ACTA AGROBOTANICA
Vol. 63 (1): 129–135
2010

FUSARIUM HEAD BLIGHT OF WINTER RYE (*Secale cereale* L.)

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Received: 27.11.2009

Abstract

Investigations on *Fusarium* head blight of rye were carried out in the years 2005-2007 on 10 production fields in the Lublin region. The percentage of heads showing the fusariosis symptoms in the years 2005-2007 ranged from 0 to 7%.

Mycological analysis of kernels and chaff obtained from heads with *Fusarium blight* (scab) symptoms showed that *Fusarium avenaceum*, *Fusarium culmorum* and *Fusarium sporotrichioides* were the largest threat to heads of this cereal. The species of *Fusarium poae* and *Fusarium crookwellense* were also isolated from infected rye heads. The dominance of particular species in infecting rye heads was determined by weather conditions.

Key words: *Fusarium avenaceum, F. culmorum, F. sporotrichioides*, head blight, winter rye

INTRODUCTION

Fusarium head blight is a dangerous disease of cereals cultivated in different climatic zones (Kiecana, 1994; Bottalico, 1998; Bottalico and Perrone, 2002; Šrobarová et al. 2008; Muthomi et al. 2008). The first reports on scab of rye come from Canada from the 1950's. The species of *F. avenaceum, F. culmorum, F. graminearum, F. poae* and *F. sporotrichioides* were found to be the main cause of this disease (Parry et al. 1995; Bottalico, 1998; Panisson et al. 2003). For rye grown in Poland and Germany, *F. culmorum* and *F. graminearum* have a considerable importance in causing fusariosis of rye heads (Kiecana, 1988; Miedaner et al. 2001; 2003). Among other species from the genus of *Fusarium*, some studies found the presence of *F. avenaceum, F. poae* and *F. sporotrichioides* as well as *Microdochium nivale* on infected heads of rye in our country (Kiecana, 1988; Chełkowski, 1989; Wakuliński and Chełkowski, 1993).

By infecting heads and kernels of cereals, *Fusarium* spp. cause not only a decrease of the yield, but they are also dangerous to homoithermic organisms because the latter produce toxic metabolites in the infected kernels and these include trichothecene compounds, zearelenon, moniliformin and many others (Miedaner et al. 2001; 2003; Bottalico and Perrone, 2002).

Due to the lack of reports in phytopathological literature of recent years on *Fusarium* spp. colonizing rye heads and because of the common occurrence of toxin-producing species from the genus of *Fusarium* on other cereals, studies were undertaken on *Fusarium* head blight of rye grown in the Lublin region.

MATERIALS AND METHODS

The studies were carried out in the years 2005-2007 on 10 production plantations of winter rye (*Secale cereale* L.) cv. Dańkowskie Złote which were situated in the Lublin region (two in each of the following localities: Wola Sernicka (plantations 1, 2), Brzostówka (plantations 3, 4), Wólka Zabłocka (plantations 5, 6), Uścimów (plantations 7, 8) and Głębokie (plantations 9, 10) (Fig. 1).

In each year of the study, the percentage of heads with fusariosis symptoms of was determined at the stage of full maturity of kernels (92 in Tottman's scale, 1987). Following the pattern of studies on spring barley (Kiecana, 1994), 400 heads (100 heads from each site of particular plantations) were analyzed from each field.

Next, 20 heads infected by *Fusarium* spp. were taken for laboratory analysis from each of the studied plantations.

100 kernels and 100 chaff from the heads, from each plantation, were taken for mycological analysis.

A mineral medium (Łacicowa, 1970) was used for the isolation of fungi from the plant material. The method of conducting the analysis was like that in the study by Mielniczuk (2001).

Fungi from the genus of *Fusarium* were identified using the keys by Nelson et al. (1983) and Burgess et al. (1988). Other species were identified according to the keys and monographs by Kiecana et al. (2009).

The information concerning the weather conditions during the investigations was obtained from the Department of Agrometeorology, University of Life Sciences in Lublin.

RESULTS

Field observations carried out at the stage of full maturity of kernels in rye sown on the plantations of the Lublin region pointed to the occurrence of plants with fusariosis symptoms on the heads. In all the plantations, the heads were diminished, whereas on chaff there was visible an orange-rosy powder, especially at the points of contact with the rachis, which consisted of the mycelium and spores of *Fusarium* spp. The kernels from the infected heads were usually smaller and of white-greyish colour. In 2005 the percentage of heads showing fusariosis symptoms ranged from 0 to 5, in 2006 from 0 to 0.5, and in 2007 from 1 to 7 (Fig. 1).

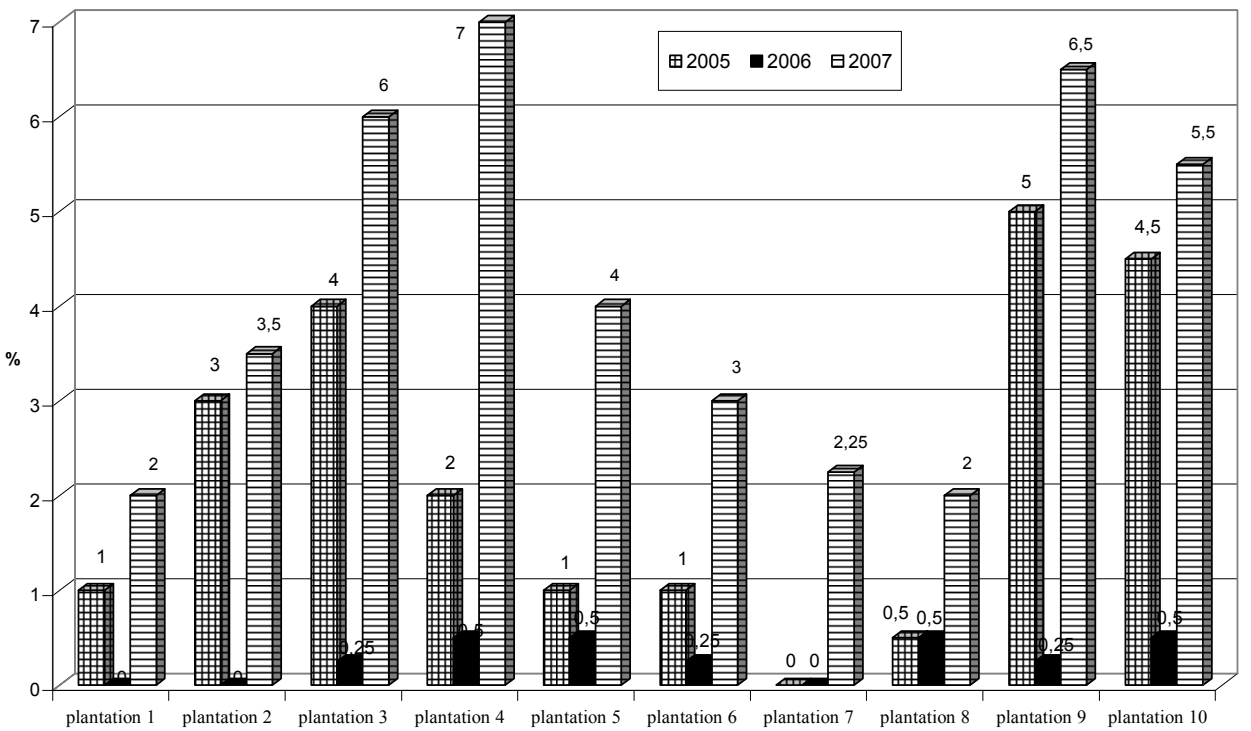

Fig. 1. Percentage of rye heads with fusarium head blight symptoms in the years 2005-2007

As a result of mycological analysis of kernels from the heads with the disease symptoms, over the 3 years of the study 2837 colonies of fungi were isolated, while 929 isolates were obtained from chaff (Table 1). In the years 2005, 2006 and 2007 *Fusarium* spp. colonies amounted to, respectively, 33%, 41% and 21% of all fungal isolates from kernels, whereas isolates from chaff accounted for 41% (2005), 23% (2006) and 48% (2007), and they were represented by: *F. avenaceum, F. crookwellense, F. culmorum. F. poae* and *F. sporotrichioides* (Table1). Regardless of the vegetation season, the species of *F. avenaceum* and *F. culmorum* distinguished themselves by causing general infection of heads. During the study years, *F. avenaceum* isolates amounted from 35.7% (2005) to 42.5% (2007), whereas isolates of *F. culmorum* from 25.8% (2006) to 29.2% (2005) of all *Fusarium* spp. from kernels (Fig. 2). In the case of chaff, *F. avenaceum* isolates amounted from 33.3% (2005) to 47.7% (2006), whereas *F. culmorum* from 30.0% (2007) to 37.8% (2005) of all *Fusarium* spp. from chaff (Fig. 3).

Besides, in each year of the study, the species of *F. sporotrichioides* were frequently obtained from infected kernels, and their isolates amounted from 11.4% of total *Fusarium* spp. from kernels in 2007 up to 27.0% in 2006 (Fig. 2). On the other hand, in the case of chaff, the colonies of this fungus constituted from 13.6% to 24.1% of all *Fusarium* spp. (Fig. 3). The proportion of *F. crookwellense* and *F. poae* in the years in question ranged, respectively, from 2.9% to

8.7% and from 5.6% to 9.6% of all isolates from kernels (Fig. 2), and from 0% to 1.8%, and from 1.8% to 7.1% of total colonies from chaff (Fig. 3).

Isolates of other fungi belonged to the following: *Alternaria alternata* (37.68% of all isolates from kernels and chaff over the 3 years of the study), *Aspergillus flavus* (0.16%), *Bipolaris sorokiniana* (0.21%), *Botrytis cinerea* (0.27%), *Chaetomium globosum* (0.24%), *Cladosporium cladosporioides* (3.24%), *Epicoccum nigrum* (23.74%), *Penicillium verrucosum* var. *cyclopium* (0.21%) as well as non-sporulating forms (1.3%) (Table 1).

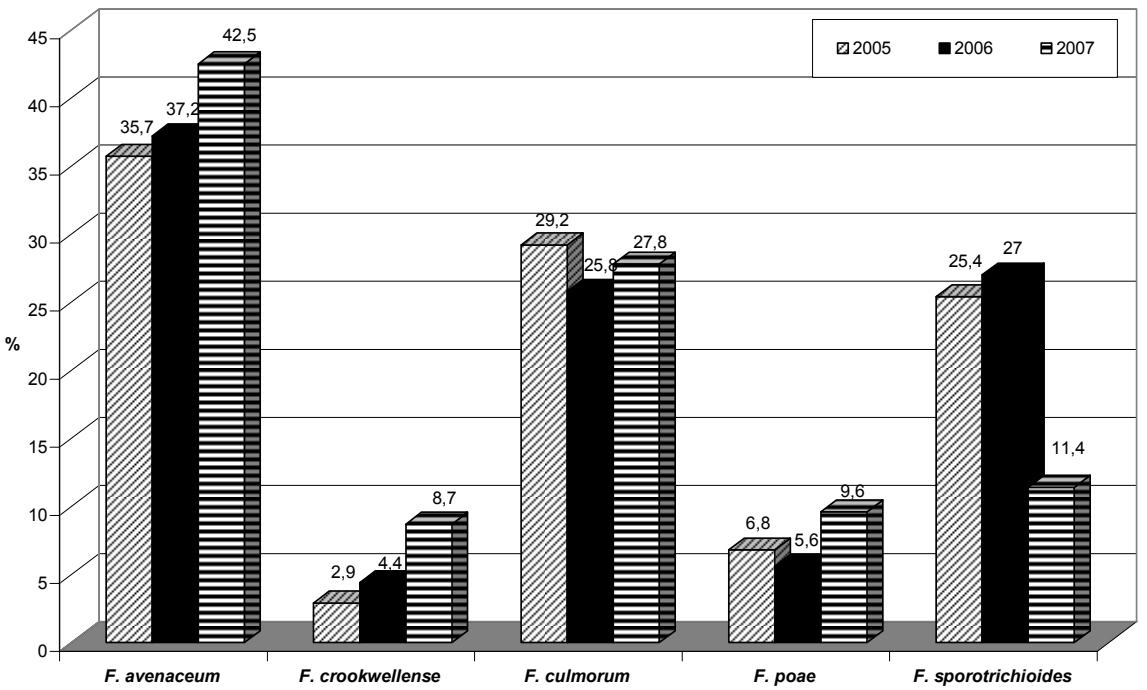

Fig. 2. The proportion of individual species in all *Fusarium* spp. isolates obtained from rye kernels in the years 2005, 2006 and 2007

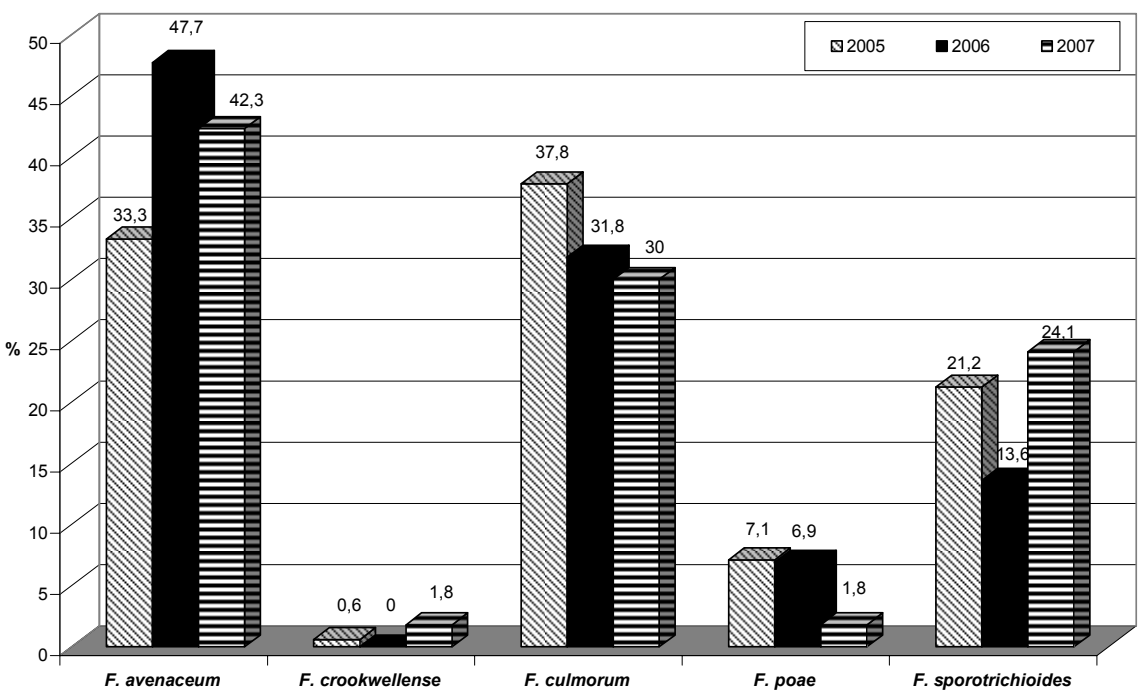

Fig. 3. The proportion of individual species in all *Fusarium* spp. isolates obtained from rye chaff in the years 2005, 2006 and 2007

Table 1

Fungi isolated from rye kernels and chaff obtained from heads with fusariosis (scab) symptoms

Fungal species	Number of isolates (%)								Total number of isolates
	2005		2006		2007		total		
	k	ch	k	ch	k	ch	k	ch	
Alternaria alternata (Fr.) Keissler	378 (40.1)	106 (27.7)	289 (34.4)	93 (48)	429 (40.7)	124 (35.1)	1096(38.6)	323 (34.8)	1419(37.68)
Aspergillus flavus Link	-	3 (0.8)	1(0.1)	-	2 (0.2)	-	3 (0.1)	3 (0.3)	6 (0.16)
Bipolaris sorokiniana (Sacc.) Shoem.	-	-	4 (0.5)	1 (0.5)	3 (0.3)	-	7 (0.3)	1 (0.1)	8 (0.21)
Botrytis cinerea Pers.	2 (0.2)	2 (0.5)	5 (0.6)	-	-	1 (0.3)	7 (0.3)	3 (0.3)	10 (0.27)
Chaetomium globosum Kunze	-	-	7 (0.8)	2 (1.0)	-	-	7 (0.3)	2 (0.2)	9 (0.24)
Cladosporium cladosporioides (Fres.) de Vries	18 (1.9)	37 (9.7)	23 (2.7)	9 (4.6)	11 (1.0)	24 (6.8)	52 (1.8)	70 (7.5)	122 (3.24)
Epicoccum nigrum Link ex Link	229 (24.3)	72 (18.8)	156 (18.6)	32 (16.5)	378 (35.8)	27 (7.7)	763 (26.9)	131 (14.1)	894 (23.74)
Fusarium avenaceum (Fr.) Sacc.	111 (11.8)	52 (13.6)	127 (15.1)	21 (10.8)	93 (8.8)	72 (20.4)	331 (11.7)	145 (15.6)	476 (12.64)
Fusarium crookwellense Burgess, Nelson, Toussoun	9 (0.9)	1 (0.3)	15 (1.8)	-	19 (1.8)	3 (0.8)	43 (1.5)	4 (0.4)	47 (1.25)
Fusarium culmorum (W.G.Sm.) Sacc.	91 (9.7)	59 (15.4)	88 (10.5)	14 (7.2)	61 (5.8)	51 (14.5)	240 (8.5)	124 (13.3)	364 (9.67)
Fusarium poae (Peck.) Wollenw.	21 (2.2)	11 (3.0)	19 (2.3)	3 (1.6)	21 (2.0)	3 (0.8)	61 (2.1)	17 (2.0)	78 (2.07)
Fusarium sporotrichioides Sherb.	79 (8.4)	33 (8.6)	92 (11.0)	6 (3.1)	25 (2.4)	41 (11.6)	196 (6.9)	80 (8.6)	276 (7.33)
Penicillium verrucosum Dierckx var. *cyclopium* (West.) Samson, Stolk et Hadlok	1 (0.1)	3 (0.8)	2 (0.2)	-	1 (0.1)	1 (0.3)	4 (0.1)	4 (0.4)	8 (0.21)
non-sporulating forms	3 (0.3)	3 (0.8)	12 (1.4)	13 (6.7)	12 (1.4)	6 (1.7)	27 (0.9)	22 (2.4)	49 (1.30)
Total	942 (100)	382 (100)	840(100)	194 (100)	1055(100)	353 (100)	2837(100)	929 (100)	3766 (100)

k – isolates obtained from kernels, ch – isolates obtained from chaff

The temperature in the Lublin region during the 2005 growing season (the period of heading, flowering and grain maturation of winter rye) was higher as compared to the long-term means in months of April, May and July from 0.2°C to 2.1°C, while in June air temperature was about 0.4°C lower compared to the long-term means. On the other hand, rainfall exceeded the long-term means in May and July by, respectively, 67.52% and 41.13%. The lowest rainfall was recorded in April of that year – only 47.94% of the normal level. In 2006 air temperature between April and July was higher than the long-term mean by 0.5°C (June) to 4.2%°C (July). The percentage of normal rainfall ranged from 8.74 in June to 269.06 in July. In 2007 air temperature was higher than the long-term mean by 1.3°C in April to 2.0°C in May. On the other hand, rainfall exceeded the long-term mean in May, June and July, respectively, by 37.61, 29.31 and 11.82%. The lowest amount of rainfall was observed in April of 2007 – 44.84% of the normal level (Table 2).

Table 2

Air temperature and rainfall in the growing season – in the period of heading, flowering and grain maturation of winter rye, in the years 2005-2007

Month	Mean for 1951-1990		Air temperature difference compared with the mean for 1951 – 1990 [°C]			Percentage of rainfall compared with the mean for 1951 – 1990 [%]		
	Air temperature [°C]	Rainfall [mm]	2005	2006	2007	2005	2006	2007
April	7.4	38.8	+1.7	+1.3	+1.3	47.94	101.71	44.84
May	13.0	58.5	+0.2	+0.6	+2.0	167.52	55.82	137.61
June	16.4	67.9	-0.4	+0.5	+1.7	82.33	8.74	129.31
July	17.7	73.7	+2.1	+4.2	+1.5	141.13	269.06	111.82

DISCUSSION

The results of the study carried out in the years 2005-2007 show that *Fusarium* head blight of rye grown in the north-eastern part of the Lublin region occurred in each year of the study, with the proportion of infected heads not exceeding 7%. The studies conducted in the conditions of the Lublin region indicate a similar frequency in the infection of triticale heads by fungi of the *Fusarium* genus (Kiecana, 1986), while this frequency was higher in the infection of wheat heads (Łacicowa et al. 1987) and oat panicles (Mielniczuk, 2001).

The studies show that the species of *F. avenaceum, F. culmorum* and *F. sporotrichioides* are the cause of rye scab, as in the case of other cereals (Kiecana, 1994; Mielniczuk, 2001; Vančo et al. 2007; Šrobarová et al. 2008). The proportions of particular species in infecting heads are determined by weather conditions (Kiecana, 1994; Mielniczuk, 2001; Bottalico and Perrone, 2002; Xu et al. 2008).

The common occurrence of *F. avenaceum* on rye heads in each year of the study, varying from year to year, is explained by high tolerance of this fungus to temperature and humidity (Kiecana, 1994; Mielniczuk, 2001; Kiecana et al. 2003; Xu et al. 2008).

The present authors' earlier studies showed that the species of *F. avenaceum* posed a threat to rye grown in the Lublin region, mainly due to its high harmfulness to seedlings of this cereal (Kiecana et al. 2009).

The present study confirmed that the infection of rye heads by *F. culmorum* – like in the case of barley heads and oat panicles – is favoured by hot weather with passing rainfalls (Kiecana, 1994; Mielniczuk, 2001; Miedaner et al.1993; 2001). In the case of the present study, such weather conditions occurred in the years 2005 and 2007 and it is these conditions that account for a considerable proportion of the species under discussion in the infection of rye heads in these growing seasons.

It has been established that in Poland *F. culmorum* has a significant proportion in the infection of root and stem bases of rye (Pałys et al. 2004; Kiecana et al. 2009).

In 2007 the species of *F. crookwellense,* besides *F. culmorum*, occurred on rye heads with greater frequency as compared to the other years. It should be supposed that weather conditions conducive to the development of this fungus are similar to the requirements of *F. culmorum* as far as the climatic conditions are concerned.

Every year, a considerable number of *F. sporotrichioides* isolates were obtained from the analyzed

rye heads with the symptoms of fusariosis. Earlier, this species was isolated from the heads of barley (Kiecana, 1994; Perkowski et al. 1997), wheat (Tóth, 1997) and oat panicles (Mielniczuk, 2001). *Fusarium sporotrichioides* has been found to be the cause of chaff necrosis and leaf spot in the state of Minnesota (Vargo and Baumer, 1986), changes in the colour and consistency of barley and oat kernels (Kiecana, 1994, Mielniczuk, 1999) as well as necrosis of roots and leaf sheath of oat seedlings (Kiecana and Kocyłak, 1999).

The species frequently isolated from the analyzed rye heads included *F. poae*. This fungus commonly occurred on oat panicles in the Lublin region (Kiecana and Perkowski, 1998; Kiecana et al. 2005). Under different cultivation conditions, *F. poae* is considered to be the cause of fusariosis of cereal heads in Europe (Tóth, 1997; Thrane, 2001; Mielniczuk, 2001), and in other continents (Tekauz et al. 2004; Muthomi et al. 2008).

Like in the case of other cereals, *A. alternata* was frequently observed on rye heads (Kiecana, 1994; Mielniczuk, 2001; Muthomi et al. 2008).

Epicoccum nigrum, which was frequently isolated from rye kernels and chaff, was found to be the cause of wheat leaf spot (Goel and Gupta 1979 according to Ting and Reedler 1991).

The presence of the polyphagous species of *B. cinerea* on the heads was probably caused by the stimulating effect of pollen on the germination of spores, which made heads infection at the stage of anthesis possible. Earlier investigations of Pokacka (1987) concerning rye allow such an interpretation.

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Fuzarioza kłosów żyta ozimego (*Secale cereale* L.)

Streszczenie

Badania nad fuzariozą kłosów żyta przeprowadzono w latach 2005-2007 na 10 polach produkcyjnych zlokalizowanych w okolicach Lublina. Procent kłosów żyta z objawami fuzariozy w latach 2005 - 2007 roku wynosił od 0 do 7.

Analiza mikologiczna ziarniaków i plew uzyskanych z kłosów żyta z objawami fuzariozy wykazała, że największym zagrożeniem dla kłosów tego zboża, były *Fusarium avenaceum, Fusarium culmorum* i *Fusarium sporotrichioides.* Z porażonych kłosów uzyskiwano także gatunki *Fusarium poae* oraz *Fusarium crookwellense*. Dominację w porażaniu kłosów żyta przez poszczególne gatunki *Fusarium* spp. determinowały warunki pogodowe.