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THE OCCURRENCE OF FUNGI ON ROOTS AND STEM BASES OF COMMON WHEAT (*Triticum aestivum* ssp. *vulgare* L.) AND DURUM WHEAT (*Triticum durum* Desf.) GROWN UNDER TWO LEVELS OF CHEMICAL PROTECTION

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Abstract

Investigations were carried out in 2007-2009 on the plots of the Felin Experimental Station belonging to the University of Life Science in Lublin. The studies comprised two cultivation lines of durum wheat (*Triticum durum* L.): STH 716 and STH 717, as well as the 'Tonacja' cultivar of common wheat (*T. aestivum* ssp. *vulgare* L.). Two levels of chemical protection were applied in the cultivation: minimal and complex protection. Infection of wheat roots and stem bases was recorded in each growing season at hard dough stage (87 in Tottman's scale, 1987). After three years of study, the mean disease indexes for the analyzed wheat genotypes in the experimental treatment with minimal protection were 31.13, 30.43 and 38.83 for, respectively, the 'Tonacja cultivar' and the cultivation lines of *T. durum* STH 716 and STH 717. In the experimental combination with complex protection, after three years of study the disease indexes ranged from 25.26 (*T. durum* STH 716) to 30.83 (*T. durum* STH 717). The results of mycological analysis of diseased plants showed that *Fusarium* spp., especially *F. culmorum, F. avenaceum* as well as *Bipolaris sorokiniana* and *Rhizoctonia solani*, caused root rot and necrosis of wheat stem bases. The analyzed chemical protection levels did not significantly influence grain yield of the investigated genotypes of *T. aestivum* and *T. durum.*

Key words: *Bipolaris sorokiniana, Fusarium* spp., foot root, root rot, wheat

INTRODUCTION

In recent years, interest in the cultivation of durum wheat (*Triticum durum* Desf.), which was only of regional character, has been on the increase. Durum wheat is the best raw material to produce pasta (Rachoń and Szumiło, 2006). According to the present authors, the quality of the grain of Polish cultivars and lines of *T. durum* satisfies raw material standards to produce pasta and it does not significantly differ from foreign cultivars (Rachoń and Szumiło, 2002). Agrotechnical studies by Rachoń et al. (2002) on new cultivation lines of durum wheat from the Lublin Centre of the Institute of Genetics, Plant Breeding and Biotechnology point to the possibility of obtaining high and stable yields of this wheat in the climatic conditions of the Lublin region.

The factors decreasing the quality and size of the yield of wheat, including *T. durum,* are infectious diseases. In the countries where durum wheat is grown in larger areas the crops are infected by the bacterium *Clavibacter tritici* (Carlton and Vidaver; Davis et al.; Wiese, 1998) and by fungi of the genus *Fusarium* (Tamburin-Ilinic and Griffey, 2008). Among the pathogens of the assimilation apparatus, a serious role is played by *Blumeria graminis* DC. Speer f. sp. *tritici*, *Drechslera tritici-repentis* (Died.) Shoem. as well as by *Puccinia recondita* Rob. ex Desm. f. sp. *triticina* (Eriks.) (Wiese, 1998: Panasiewicz et al. 2008).

Agrotechnical studies on yields of durum wheat (*T. durum)* have been conducted at the Department of Plant Cultivation of the University of Life Sciences in Lublin for a few years. Because of considerable importance of common wheat (*T. aestivum* ssp. *vulgare* L.) diseases caused by fungi responsible for root and foot rot diseases, research was undertaken on the role of these pathogens in infecting the roots and the stem base of *T. aestivum* ssp. *vulgare* L., 'Tonacja' and the cultivation lines of *T. durum* using two levels of chemical protection.

MATERIALS AND METHODS

The studies were conducted in 2007-2009 in the field of the Felin Experimental Farm belonging to the University of Life Sciences in Lublin (51°22' N, 22°64'E) on lessive soil made from loess formations, with the granulometric composition of medium loam classified as the good wheat complex, soil quality class II. The content of available forms of P, K and Mg was as follows: P – 76.0; K – 119.0; Mg – 55.5 (mg×kg^{-1} of soil), and its pH was 6.3 in KCl solution.

The studies comprised two cultivation lines of durum wheat (*Triticum durum* Desf.): STH 716 and STH 717 as well as the 'Tonacja' cultivar of common wheat (*T. aestivum* ssp. *vulgare* L.). Two levels of chemical protection were applied in the cultivation. The first level included minimal protection where the grain was dressed with Oxafun T 75 DS/WS (200 g×100 kg^{-1} of grain). Chwastox Trio 540 SL in the dose of 2 dm^3×ha^{-1} was used to control weeds. The second level of complex chemical protection included seed dressing with Oxafun T 75 DS/WS at a rate of 200 g×100 kg^{-1} of grain; weeds were controlled by using two herbicides: Puma Uniwersal 069 EW at a dose of 1.2 dm^3×ha^{-1} and Chwastox Trio 540 SL at 2 dm^3×ha^{-1}. At the tillering stage (20 in Tottman's scale 1987), the fungicide Alert 375 S.C. at a rate of 1.8×ha^{-1}, the insecticide Decis 2,5 EC at 250 cm^3×ha^{-1}, and Stabilan 750 SL at 1.8 dm^3×ha^{-1} were also applied. In both protection levels, mineral fertilization was applied before sowing at a rate of 26 kg P. ha^{-1} and 66 kg K×ha^{-1}. Besides, top dressing was applied twice: using nitrogen at a rate of 70 kg×ha^{-1} – after the start of growth and 30 kg N×ha^{-1} at the third node stage. Soil tillage was typical of the plough system. Wheat was sown in the third decade of September in each year. The sowing density was 500 grains per m^2.

The experiment was carried out in a randomized block design, in four replications in the field after winter rape. The area of the plots was 10 m^2.

In each growing season, the infection of the wheat roots and stem base was assessed at the hard dough stage of grain (87 in Tottman's scale, 1987). For this propouse, 200 stems (4×50) were taken from each experimental treatment in different places of the plots of the cultivar and cultivation lines. In the laboratory, the proportion of stems with necrotic streaks on the roots and lower internodes was determined and the degree of infection was established according to a 5-grade scale (Eng-Chong Pua et al. 1985). Disease indexes were calculated using McKinney's formula (Łacicowa, 1969). Besides, in each year of the study, after harvest grain yield was determined, on a per hectare basis, from the plots sown with the analyzed wheat genotypes and with two levels of protection. The obtained results were statistically analyzed using Tukey's confidence half-intervals (Żuk, 1989).

A laboratory mycological analysis was also conducted. The number of plant fragments taken for the analysis and the method of analysis were the same as in earlier studies (Kiecana et al., 2003). Fungi of the genus *Fusarium* were identified according to Nelson et al. (1983) as well as Leslie and Summerell (2006). Other fungi species were determined according to the keys and monographs by Ellis (1971), Domsch et al.(1980), Ramirez (1982), and Rifai (1969).

RESULTS

Plants with the symptoms of root rot and necrotic streaks on the lower internodes occurred in each growing season with minimal and complex protection. In 2007 the disease indexes in the experimental combination with minimal protection ranged from 21.3 (Tonacja) to 27.8 (*T. durum* STH 716) and they did not differ significantly (Table 1). In 2008 significantly higher values of the disease index were observed in the case of the cultivar Tonacja and the cultivation line *T. durum* STH 717; they were, respectively, 33.7 and 38.7. In 2009 a significantly higher value of the disease index was found for the cultivation line *T. durum* STH 717 – 50.6 (Table 1). After three years of study, the disease indexes for the analyzed wheat genotypes in the experimental treatment with minimal protection were 31.13, 30.43 and 38.83 for, respectively, the 'Tonacja cultivar' and the cultivation lines of *T. durum* STH 716 and STH 717, and they did not differ significantly (Table 1).

Table 1.
Values of the disease index in each year of the study (2007-2009)

Genotypes	Study year / protection level							
	2007		2008		2009		Mean after 3 years	
	1	2	1	2	1	2	1	2
T. aestivum Tonacja	21.3 a	20.0 a	33.7 b	26.6 a	38.4 a	31.7 a	**31.13a**	**26.1a**
T. durum STH 716	27.8* a	15.6 a	25.1 a	25.2 a	38.4 a	35.0 ab	**30.43a**	**25.26a**
T. durum STH 717	27.2* a	18.6 a	38.7* b	32.4 b	50.6* b	41.5 b	**38.83a**	**30.83a**

1 – minimal chemical protection; 2 – complex chemical protection
Means in lines, in particular years for each genotype, marked * differ significantly (P ≤ 0.05)
Means in columns differ significantly (P ≤ 0.05) if they are not marked with the same letter

Table 2.
Fungi isolated from the diseased roots and stem base of *T. aestivum* and *T. durum* cultivated under minimal and complex plant protection conditions in 2007-2009

Fungus species	Number of isolates in 2007-2009																								Total number of isolates
	2007						2008						2009						Total after 3 years						
	1			2			1			2			1			2			1			2			
	r	s	r+s	r	s	r+s	r	s	r+s	r	s	r+s	r	s	r+s	r	s	r+s	r	s	r+s	r	s	r+s	
Alternaria alternata (Fr.) Keissler	3	6	9	7	3	10	39	40	79	7	2	9	17	22	39	10	-	10	59	68	**127**	24	5	**29**	**156**
Aureobasidium pullulans (de Bary) Arnaud.	7	-	7	3	-	3	-	-	-	-	-	-	-	-	-	10	5	15	7	-	**7**	13	5	**18**	**25**
Bipolaris sorokiniana (Sacc.) Shoemaker	3	6	9	3	7	10	4	10	14	7	3	10	-	-	-	-	-	-	7	16	**23**	10	10	**20**	**43**
Fusarium avenaceum (Fr.) Sacc.	5	32	37	8	5	13	31	36	67	22	46	68	46	59	105	12	60	72	82	127	**209**	42	111	**153**	**362**
Fusarium crookwollense Burges, Nelson, Tousson	1	3	4	7	-	7	-	-	-	-	-	-	-	-	-	-	-	-	1	3	**4**	7	-	**7**	**11**
Fusarium culmorum (W. G. Sm.) Gams	140	232	372	184	209	393	16	45	61	13	45	58	-	18	18	12	4	16	156	295	**451**	209	258	**467**	**918**
Fusarium equiseti (Corda) Sacc.	-	-	-	-	-	-	-	11	11	-	-	-	-	6	6	1	-	1	-	17	**17**	1	-	**1**	**18**
Fusarium graminearum Schwabe	4	6	10	2	9	11	-	-	-	-	-	-	-	-	-	-	-	-	4	6	**10**	2	9	**11**	**21**
Fusarium oxysporum Schl.	36	4	40	-	1	1	19	29	48	19	16	35	27	52	79	27	40	67	82	85	**167**	46	57	**103**	**270**
Fusarium poae (Peck.) Wollenw.	-	3	3	-	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	3	**3**	-	2	**2**	**5**
Fusarium sporotrichioides Sherb.	14	9	23	6	3	9	-	-	-	-	4	4	-	-	-	-	-	-	14	9	**23**	6	7	**13**	**36**
Rhizoctonia solani Kühn	-	-	-	11	2	13	18	-	18	1	-	1	10	1	11	6	-	6	28	1	**29**	18	2	**20**	**49**
Other colonies	17	17	34	10	13	23	17	8	25	5	18	23	89	62	151	2	19	21	123	87	**210**	17	50	**67**	**277**
Razem	**230**	**318**	**548**	**241**	**254**	**495**	**144**	**179**	**348**	**74**	**134**	**208**	**189**	**220**	**409**	**80**	**128**	**208**	**563**	**717**	**1280**	**395**	**516**	**911**	**2191**

1 – minimal chemical protection
2 – complex chemical protection
r – roots, s – stem base

The disease indexes in the experimental treatment with complex protection ranged in 2007 from 15.6 (*T. durum* STH 716) to 20 (Tonacja), in 2008 – from 25.2 (*T. durum* STH 716) to 32.4 (*T. durum* STH 717), while in 2009 from 31.7 (Tonacja) to 41.5 (*T. durum* STH 717). In the last two years of the study, the disease indexes for the cultivation line *T. durum* STH 717 were significantly the highest (Table 1).

The statistical analysis of the disease indexes showed a significant effect of the level of protection on the health of stems in 2007 in relation to the cultivation line *T. durum* STH 716, while in the years 2007, 2008 and 2009 with respect to the cultivation line STH 717. In the case of the cultivar 'Tonacja' (*T. aestivum)*, no significant effect of the level of chemical protection on the health of plants was observed in any of the years of the study (Table 1).

1280 fungi isolates, including 563 from the roots and 717 from the stem base, were obtained as a result of the mycological analysis of the diseased plants from the experimental treatment with minimal protection (Table 2). In each growing season, colonies of the genus *Fusarium* spp. were obtained both from the roots and the stem base. In the period 2007-2009, isolates of those fungi accounted for, respectively, 89.2% (489 isolates), 53.7% (187 isolates), and 50.9% (208 isolates) of all isolations (Table 2). In total, after three years of study isolates of fungi of the genus *Fusarium* constituted 69.1% (884 isolates) of all the obtained fungi isolates (Table 2). The species composition of *Fusarium* spp. differed in the analyzed growing seasons, with *F. culmorum* being a dominant species in 2007. Its isolates accounted for 76.1% (372 isolates) of all *Fusarium* spp. (489 isolates), while colonies of *F. avenaceum* in this study year constituted 7.6% (37 isolates) of all *Fusarium* spp. In 2007 the other species of this genus were represented by *F. crookwellense, F. graminearum, F. oxysporum, F. poae* and *F. sporotrichioides*, whose colonies made up, respectively, 0.8% (4 isolates), 2.0% (10 isolates), 8.2% (40 isolates), 0.6% (3 isolates), and 4.7% (23 isolates) of total *Fusarium* spp. The dominating species in the years 2008 and 2009 appeared to be *F. avenaceum*, whose isolates constituted, respectively, 35.8% (67 isolates among 187 *Fusarium* spp. isolates) and 50.5% (105 isolates) of all *Fusarium* spp. isolates (208) (Table 2). Besides, *F. culmorum*, *F. oxysporum* and *F. equiseti* were isolated from the diseased plants in 2008 and 2009. Isolates of *F. culmorum* constituted, respectively, 32.6% (61 isolates) and 8.6% (18 isolates), *F. oxysporum* 25.7% (48 isolates) and 38.0% (79 isolates), while *F. equiseti* 5.9% (11 isolates) and 2.9% (6 isolates) of total *Fusarium* spp. isolates (Table 2).

Considering the total number of fungi isolates of the genus *Fusarium* from the diseased plants of durum wheat and common wheat obtained within the three-years study period, the dominating species was *F. culmorum* whose isolates constituted 51.0% (451 isolates) of all *Fusarium* spp. (884 isolates). Considerable quantities of *F. avenaceum* – 23.6% (209 isolates) of total *Fusarium* spp. and *F. oxysporum* – 18.9% (167 isolates) were also isolated (Table 2).

In all the years of the study, the species *Alternaria alternata,* whose colonies constituted 9.9% (127 isolates) of all isolations, was also isolated from the infected plants (Table 2).

23 isolates of the species *Bipolaris sorokiniana* were isolated in 2007 and 2008 from the roots and the stem base, which accounts for 1.8% of all isolates during the three years of the study. Besides, *Rhizoctonia solani* was obtained in 2008 and 2009 from the roots and stem base; isolates of this species constituted, respectively, 5.2% (18 isolates) and 2.7% (11 isolates) of all fungi in those years. In 2007 *Aureobasidium pullulans* was also obtained; its isolates made up 0.5% (7 isolates) of total isolations (Table 2).

Colonies of other fungi belonged to the following: *Botryotrichum pilluliferum, Cladosporium cladosporioides, Epicoccum nigrum, Gliocladium roseum, Mucor hiemalis, Penicillium notatum, Penicillium verrucosum* var. *cyclopium, Periconia macrospinosa, Stemphylium botryosum, Talaromyces flavus, Trichoderma koningii, T. viride* as well as to non-sporulating forms, which constituted 16.4 % of all isolations (210 isolates) (Table 2).

The mycological analysis of common and durum wheat growing on the plots with complex protection provided 911 fungi isolates, including 395 from the roots and 516 from the stem base (Table 2). The colonies isolated during the three years of the study included 83.1% (757 isolates) of fungi of the genus *Fusarium*. In 2007 88.1% (436 isolates) of the obtained fungi isolates belonged to this species, whereas in the years 2008 and 2009 the colonies of *Fusarium* spp. constituted, respectively, 79.3% (165 isolates) and 75.0% (156 isolates) of total isolations (Table 2). The dominating species in 2007 was *F. culmorum* whose isolates accounted for 90.1% (393 isolates) of all isolations of *Fusarium* spp. (436 isolates) from the roots and the stem base. The other colonies of fungi of the genus *Fusarium* belonged to the following: *F. avenaceum* – 3.0% (13 isolates), *F. graminearum* – 2.5% (11 isolates), *F. sporotrichioides* – 2.1% (9 isolates), *F. crookwellense* – 1.6 (7 isolates) of all *Fusarium* spp. isolates (436). Few isolates were obtained from *F. poae* and *F. oxysporum* (Table 2). In the growing seasons of 2008 and 2009,

considerable numbers of *F. avenaceum* were obtained both from the roots and the stem base. In 2008 its isolates constituted 41.2% (68 isolates) of all *Fusarium* spp. isolates (165), whereas in 2009 they made up 46.2% (72 isolates) of all *Fusarium* spp. isolates (156) isolated from the roots and the stem base (Table 2). Isolates of *F. culmorum* from the roots and the stem base in the growing seasons of 2008 and 2009 constituted, respectively, 35.2% (58 isolates) and 10.3% (16 isolates) of all *Fusarium* spp. isolates isolated from the roots and lower internodes. In 2008 the other species from this genus were represented by *F. oxysporum* – 21.2% (35 isolates) and *F. sporotrichioides* – 2.4% (4 isolates), whereas in 2009 by *F. oxysporum* – 42.9% (67 isolates) and *F. equiseti* – 0.6% (1 isolate) of the total number of *Fusarium* spp. Isolates (Table 2). In 2007 and 2008 the species *B. sorokiniana* was isolated both from the roots (10 isolates) and the stem base (10 isolates); it accounted for 2.2% of total isolations in the three years of the study. Colonies of *A. alternata* constituted 3.2% (29 isolates) of all fungi isolates obtained during the three years of the study, *A. pullulans* 2.0% (18 isolates), while *R. solani* made up 2.2% (20 isolates) (Table 2).

Colonies of other fungi belonged to the following: *Botryotrichum pilluliferum, Chaetomium globosum, Cladosporium cladosporioides, Epicoccum nigrum, Humicola fuscoatra, Penicillium notatum, Penicillium verrucosum* var. *cyclopium, Periconia macrospinosa, Trichoderma aureoviride, T. viride,* and non-sporulating forms which constituted 7.4% of all isolations (67 isolates) (Table 2).

In the case of both experimental treatments, the significantly highest grain yield, on average during the three-year study period, was observed for cv. 'Tonacja'. It was 7.85 t×ha^{-1} in the treatment with minimum protection and 9.33 t×ha^{-1} in the one with complex protection (Table 3). On the other hand, the mean grain yield of the cultivation lines STH 716 and STH 717 in the case of minimum protection was, respectively, 4.27 t×ha^{-1} and 4.65 t×ha^{-1}, whereas in the case of complex protection it was 5.1 t×ha^{-1} and 6.10 t×ha^{-1}. No statistically significant differences were observed in the yield of particular wheat genotypes depending on the level of chemical protection (Table 3).

The temperature in the Lublin region – Felin during the 2006/2007 growing season was higher as compared to the long-term mean in all the months (September 2006 – August 2007) from 1.1°C (August 2006) to 6.2°C (January 2007). On the other hand, rainfall exceeded the long-term average in November 2006, January, March, May, June and July 2007 by respectively: 5.0; 137.0; 17.0; 39.8; 33.4 and 11.5%. The lowest rainfall was recorded in September 2006 – only 21.1% of the normal level. In 2007/2008 air temperature between September 2007 and August 2008 was lower than the long-term mean in the months of October and November 2007 and May 2008 by respectively 0.3, 1.5 and 0.2°C, while in the other months it was higher from 0.1°C (September 2007) to 5.0°C (February 2008). The rainfall level ranged from 39.4 mm in June 2008 to 251.2 mm in March 2008. In the 2008/2009 growing seasons, air temperature was lower than the long-term mean by 0.3°C in September 2008 and 0.1°C in June 2009. On the other hand, rainfall exceeded the long-term mean in the following months: September 2008 by 96.2%, October 2008 by 37.7%, December 2008 by 39.0%, February 2009 by 48.8%, March 2009 by 169.8%, May 2009 by 21.9%, and June 2009 by 90.7%. The lowest amount of rainfall was observed in April of 2009 – 7.1% of the normal level (Table 4).

Table 3.
Grain yield of common wheat and durum wheat in 2007-2009 [t×ha^{-1}]

Genotypes of wheat	Level of chemical protection							
	Minimal protection				Complex protection			
	2007	2008	2009	Mean	2007	2008	2009	Mean
Tonacja	6.63	8.90	8.01	7.85 bA	8.31	10.76	8.92	9.33 bA A
T. durum STH 716	3.48	5.80	3.52	4.27 aA	3.79	6.85	4.65	5.10 aA
T. durum STH 717	4.57	5.95	3.42	4.65 aA	5.91	6.70	5.70	6.10 aA

Means in columns differ significantly ($P \leq 0.05$) if they are not marked with the same small letter
Means in lines differ significantly ($P \leq 0.05$) if they are not marked with the same capital letter

Table 4.
Air temperature and rainfall in the 2006/2007-2008/2009 growing seasons of winter wheat (*T. aestivum, T. durum*)

Month	Long- term mean for 1951-2000		Air temperature difference compared with the mean for 1951-2000				Percentage of rainfall compared with the mean for 1951-2000 [%]			
			Growing seasons of winter wheat							
	Air temperature [°C]	Rainfall [mm]	2006	2007	2008	2009	2006	2007	2008	2009
I	-3.6	21.7	-	+6.2	+4.0	+0.9	-	237.0	166.8	93.1
II	-2.8	24.8	-	+1.2	+5.0	+1.6	-	89.9	71.8	148.8
III	1.0	25.8	-	+5.2	+2.4	+0.4	-	117.0	251.2	269.8
IV	7.5	40.6	-	+1.2	+1.8	+3.9	-	43.9	137.4	7.1
V	13.0	58.3	-	+2.0	-0.2	+0.6	-	139.8	174.3	121.9
VI	16.5	65.8	-	+1.6	+1.2	-0.1	-	133.4	39.4	190.7
VII	17.9	78.0	-	+1.3	+0.4	+2.0	-	111.5	98.8	73.2
VIII	17.3	69.7	-	+1.1	+2.0	+1.7	-	53.9	64.6	78.5
IX	12.9	52.1	+2.9	+0.1	-0.3	+2.4	21.1	249.1	196.2	-
X	7.9	40.3	+2.2	-0.3	+2.2	-1.0	35.2	43.9	137.7	-
XI	2.5	39.1	+2.8	-1.5	+2.3	+3.0	105.0	79.5	84.7	-
XII	-1.4	31.5	+4.3	+0.2	+3.8	-0.3	59.0	47.3	139.0	-

DISCUSSION

The results of the present study, pointing to frequent infection by fungi of the genus *Fusarium* of the roots and stem base of durum and common wheat cultivated using two levels of chemical protection, confirmed their great importance as pathogens causing root and foot rot of cereals (Łacicowa et al. 1985; Łacicowa and Pięta, 1998; Kiecana and Mielniczuk, 2001; Kiecana et al. 2003; 2008; 2009; Kurowski et al. 2007). The species composition and number of *Fusarium* spp. isolates differed in particular years of the study and it can be assumed that their occurrence was mainly affected by climatic factors, while the level of the applied chemical protection did not have any considerable effect, like in the study by Pląskowska and Chrzanowska-Drożdż (2008).

Special attention should be paid to *F. culmorum* obtained both from the roots and lower internodes of the stems at both levels of chemical protection, especially in the year 2007 which was characterized by warm humid weather in May, June and July and which proved conducive to the occurrence of this species. According to Łacicowa and Pięta (1998) as well as Kiecana et al. (2003), the harmfulness of *F. culmorum* to cereals is greater in higher temperature. This species plays a big role in injuring wheat, especially its roots, under different conditions of cultivation (Łacicowa et al. 1985; Kurowski et al. 2007; Majchrzak et al. 2008; Fernandez et al. 2009). *Fusarium culmorum* proved to be the most pathogenic to wheat seedlings as compared to *F. equiseti, F. reticulatum* and *F. acuminatum* (Strausbaugh et al. 2004). This fungus colonizes both live and dead tissues in a similar way. This is a so-called indirect way of colonization characterized by fast overgrowth of the tissues, slow utilization of the subsoil and the ability to survive unfavourable periods in the form of chlamydospores (Łacicowa et al. 1985). Metabolites of *F. culmorum* contain, among others, inorganic acids, which are highly toxic to cereal seedlings. They cause excessive intake of phosphorus by plants, inhibition of germination and a decrease in root length as well as in the formation of root hairs (Kautouli and Marchant, 1981). Besides, *F. culmorum* produces deoxynivalenol, which reduces the content of chlorophyll a and b and caretonoids in leaf tissues (submitted to the effect of this compound at a concentration of 30-90 ppm) (Bushnell et al. 2010). Deoxynivalenol also causes disturbances in the permeability of cell membranes and inhibits the biosynthesis of protein and nucleic acids in plant cells (Wojciechowski et al. 1995); moreover, it increases the level of free fatty acids (Ueno, 1983; Kendal and McKersie, 1989; Miller and Even, 1997). Moreover, trichothecenes, including DON, also affect ribosomal L3 (coded by the Rpl 3 gene from rice), which is necessary for the proper functioning of peptide transferase (Harris and Gleddie, 2001).

In addition to *F. culmorum*, the species *F. avenaceum*, known for its harmfulness to wheat, was obtained from this cereal species under analysis (Łacicowa et al. 1985; Fernandez et al. 2009). The presence of *F. avenaceum* on wheat stems in the growing seasons with different weather conditions is confirmed by the reports about a great tolerance of this fungus to temperature and humidity (Kiecana, 1994; Mielniczuk, 2001; Kiecana et al. 2003; Kiecana and Mielniczuk, 2010). Furthermore, a study on the population of this fungus present in crop residues of wheat grown in Canada (Saskatchewan) pointed to the common occurrence of *F. avenaceum* in them, since it can constitute a threat to the next crops (Fernandez et al. 2009). Pathogenicity of *F. avenaceum* results, for example, from the production of toxic moniliformin (Packa, 1997).

The occurrence of the species *F. avenaceum* and *F. culmorum* on the roots and the stem base of wheat in both chemical protection treatments and in all the study years confirms the competitive abilities of these fungi, enabling them to live in the soil, and infection of plant roots (Łacicowa et al. 1985; Łacicowa and Kiecana, 1987). The species *F. crookwellense*, which is a recognized pathogen of cereals, including wheat, was isolated under different climatic conditions from the infected roots and stem base of wheat in the analyzed cultivation systems (Rossi et al. 1995; Kiecana and Mielniczuk, 2001; Kiecana et al. 2003, 2008; Strausbaugh et al. 2004, 2005).

The applied chemical treatments to control weeds which were hosts to *Fusarium* spp. decreased the population of species such as *F. avenaceum* and *F. sporotrichioides*. Besides, the reduction of the occurrence of weeds by herbicide treatments that decreased moisture in the crop also affected the population of other species colonies of the genus *Fusarium* (Farr et al. 1989, according to Shar, 2003).

It turned out that at both levels of protection, in the conditions when wheat was threatened by *Fusarium* spp., the cultivation line *T. durum* STH 717 was most infected by those fungi, which is indicated by the values of the disease indexes.

The fungi accompanying *Fusarium* spp. in the infection of the roots and stem base of the analysed wheat species were *B. sorokiniana* and *R. solani*. *Bipolaris sorokiniana* constitutes a serious threat to cereals, especially barley and wheat cultivated in various climatic regions of both Americas, the Republic of South Africa and Europe (Łacicowa et al. 1990; Scott, 1995; Valjavec-Gratian and Stefenson, 1997; Almgren et al. 1999; Duveiller and Garcia Altamarino, 2000; Fernandez et al. 2000). The pathogenicity of *B. sorokiniana* is related to the production of secondary metabolites, especially prehelminthosporol (Pryce et al. 1999, according to Kumar et al. 2001; Carlson et al. 1991, according to Almgren et al. 1999). The latter reduces the efficiency of hydrogen-calcium pumps in a plant cell (Olbe et al. 1995). Besides, common reactions of plants to the effect of toxins of *B. sorokiniana* include disturbances in the functioning of the cell cytoplasmatic membranes. In the case of barley infection by *B. sorokiniana*, the effect of increased permeability of cell membranes was found by Wiśniewska et al. (1998).

In the analysed conditions at both chemical protection levels, *R. solani* should be considered an additional infectious factor causing root and stem base diseases of durum and common wheat, like in the study by Łacicowa et al. (1990) concerning spring barley.

Similarly to the study by Pląskowska and Chrzanowska-Drożdż (2008), the present research showed that weather conditions had a greater effect on grain yield than the level of chemical protection of plants.

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Grzyby występujące na korzeniach i podstawie źdźbła pszenicy zwyczajnej (*Triticum aestivum* ssp. *vulgare* L.) i pszenicy twardej (*Triticum durum* Desf.) wzrastających w dwu poziomach ochrony chemicznej

Streszczenie

Badania przeprowadzono w latach 2007-2009 na polach Gospodarstwa Doświadczalnego Felin należącego do Uniwersytetu Przyrodniczego w Lublinie. Objęto nimi dwa rody hodowlane pszenicy twardej (*Triticum durum* L.): STH 716 i STH 717 oraz odmianę pszenicy zwyczajnej (*T. aestivum* subsp. *vulgare* L.) 'Tonacja'. W uprawie zastosowano dwa poziomy ochrony chemicznej: minimalną i kompleksową. W każdym sezonie wegetacji oceniano porażenie korzeni oraz podstawy źdźbła pszenicy w fazie dojrzałości późno woskowej ziarna (87 w skali Tottmana 1987). Średnie wskaźniki chorobowe dla analizowanych genotypów pszenicy w kombinacji doświadczenia z minimalną ochroną po trzech latach badań wynosiły dla odmiany Tonacja, rodów hodowlanych *T. durum* STH 716 i STH 717 odpowiednio: 31.13; 30.43 i 38.83. W kombinacji doświadczenia

z ochroną kompleksową wartości wskaźników chorobowych wahały się od 25,26 (STH 716) do 30,83 (STH 717). Analiza mikologiczna chorych roślin wykazała, że przyczyną zgnilizny korzeni i nekrozy podstawy źdźbła pszenicy były grzyby z rodzaju *Fusarium,* a w szczególności gatunki *F. culmorum* i *F. avenaceum* oraz *Bipolaris sorokiniana* i *Rhizoctonia solani.* Analizowane poziomy ochrony chemicznej nie wpłynęły istotnie na plon ziarna badanych genotypów *T. aestivum* i *T. durum*.