculated as percentage of infected ears of a cultivar with particular resistance gene as compared to a cultivar without any resistance gene. In both experiments winter wheat seeds contaminated with teliospores of *T. caries* were used. Virulence corresponding to genes Bt-3 and Bt-7 occurred in all three seasons. Virulence corresponding to genes: Bt-4, Bt-8 and Bt-11 was not found in any of the seasons. Among 20 cultivars of winter wheat the mean percentage of infected ears for three seasons varied from 16.5 ('Mikon') to 33.7 ('Wilga').

Key words: *Tilletia caries*, winter wheat, susceptibility

Introduction

Wheat is the most important cereal crop grown in Poland (about 28% of total cereal cultivated area). Winter wheat is much more popular than spring wheat due to the higher yield of the former. The yield losses are caused by unfavourable weather or soil conditions as well as diseases and pests. Common bunt caused by *Tilletia caries* is a serious disease of wheat in Poland. Usually winter wheat is infected by the pathogen at a degree higher than spring wheat because of more favourable environment conditions for the pathogen in autumn than in spring (Purdy and Kendrick 1957, Zscheile 1965). However, the pathogen's response to soil temperature and humidity depends on its race (Lowther 1950).

Common bunt is a problem in the countries or regions, including Poland, in which sowing material is not free from the pathogen (Bakuniak 1995, Sadowski

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and Łukanowski 2005, Váňová et al. 2006, Dumalasová and Bartoš 2007 a). Yield losses may exceed 50% when the inoculum level is high and environment conditions are favourable for the pathogen development (Goates 1996, Laroche et al. 2000). Beside quantity also yield quality is decreased (Borgen 2004, Kochanová et al. 2004). Moreover, wheat seedlings infected by *T. caries* are more sensitive to frost damage than healthy ones (Veisz et al. 2000).

The aim of the research was assessment of *T. caries* virulence frequency and the common bunt occurrence on 20 winter wheat cultivars.

Materials and methods

Experiment on *T. caries* virulence frequency evaluation was conducted in Poznań in three growing seasons: 1998/99, 1999/2000 and 2004/05. In the experiment 12 monogenic lines of winter wheat with different resistance genes (Goates 1996) were used as test plants (Table 1). 'Heines VII' cultivar was the only one without any resistance gene. *Tilletia caries* population originated from the experimental field in Winna Góra, near Poznań. Seeds of test cultivars originated from The State Stende Plant Breeding Station (Latvia) and USDA-ARS National Facility in Aberdeen (USA). Sowing material from Latvia was used in seasons 1998/99 and 1999/2000 whereas from the USA in 2004/05.

The experiment was conducted on 0.053 m^2 microplots in four replications in Institute of Plant Protection in Poznań. Sowing was done on October 16^{th}, 19^{th} and 14^{th}

Table 1

Resistance characteristics of winter wheat cultivars (lines) used for estimation of *Tilletia caries* virulence frequency

Cultivar (line)	Resistance gene
'Heines VII'	Bt-0 (lack)
Sel-2092	Bt-1
Sel-1102	Bt-2
'Ridit'	Bt-3
CI-1558B/CI-1558*	Bt-4
'Hohenheimer'	Bt-5
'Rio'	Bt-6
Sel-50077	Bt-7
PI-554120	Bt-8
PI-554099	Bt-9
PI-554118	Bt-10
PI-554119	Bt-11
'Thule III'	Bt-13

*CI-1558B in years 1998/99 and 1999/2000 whereas CI-1558 in 2004/05 were used.

in 1998, 1999 and 2004, respectively. Seeds before sowing were mixed with excess of *T. caries* teliospores (100 g of teliospores per 1 kg of seeds; Miczyński 1953, 1956, Gaudet et al. 1991, Rubiales and Martin 1999, Rubiales et al. 2001). Evaluation of common bunt occurrence was performed during wheat ripening in three places of ears: at the base, in the middle and the top (Zaleski et al. 1957). Occurrence of at least one infected seed decided the ear was assessed as infected (Griffith et al. 1955). Percentage of infected ears was calculated for each cultivar. *Tilletia caries* virulence frequency was calculated in percentage of infected ears in a cultivar with particular resistance gene as compared to a cultivar without any resistance gene.

The common bunt occurrence on 20 winter wheat cultivars was evaluated in three vegetation seasons: 1995/96, 1996/97 and 1998/99. Split plot field experiments in four replications were conducted in Agricultural Experimental Station Winna Góra of Institute of Plant Protection in Poznań. Plot area was 7.5 m^2 (1.5 × 5) in 1995/96 and 16.5 m^2 (1.5 × 11) in 1996/97 and 1998/99 seasons. Experimental objects were 20 winter wheat cultivars registered for cultivation in Poland: 'Alba', 'Aleta', 'Almari', 'Begra', 'Elena', 'Emika', 'Gama', 'Jawa', 'Jubilatka', 'Juma', 'Kamila', 'Kobra', 'Maltanka', 'Mikon', 'Olcha', 'Panda', 'Roma', 'Tercja', 'Wilga' and 'Zorza' (Lista odmian... 1995). Contaminated and not contaminated seeds were used in the experiment. 6 g of *T. caries* teliospores were used for contamination of 1 kg of wheat seeds. Teliospores were mixed with seeds for 0.5 min using device "Hege 11" with 3000 rotations per minute. The contamination was performed in seasons 1995/96 and 1998/99. Seeds naturally contaminated with teliospores from the last year experiment were used in the season 1996/97. Sowing was done at the following dates: October 5th 1995, October 2nd 1996 and October 8th 1998. Assessment of common bunt occurrence was conducted on 50 ears randomly taken from plots during full ripening of seeds (BBCH 89). Evaluation of the common bunt occurrence was performed in the same way as in the first experiment and afterwards the percentage of infected ears was calculated.

Results concerning the percentage of ears of 20 winter wheat cultivars infected by *T. caries* were statistically analyzed. Analysis of variance was performed. Tukey's test was used for comparison of means.

Weather conditions in Poznań and Winna Góra in particular seasons were different. October decade data were analysed for comparison of temperature and precipitation influence on number of ears infected by *T. caries* (Tables 2 and 3).

Table 2

Weather conditions in October in Poznań

Decade	Temperature (°C)			Precipitation (mm)		
	1998	1999	2004	1998	1999	2004
I	6.7	10.8	12.2	33	20	11.7
II	8.8	6.2	7.1	9	15	19.4
III	9.0	8.5	11.0	37	9	14.6
Mean/total	8.2	8.5	10.1	79	44	45.7

Table 3

Weather conditions in October in Winna Góra

Decade	Temperature (°C)			Precipitation (mm)		
	1995	1996	1998	1995	1996	1998
I	13.4	11.3	6.7	3	0.2	29.9
II	12.2	10.4	8.8	2	5.5	9.5
III	7.0	7.5	9.0	7	11.4	34.2
Mean/total	10.9	9.7	8.2	12	17.1	73.6

Results

The common bunt was not found on: five wheat cultivars (Sel-2092, CI-1558B, PI-554120, PI-554118 and PI-554119) in 1998/99, four wheat cultivars (Sel-1102, CI-1558B, PI-554120 and PI-554119) in 1999/2000 and on most of the cultivars in 2004/05 (Table 4). Virulence corresponding to genes Bt-4, Bt-8 and Bt-11 was not found in any of the seasons (Table 5). Virulence corresponding to genes Bt-3 and Bt-7 occurred in all three seasons.

Mean percentage of ears of all the cultivars tested infected by *T. caries* calculated for three seasons varied from 16.5 ('Mikon') up to 33.7 ('Wilga') (Table 6). Differ-

Table 4

Ears with common bunt symptoms in wheat cultivars with different resistance genes

Cultivar (line)	1998/99		1999/2000		2004/05	
	evaluated (number)	infected (%)	evaluated (number)	infected (%)	evaluated (number)	infected (%)
'Heines VII'	69	31.9	45	48.9	113	42.5
Sel-2092	61	0.0	22	4.5	24	0.0
Sel-1102	84	40.5	14	0.0	90	48.9
'Ridit'	95	10.5	8	12.5	45	15.6
CI-1558B/CI-1558*	102	0.0	55	0.0	102	0.0
'Hohenheimer'	63	14.3	28	14.3	128	0.0
'Rio'	62	3.2	72	1.4	86	0.0
Sel-50077	134	32.1	82	14.6	95	1.1
PI-554120	62	0.0	78	0.0	26	0.0
PI-554099	68	4.4	70	1.4	31	0.0
PI-554118	88	0.0	101	1.0	61	0.0
PI-554119	92	0.0	41	0.0	15	0.0
'Thule III'	57	36.8	168	19.6	85	0.0

*CI-1558B in years 1998/99 and 1999/2000 whereas CI-1558 in 2004/05 were used.

Table 5

Tilletia caries virulence frequency (%)

Cultivar (line)	1998/99	1999/2000	2004/05	Mean
'Heines VII'	100.0	100.0	100.0	100.0
Sel-2092	0.0	9.3	0.0	3.1
Sel-1102	126.9	0.0	115.0	80.6
'Ridit'	33.0	25.6	36.6	31.7
CI-1558B/CI-1558*	0.0	0.0	0.0	0.0
'Hohenheimer'	44.8	29.2	0.0	24.7
'Rio'	10.1	2.8	0.0	4.3
Sel-50077	100.6	29.9	2.5	44.3
PI-554120	0.0	0.0	0.0	0.0
PI-554099	13.8	2.9	0.0	5.6
PI-554118	0.0	2.0	0.0	0.7
PI-554119	0.0	0.0	0.0	0.0
'Thule III'	115.5	40.2	0.0	51.9

*CI-1558B in years 1998/99 and 1999/2000 whereas CI-1558 in 2004/05 were used.

ences between mean percentages of infected ears were not significant. However, in particular seasons differences between percentages of infected ears of some cultivars were significant. It is worth to point out to small mean percentages of infected ears in seasons 1995/96 (13.2) and 1996/97 (15.0) as well as to the high percentage in 1998/99 season (44.6).

Discussion

Virulence frequency was evaluated for some pathogens (Gacek 1990, Tratwal and Weber 2006). Many physiological races are described within *T. caries* population (Hoffmann and Metzger 1976). Sets of wheat cultivars (lines) with particular Bt resistance genes were previously used by many authors (Blažková and Bartoš 2002, Babayants et al. 2006, Huber and Buerstmayr 2006, Dumalasová and Bartoš 2007 b). Out of 15 resistance genes only 13 (Bt-1 to Bt-13) occurred in winter wheat cultivar set (Goates 1996). In our work spring wheat test cultivars with genes Bt-14 and Bt-15 or winter wheat cultivar with gene Bt-12 were not used. Virulence corresponding to genes Bt-3 and Bt-7 were the only ones occurring in all three years. Virulence frequency corresponding to the gene Bt-3 was similar in all three years (25.6 to 36.6%). However, virulence frequency corresponding to the gene Bt-7 varied very much (2.5 to 100.6%). Veisz et al. (2000) also found big differences between successive years in percentages of infected wheat plants with particular Bt genes. This may be caused by occurrence of different pathogen races in successive years. Virulences corresponding with genes Bt-1, Bt-2 and Bt-7 prevailed in the work of Blažková and Bartoš (2002).

Table 6

Ears with common bunt symptoms in the investigated winter wheat cultivars in Winna Góra (%)

Cultivar	1995/96	1996/97	1998/99	Mean*
'Alba'	8.5 ab	5.5 bc	44.9 abc	19.6
'Aleta'	12.7 ab	20.1 abc	32.6 bc	21.8
'Almari'	11.5 ab	13.3 abc	52.4 abc	25.7
'Begra'	1.5 b	9.5 abc	44.0 abc	18.3
'Elena'	1.6 b	31.0 a	31.9 c	21.5
'Emika'	7.5 ab	17.5 abc	68.5 ab	31.2
'Gama'	2.5 b	14.7 abc	38.8 abc	18.7
'Jawa'	18.0 ab	23.0 ab	51.5 abc	30.8
'Jubilatka'	12.5 ab	2.5 c	50.0 abc	21.7
'Juma'	2.3 b	3.5 c	55.0 abc	20.3
'Kamila'	15.5 ab	12.6 abc	59.0 abc	29.0
'Kobra'	40.3 a	14.5 abc	33.7 bc	29.5
'Maltanka'	14.1 ab	31.0 a	31.0 c	25.4
'Mikon'	8.5 ab	7.0 bc	34.0 bc	16.5
'Olcha'	14.3 ab	4.5 bc	32.3 c	17.0
'Panda'	13.0 ab	10.5 abc	74.3 a	32.6
'Roma'	22.1 ab	14.1 abc	37.5 bc	24.6
'Tercja'	12.5 ab	14.5 abc	24.9 c	17.3
'Wilga'	23.0 ab	29.5 a	48.5 abc	33.7
'Zorza'	21.5 ab	20.5 abc	47.2 abc	29.7
Mean	13.2	15.0	44.6	–

*No significant differences at 5% level.
Means followed by the same letters in columns are not significantly different.

In our work the percentage of winter wheat ears infected by *T. caries* varied from 16.5 ('Mikon') to 33.7 ('Wilga'). In Lithuania (Liatukas and Ruzgas 2005) these percentages varied from 16.5 to 55.3 and partially they depended on the year (Liatukas and Ruzgas 2006). In Germany (Spieß et al. 2003) in 100 evaluated wheat cultivars the percentage of ears infected by *T. caries* varied from 0.0 to 82.5. In Switzerland (Bänziger et al. 2003) the percentage of ears infected by *T. caries* varied from 11.4 to 50.5.

Large differences of the disease occurrence in particular years were observed by many authors (Benada et al. 1995, Dumalasová and Bartoš 2006, Liatukas and Ruzgas 2006). The differences are explained by different weather conditions (Miczyński 1953) and by the presence of different virulence genes within the pathogen population (Dumalasová and Bartoš 2006).

Humidity and soil temperature influence teliospores germination and wheat sprouts infection by *T. caries* (Kendrick and Purdy 1959). Common bunt occurrence depends on soil temperature in the first two weeks after sowing (Bänziger et

al. 2003) or even only in the first 11 days (Johnsson 1992). In our work mean percentages of infected wheat ears were smaller in seasons 1995/96 and 1996/97 than in 1998/99. Taking into account wheat sowing in the first decade of October, the highest influence on wheat infection by *T. caries* had temperatures in the first two decades of October. The air temperature was as follows: 12.8°C (1995/96), 10.9°C (1996/97) and 7.8°C (1998/99). The temperature 7.8°C was close to the range 6 to 7°C (Johnsson 1992) or 4 to 9°C (El-Naimi et al. 2000) in which the highest infection degree was observed.

In our work large percentage diversity of infected ears in particular cultivars in successive years was observed. Miczyński (1953) obtained similar results. He claimed that changes in composition of the pathogen population on seeds were the main reason of the phenomenon.

Most of the wheat cultivars are susceptible to different degree to *T. caries* (Polišenská et al. 1998, Rajković and Dolovac 2006), though, information about cultivars resistant to the pathogen are also available in the literature (Babayants et al. 2006, Huber and Buerstmayr 2006).

Streszczenie

FREKWENCJA WIRULENCJI *TILLETIA CARIES* I WYSTĘPOWANIE ŚNIECI CUCHNĄCEJ NA 20 ODMIANACH PSZENICY OZIMEJ

Podczas trzech sezonów wegetacyjnych oceniano frekwencję wirulencji populacji *Tilletia caries* pochodzącej z Winnej Góry i występowanie śnieci cuchnącej na 20 odmianach pszenicy ozimej. Frekwencję wirulencji wyrażono w procentach porażonych kłosów odmiany pszenicy z określonym genem odporności względem odmiany bez żadnego genu odporności.

W obydwu doświadczeniach używano nasion pszenicy ozimej zanieczyszczonych teliosporami *T. caries*. Wirulencje korespondujące z genami odporności Bt-3 i Bt-7 występowały we wszystkich trzech sezonach. Wirulencji korespondujących z genami Bt-4, Bt-8 i Bt-11 nie stwierdzono w żadnym sezonie. U 20 odmian pszenicy ozimej średnio dla trzech sezonów procenty porażonych kłosów nie różniły się w stopniu istotnym i wynosiły od 16,5 (‘Mikon’) do 33,7 (‘Wilga’).

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