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EFFECT OF THE FORECROP AND FUNGICIDAL PROTECTION ON THE OCCURRENCE OF FUSARIUM HEAD BLIGHT (*FUSARIUM* SPP.)

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Abstract: From 1999 to 2007, in separate experiments located in Mazury, Żuławy Wiślane and Powiśle, the presence of Fusarium head blight (FHB) of wheat as dependent on the forecrop and fungicide application was studied. During the experiments, FHB occurred in different intensities. High intensity was observed in the years 1999, 2001 and 2007. In other years it was low or only at trace levels. More disease symptoms were observed on the plots after wheat than after oilseed rape. Controlled treatments, applied during the period of shoot development, only limited the presence of FHB.

Key words: Fusarium head blight, forecrop, fungicides, cultivars

INTRODUCTION

Fusarium head blight in cereals not only causes decrease in the grain yield but also deterioration of grain quality. Bottalico (1998) and Mielke *et al*. (2000) consider it to be one of the most important wheat diseases. Head blight is caused by the *Fusarium* genus fungi. These fungi have the capacity to produce mycotoxins which are metabolites dangerous for human and animal health. The threat of fusariosis is even greater since it can be caused by as many as a dozen or so separate *Fusarium* species of varied climate requirements. In the northern regions of Europe, *Fusarium culmorum* ocurrs the most. In southern and central regions – *F. graminearum*. Both those species clearly dominate and show greater harmfulness than other representatives of the *Fusarium* genus. Besides weather conditions, disease intensity was affected considerably by agrotechnical treatments and the cultivars grown (Miller 1994; Parry *et al*. 1995; Goliński *et al*. 1997, 2002; Dardis and Walsh 2002; Bottalico and Perrone 2002; Champeil *et al*. 2004; Pląskowska *et al*. 2009].

The aim of the present research was to determine the intensity of Fusarium head blight in winter wheat depending on the forecrop, cultivar and the fungicides applied.

MATERIALS AND METHODS

The experiments were carried out in Mazury (Szestno, 53°55'N, 21°18'E) and Żuławy Wiślane (Wielgłowy, 54°01' N, 18°44E'). From 1999 to 2001, at Szestno and Wielgłowy, the reaction of the winter wheat cultivars Kobra and Roma and Flair, grown after oilseed rape and after wheat was investigated. Two variants of fungicidal protection were applied: as a single treatment, and as 2 treatments. The single treatment was with kresoxim methyl + epoxyconazole at a dose of 1.0 l/ha[1], made at the flag leaf-tillering phase (BBCH 39-49). For the 2 treatments, the first application was with kresoxim methyl + epoxyconazole at a dose of 0.8 l/ha[1] at the 1–2 node phase (BBCH 32). The second application was with tridemorph + epoxyconazole at a dose of 1.0 l/ha[1] at the beginning-to-full tillering phase (BBCH 51-55). From 2002 to 2004, at Wielgłowy, the experiment covered 4 cultivars (Drifter, Kobra, Pegassos, Flair) grown after oilseed rape and after wheat. From 2005 to 2007, Drifter was grown after oilseed rape. The experiments were carried out in the complete randomized block design, in 4 reps, on plots of 20 m^2.

Fusarium head blight was evaluated at the phase of BBCH 85 with 100 randomly sampled heads from each plot. A 6-degree scale was applied, where 0° – stands for no disease symptoms, and 5° – disease symptoms over 50% of the head area. The results were transformed into the disease index (DI) according to the Townsend and Heuberger formula (Wenzel 1948), and then exposed to the analysis of variance. The mean values were tested with the Tukey's test.

RESULTS

At Szestno, in 1999 and 2001 there was reported significantly higher symptoms of fusariosis (in DI) in wheat grown after wheat, than after oilseed, while in 2000, due to long-term drought, there were no significant changes between the forecrops (Table 1). Considering the healthi-

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Table 1. Winter wheat ear infestation by *Fusarium* spp. in Szestno, as dependent on forecrop (A), cultivar (B) and number of treatments (C), (DI in %)

Forecrop	Cultivar	Years A x B			
		1999	2000	2001	1999–2001
Oilseed rape	Kobra	18.2	0.0	13.0	10.4
	Roma	11.7	0.0	16.1	9.2
	mean	14.9	0.0	14.5	9.8
Wheat	Kobra	37.2	0.0	20.0	19.1
	Roma	23.4	1.4	17.5	14.1
	mean	30.3	0.7	18.7	16.6
Mean	Kobra	27.7	0.0	16.5	14.7
	Roma	17.5	0.7	16.8	11.7
Mean for years		22.6	0.3	16.6	13.2
Cultivar	treatment	B x C			
Kobra	no treatment	30.7	0.0	18.8	16.5
	1 treatment	27.5	0.0	15.5	14.3
	2 treatment	25.0	0.0	15.2	13.4
	mean	27.7	0.0	16.5	14.7
Roma	no treatment	18.8	2.0	18.3	13.1
	1 treatment	18.2	0.0	16.9	11.7
	2 treatment	15.6	0.0	15.1	10.2
	mean	17.5	0.7	16.8	11.7
Mean	no treatment	24.7	1.0	18.6	14.8
	1 treatment	22.8	0.0	16.2	13.0
	2 treatment	20.3	0.0	15.1	11.8
Mean for years		22.6	0.3	16.6	13.2
Treatment	forecrop	C x A			
No treatment	oilseed rape	16.5	0.0	15.7	10.7
	wheat	33.0	2.0	21.5	18.9
	mean	24.7	1.0	18.6	14.8
1 treatment	oilseed rape	15.3	0.0	13.7	9.7
	wheat	30.3	0.0	18.7	16.3
	mean	22.8	0.0	16.2	13.0
2 treatments	oilseed rape	13.0	0.0	14.2	9.1
	wheat	27.6	0.0	16.0	14.5
	mean	20.3	0.0	15.1	11.8
Mean	oilseed rape	14.9	0.0	14.5	9.8
	wheat	30.3	0.7	18.7	16.6
Mean for years		22.6	0.3	16.6	13.2
LSD $\alpha = 0.05$ for					
A and B		1.61	–	1.71	0.67
B x A and A x B		2.28		2.42	0.95
C		2.38		2.52	0.90
C x A and A x C		–		–	1.27
C x B and B x C		–		–	–

Table 2. Infestation of winter wheat ears cv. Flair by *Fusarium* spp. in Wielgłowy, as dependent on forecrop (A) and number of treatments (C), [%]

Forecrop	Treatment	Years		
		1999	2000	2001
Oilseed rape	no treatment	14.0	trace infestation	27.8
	1 treatment	13.4		20.3
	2 treatment	13.0		19.0
	mean	13.5		22.4
Wheat	no treatment	16.2		33.5
	1 treatment	13.7		32.0
	2 treatment	14.4		26.3
	mean	14.7		30.6
Mean	no treatment	15.1		30.7
	1 treatment	13.5		26.2
	2 treatment	13.7		22.6
Mean for years		14.1		26.5
LSD α = 0.05 for				
A		n.s.	–	3.03
C				4.51
C x A				6.37
A x C				5.05

n.s. – not significant

Table 3. Infestation of winter wheat ears by *Fusarium* spp. in Wielgłowy, as dependent on cultivar (B) and number of treatments (C), [%]

Cultivar	Treatment	Years		
		1999	2000	2001
Kobra	no treatment	31.4	trace infestation	17.2
	1 treatment	29.5		13.8
	2 treatment	24.6		12.6
	mean	28.5		14.5
Roma	no treatment	14.9		28.4
	1 treatment	14.3		24.4
	2 treatment	11.5		20.7
	mean	13.5		24.5
Mean	no treatment	23.1		22.8
	1 treatment	21.9		19.1
	2 treatment	18.0		16.6
Mean for years		21.0		19.5
LSD α = 0.05 for				
B		3.25	–	2.90
C		4.84		4.31
C x B		n.s.		n.s.
B x C		n.s.		n.s.

n.s. – not significant

Table 4. Infestation of winter wheat ears by *Fusarium* spp. in Wielgłowy grown after oilseed rape, as dependent on cultivar and number of treatments [%]

Cultivar	Treatment	Years		
		2002	2003	2004
Drifter	no treatment	trace infestation	3.0	2.0
	J-T*		2.0	0.0
	J-S**		2.0	0.0
	mean		2.3	0.7
Kobra	no treatment		0.0	1.0
	J-T		0.0	0.0
	J-S		0.0	0.0
	mean		0.0	0.3
Pegassos	no treatment		0.0	1.0
	J-T		0.0	0.0
	J-S		0.0	0.0
	mean		0.0	0.3
Flair	no treatment		3.0	2.0
	J-T		0.0	0.0
	J-S		4.0	0.0
	mean		2.3	0.7
Mean	no treatment		1.5	1.5
	J-T		0.5	0.0
	J-S		1.5	0.0
Mean for years			1.2	0.5
LSD α = 0.05			n.s.	n.s.

*first Juwel TT 483 SE; second Tango Star 334 SE;
**Juwel TT 483 SE, Swing Top 183 SC; n.s. – not significant

Table 5. Infestation of winter wheat ears by *Fusarium* spp. in Wielgłowy grown after wheat, as dependent on cultivar and number of treatments, 2002–2004, [%]

Cultivar	Treatment	Years		
		2002	2003	2004
Drifter	no treatment	trace infestation	5.0	5.0
	J-T*		3.0	0.0
	J-S		2.0	0.0
	mean		3.3	1.7
Kobra	no treatment		1.0	1.0
	J-T		0.0	0.0
	J-S		2.0	0.0
	mean		1.0	0.3
Pegassos	no treatment		0.0	1.0
	J-T		0.0	0.0
	J-S		2.0	0.0
	mean		0.7	0.3
Flair	no treatment		4.0	2.0
	J-T		3.0	0.0
	J-S		2.0	0.0
	mean		3.0	0.7
Mean	no treatment		2.5	2.2
	J-T		1.5	0.0
	J-S		2.0	0.0
Mean for years			2,0	0.8
LSD α = 0.05		–	n.s.	n.s.

*see table 4

Table 6. Infestation of winter wheat ears by *Fusarium* spp. as dependent on number of treatments, (in %)

Cultivar	Treatment	Years		
		2005	2006	2007
Drifter	no treatment	trace infestation	trace infestation	18.0
	1 treatment*			16.2
	2 treatments**			9.8
LSD α = 0.05		–	–	2.08

*Juwel TT + Atak + Talius (0.6 + 0.6 + 0.1 l/ha);
**1). treatment – Juwel TT (1.2 l/ha),
2) treatment – Swing Top (1.2 l/ha)

ness of cultivars, it was found that in 1999 and 2001 cultivar Kobra grown after the winter wheat, was significantly more infected (DI = 37.2 and 20.0%) than cultivar Roma (DI = 23.4 and 17.5%). On average for the whole research period, on the control objects of both winter wheat cultivars there was a significantly higher DI in wheat grown after wheat as well as greater infection of Kobra (DI = 16.5%) than Roma (DI = 13.1%) was recorded. The susceptibility of the Kobra cultivar to *F. culmorum* is reported by Kostecki *et al*. (1997). Fungicide treatments slightly limited the intensity of the disease, while 2 treatments were more effective.

At Wielgłowy, the Flair research results were comparable with those reported at Szestno (Table 2), while Kobra and Roma research varied. In the 1999 season significantly more Fusarium head blight symptoms were found for Kobra, and in 2001 – in Roma (Table 3). Even though spraying twice was significant and decreased the intensity of the disease, the effectiveness of the spraying was negligible.

From 2002 to 2004 in all of the four cultivars, Drifter, Kobra, Pegassos and Flair, grown both after rape (Table 4) and after wheat (Table 5), the disease symptoms of Fusarium head blight did not occur at considerable intensity. For this reason, it was difficult to analyse the effectiveness of the fungicides applied as well as the effect of the forecrop.

High Fusarium head blight disease intensity was observed in 2007 (Table 6). The second treatment applied at the tillering phase considerably (effectiveness of 45.6%) limited the occurrence of disease symptoms. The application of a single treatment only, at the BBCH 32 phase did not have a significant effect on the intensity of Fusarium head blight.

DISCUSSION

The occurrence of fuzariosis over the research years varied. High disease intensity was observed in 1999, 2001 and 2007. In the other years the symptoms were inconsiderable, with only trace infestation. These results were connected with low rainfall over the wheat tillering and flowering phase. This information coincides with the reports by Parry *et al*. (1995). Jennings and Turner (1996) reported that high infection occurs under average and heavy rainfall at the end of the tillering-flowering phase of plants. According Hebermeyer et Gerhard (1997) high humidity and a temperature around 20°C is also favourable for the infection during flowering.

In the present research more infected heads were observed when wheat was grown after wheat than after oilseed rape. A stronger infection of wheat with *Fusarium* genus species when growing wheat after wheat, is reported by many authors (Bojarczuk and Bojarczuk 1979; Odorfer *et al*. 1994; Mielke and Weinert 1996).

An important method of limiting the occurrence of Fusarium head blight involves treatments which limit the source of infection, *e.g*. careful soil cultivation, adequate crop rotation or ploughing-in post-harvest residue. Many authors suggested that simplified soil cultivation causes more infection of plants with *Fusarium* genus species (Parry *et al*.1995; Bateman *et al*. 1998; Krebs *et al*. 2000). However Miller *et al*. (1998) claim that the agrotechnical practises applied are less important than growing cultivars with increased resistance. On the other hand, Kiecana *et al*. (1997) found that in 14 wheat cultivars investigated in regard to resistance to *F. avenaceum* and *F. culmorum,* there was no cultivar with low susceptibility to those pathogens. The weather pattern was more important than the cultivar grown.

In general, fungicide protection did not give a satisfactory effect. The low effectiveness of fungicides in the limiting of Fusarium head blight must have been due to the fact that they were performed at BBCH 39-55 phases, and mostly aimed at protecting the top leaves from the most important pathogens. The treatments also focused on combating *Stagonospora nodorum* on the head, which the treatments limited very effectively.

The low effectiveness of the fungicides as protection systems to combat Fusarium head blight is in agreement with the results reported by Ławecki (2000) and Sadowski *et al*. (2002). These authors claim, from a practical point of view, that wheat protection treatments performed at standard dates, namely the beginning of full tillering (BBCH 51-55), have little effect on *Fusarium* spp. on heads. Similarly, Parry *et al*. (1995) claim that the application of fungicides results in high effectiveness towards other pathogens, while the effectiveness of controlling Fusarium genus fungi is, in general, low. The protection of wheat against *Fusarium* spp. can have satisfactory effects if treatment is performed shortly before or after infection (Sirranidou and Buchenauer 2000; Sadowski *et al*. 2008). Ławecki (2000), Zederbauer and Plank (2000) claim that the treatments should be made over the flowering period. This is because at the flowering period the heads are most susceptible to the pathogen infection. Mielke *et al*. (2000) reported 67% effectiveness, when spraying 3 days before infection, whereas the application of the fungicides 3 days after infection resulted in a 35% decrease in effectiveness. Suty and Mauler-Machnik (1998), Sirranidou and Buchenauer (2000), claim that the protection of the head from Fusarium head blight is difficult and they consider effectiveness of 50–70% to be a good result. Frahm *et al*. (1998) stress the high effectiveness of tebuconazole at a dose of 250 g, of the active substance, and metconazole at a dose of 90 g, of the active substance, against *F. culmorum* and *F. graminearum*. The same authors, as well as Wittouck (1997) and Guenard *et al*. (1998), observed high effectiveness of Juwel TT 483 SC against *M. nivale*. Mielke *et al*. (2000) investigated different combinations and doses of active substances to identify those most effective in inhibiting *Fusarium* spp. on heads. One of the best combinations was a mixture of Juwel TT 483 SC (0.5 l/ha) + Caramba 60 SL (0.75 l/ha), which considerably decreased the infection of heads as compared with the control. After these treatments the highest yield was reported. Czajka *et al*. (2000) did not use fungicides. They reported having the lowest Fusarium head blight infection using a 6% concentration of urea applied at the beginning of tillering. In the combinations which involved fungicides the infection was even higher.

An additional difficulty in preventing Fusarium head blight is caused by the infection of the head with a few *Fusarium* spp. species at the same time, as well as variable, unpredictable, weather conditions Parry *et al*. 1995.

CONCLUSIONS

1. Fusarium head blight (*Fusarium* spp.) in winter wheat under favourable weather conditions can occur in Poland at high intensity.
2. Applied wheat protection programmes, in which the second treatment is performed at the tillering phase, limit to some extent, the intensity of *Fusarium* head blight.
3. To decrease the infestation of potentially mycotoxinogenic fungi species, of the *Fusarium* genus, it may be necessary to perform the fungicide treatment for some years, during the wheat flowering period.

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POLISH SUMMARY

WPŁYW PRZEDPLONU I ZRÓŻNICOWANEJ OCHRONY FUNGICYDAMI NA WYSTĘPOWANIE FUZARIOZY KŁOSÓW (*FUSARIUM* SPP.) PSZENICY OZIMEJ

W latach 1999–2007, w oddzielnych doświadczeniach zlokalizowanych na Mazurach, Żuławach Wiślanych i Powiślu, badano występowanie fuzariozy kłosów pszenicy w zależności od przedplonu i stosowanych fungicydów. Fuzarioza kłosów występowała w zróżnicowanym natężeniu. Duże nasilenie obserwowano w latach 1999, 2001 i 2007. W pozostałym okresie choroba występowała bardzo rzadko. Więcej objawów chorobowych stwierdzano przy uprawie po pszenicy niż po rzepaku. Stosowane zabiegi w celu ochrony pszenicy przed chorobami w fazie kłoszenia, w pewnym tylko stopniu ograniczały występowanie fuzariozy.