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PATHOGENICITY OF *FUSARIUM CROOKWELLENSE* BURGESS, NELSON AND TOUSSOUN TO 12 GENOTYPES OF OAT (*AVENA SATIVA* L.).

ABSTRACT

Within the years 2002-2004 12 genotypes of oat (Bachmat, Budrys, Bohun, Chwat, Cwał, Deresz, Hetman, Rajtar, Sam, Szakal, STH 5501, STH 5601) were examined to determine their susceptibility to *Fusarium crookwellense*. The examination was led under field conditions of Zamość region (south - eastern part of Poland),. Both oat grains and soil were inoculated with *Fusarium crookwellense* nr 47, what caused a reduction in numbers of seedlings - from 24.6% (cv. Bohun) to 52.9% (cv. Sam); plants before harvest - from 11.6 (cv. Bohun) to 68% (cv. Sam); panicles - from 14.3% (cv. Bohun) to 60.8% (cv. Sam), (mean for 3 years). Mean reduction of grain yield in three-year inoculation experiments with *F. crookwellense* ranged from 15.8% (cv. Bohun) to 56.1% (cv. Sam). This field experiments showed the cultivar Bohun as having the lowest susceptibility to kernels infection by *F. crookwellense,* while cv. Sam was shobn to be the most susceptible.

Key words: damping off, field experiment inoculation, *Fusarium crookwellense,* oat genotypes, susceptibility

INTRODUCTION

For a long time oat has been considered as a phytosanitary plant due to avenacine – saponin of fungicidal activity present in the roots of this cereal (Osbourn *et al.* 1994). Despite the protective barrier in the rhizosphere, oat, like other cereals, is infected by fungi causing foot-rot diseases, including those caused by the species from *Fusarium* genus (Łacicowa, Pięta 1998, Kiecana, Kocyłak 1999, Chongo *et al.* 2001, Kiecana *et al.* 2003, Strausbaugh *et al.* 2005).

Fusarium spp. belonging to dangerous pathogens infecting cereals cause significant economic losses (Schaafsma 1999 according to Schaafsma *et al.* 2001, Windels 2000). The cause of seedling blight, stem base and root necrosis of different cereals, including oat, are mainly: *F. avenaceum, F. culmorum, F. crookwellense, F. pseudograminearum, F. equiseti* and *F. poae* (Łacicowa *et al.* 1990, Kiecana 1998, Kiecana, Kocyłak 1999, Kiecana, Mielniczuk 2001, Kiecana *et al.* 2003, Strausbaugh *et al.* 2004, Strausbaugh *et al.* 2005).

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Pathogenicity of *Fusarium* spp. towards cereals is associated with the production of mycotoxins, especially: deoxynivalenol, moniliformin and diacetoxyscirpenol inhibiting the growth of young plants and causing a number of changes in the metabolic processes of the cell, including disturbances in cell divisions and in the permeability of cytoplasmatic membranes (Wojciechowski *et al.* 1995, Packa 1997, Dahleen, McCormick 2001, Šrobárová, Pavlová 2001).

Fusarium crookwellense infects not only the seedlings, roots and the stem base but also the heads and grain of the cereals as well as the ears and leaves of maize (Sugiura *et al.* 1993, Perkowski, Kiecana 1998, Lauren, Di Menna 1999, Cromey *et al.* 2001, Tan *et al.* 2004, Xue *et al.* 2004). Infecting the plants, this fungus produces toxic secondary metabolites in tissues such as: nivalenol, fusarenone – X, zearalenone and its derivatives, as well as fusarin C (Goliński *et al.* 1988, Bottalico 1998, Perkowski, Kiecana 1998, Mielniczuk *et al.* 2004).

In the face of limited information in the literature concerning plant pathology on the harmful effect of *F. crookwellense* towards oat both in Poland and abroad, the presented studies have been undertaken.

MATERIAL AND METHODS

The studies were carried out in the years 2002-2004 on experimental plots in Zamość region, on leached brown soil formed on loess deposits where the root crops constituted the forecrop. The recommended rates of NPK fertilization (Mazurek 1993) and manual weeding were used every year.

The investigations comparised 12 genotypes of oat (Bachmat, Budrys, Bohun, Chwat, Cwał, Deresz, Hetman, Rajtar, Sam, Szakal, STH 5501, STH 5601) and an isolate of *Fusarium crookwellense* No 47 obtained from the oat grain which pathogenicity was tested in the laboratory by means of the method by Mishra and Bhehr (1976).

Each year of studies the experiment included a block with plots with grain and soil inoculated by *F. crookwellense* and a block with control plots, i.e. sown with the grain without inoculation. In particular combinations 25 kernels were sown on each plot in 4 replications (on 4 plots with the area of 1.25m^2). Totally, 100 kernels were sown for each analyzed oat genotype. In 2002 the experiment was established on 8 April, in 2003 – on 25 April, while in 2004 – on 14 April.

Preparation of the infection material and the technique of the grain inoculation before the sowing as well as the manner of establishing the experiment were the same as those that were used in the studies on the sensitivity of triticale to the infection by *Fusarium nivale* (Łacicowa, Kiecana 1986).

During the period of vegetation the number of plants on particular plots was calculated, i.e. 7 weeks after the sowing of grain and before the harvest. Besides, the number of panicles and the grain yield from each plot after the har-

vest were examined. The harvest date fell in each studied year on the second 10-days' period of August.

The results were statistically analysed using the t – Studet's test (Oktaba 1972).

The information concerning the weather conditions during the investigations was obtained from the Faculty of Agricultural Sciences in Zamość.

RESULTS

During the three-year field studies in each vegetation season found out a reduction of number plants grown from the grain inoculated with the studied isolate of *F. crookwellense* No. 47 as compared to the control (Fig. 1,2). The highest loss of plants number, which was the result of the pre-emergence and post- emergence damping off, was observed in the first seven weeks after the sowing of the inoculated grain. In 2002 the reduction of seedling numbers was 10.1% in case of Bohun cv. to 65.3% in case of Sam cv., whereas in 2003 from 8% (Bohun) to 60.2% (Szakal), while in 2004 from 20.5% (Deresz) to 76.6% (STH 5601) (Fig. 1). After three years of studies the mean loss of seedling numbers ranged from 24.6% (Bohun) to 52.9% (Sam). The number of 7-week-old seedlings, after 3 years of studies, differed significantly as compared to the control in 11 genotypes, with an exception of Bohun cv. (Table1).

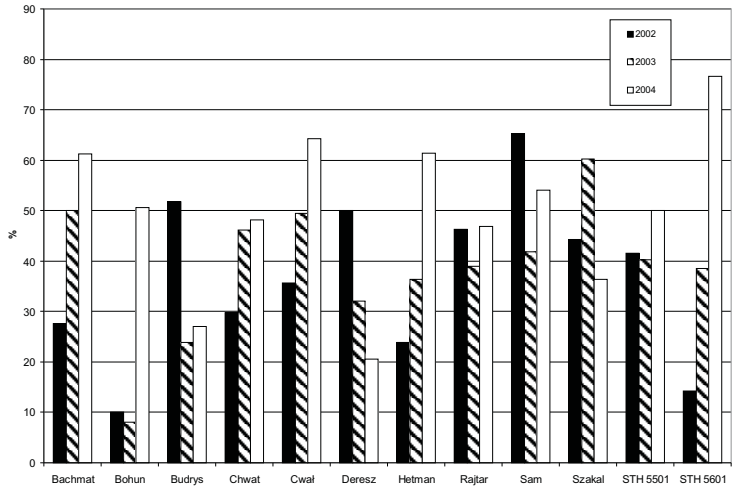

Fig. 1. Reduction (%) of seedlings number compared to the control after oat grain and soil inoculation with *F. crookwellense*, in 2002 – 2004

Similarly, in comparison with control plants significant differences in the mean number of plants before the harvest after 3 years of studies were found in the same genotypes of oat (Table1). The number of plants losses before the har-

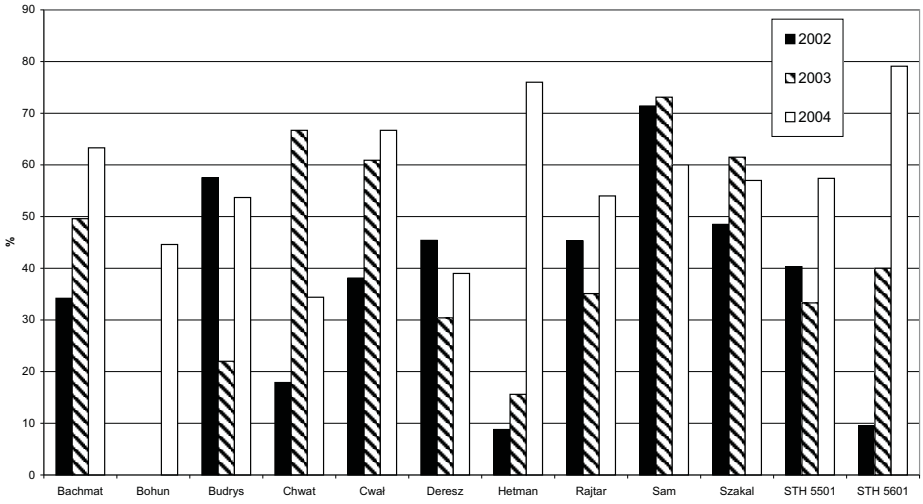

Fig. 2. Reduction (%) of plants number before harvest compared to the control, after oat grain and soil inoculation with *F. crookwellense*, in 2002 – 2004

Table 1

Influence of oat grain and soil inoculation with *F. crookwellense* on seedlings number, number of plants before harvest, number of panicles, and grain yield (average from 3 years of studies)

Genotyp genotypes	Number of seedlings		Number of plants before harvest		Number of panicles		Grain yield [g]	
	F. cr	Control	*F. cr*	Control	*F. cr*	Control	*F. cr*	Control
Bachmat	12.00*	22.58	8.17*	15.55	42.42*	85.92	68.24*	153.77
Bohun	16.58	22.00	14.08	15.92	77.35	90.25	126.81	150.55
Budrys	13.25*	20.25	8.42*	15.83	49.35*	78.92	74.24*	147.85
Chwat	12.33*	21.00	8.83*	14.75	42.67*	68.33	97.54*	170.90
Cwał	10.08*	20.08	6.33*	13.83	35.52*	72.75	68.04*	114.32
Deresz	12.83*	19.23	8.17*	13.50	37.17*	61.61	82.10*	130.49
Hetman	12.92*	21.58	9.08*	14.42	49.42*	61.08	91.89*	131.28
Rajtar	12.93*	23.08	9.33*	17.00	53.60*	87.17	99.78*	166.60
Sam	9.58*	20.33	4.33*	13.42	22.75*	58.00	56.91*	129.57
Szakal	11.25*	21.16	6.83*	15.17	35.75*	70.00	69.33*	142.41
STH 5501	12.00*	21.33	8.50*	15.17	41.75*	69.25	94.77*	143.30
STH 5601	12.67*	21.75	8.75*	15.08	51.42*	74.17	99.54*	141.32

F. cr. – Fusarium crookwellense
* significant difference of means when compared to the control (P? 0.05)

vest ranged from 0 (Bohun) to 71.4% (Sam) in 2002, from 0 (Bohun) to 73.1% (Sam) in 2003, and from 34.4% (Chwat) to 79.1% (STH 5601) in 2004 (Fig. 2). After 3 years the mean loss of plants ranged from 11.6% (Bohun) to 68% (Sam). The studies showed that inoculation of the grain and the soil by *F. crookwellense* had a significant effect on the decrease of the panicle num-

bers as compared to the control in the case of examined cultivars and breeding lines of oat, with an exception of Bohun cv. (Table1). The highest reduction of the number of panicles, on average after 3 years of studies, was observed in Sam cv. – 60.8%, while the lowest in Bohun cv. – 14.3%. In particular years of studies: 2002, 2003 and 2004, the reduction of panicles ranged, respectively, from 0 (Hetman) to 49.6% (Sam), from 0 (Bohun) to 70.4% (Sam) and from 22.2% (Chwat) to 67.2% (STH 5601) (Fig. 3).

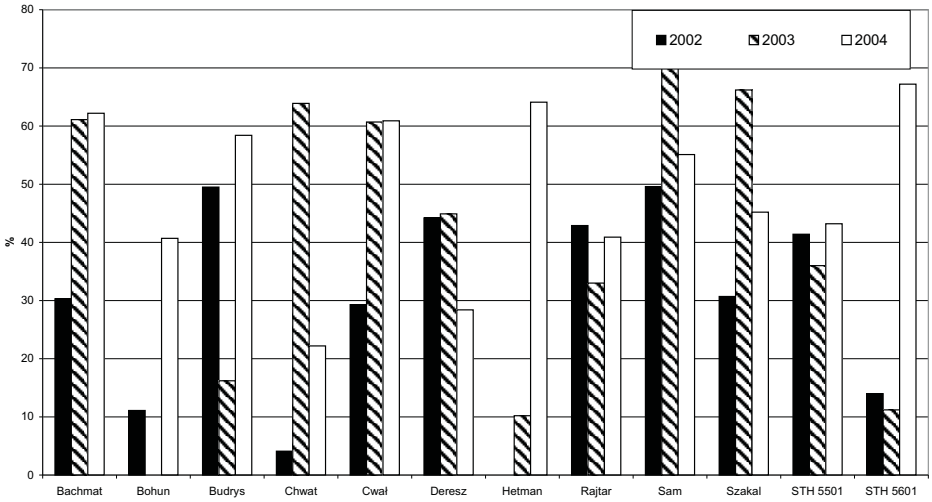

Fig. 3. Reduction (%) of panicles number compared to the control after oat grain and soil inoculation with *F. crookwellense*, in 2002 – 2004

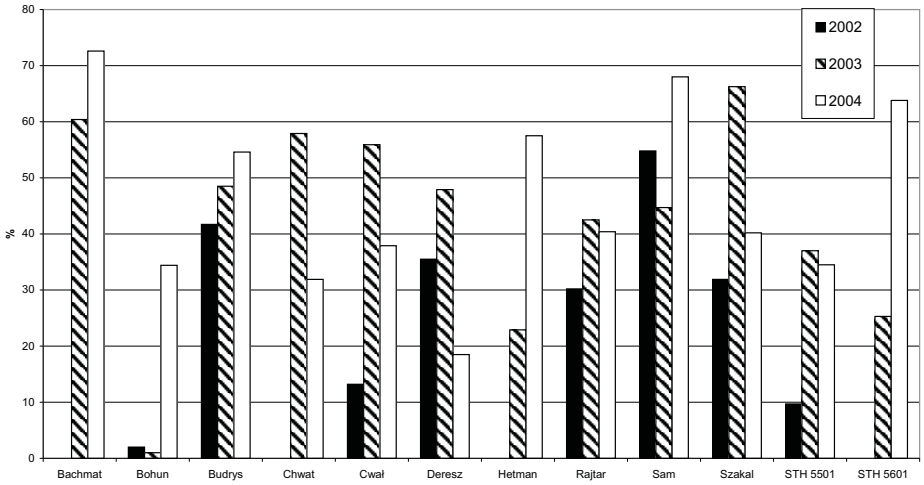

Fig. 4. Reduction (%) of grain yield per plots compared to the control after oat grain and soil inoculation with *F. crookwellense*, in 2002 - 2004

The statistical analysis of the results, carried out after 3 years of studies, showed that inoculation of the grain and the soil by *F. crookwellense* had a significant effect on the size of the grain yield from a plot in the case of 11 oat genotypes (Table 1). The yield loss in 2002 ranged from 2% (Bohun) to 54.8% (Sam), while in the case of the genotypes Bachmat, Chwat, Hetman and STH 5601 there was no yield reduction, while in 2003 it ranged from 1% (Bohun) to 66.3% (Szakal) and in 2004 from 18.5% (Deresz) to 72.6% (Bachmat) (Fig.4). After 3 years of the experiment the reduction of the grain yield as a result of inoculation by *F. crookwellense* ranged from 15.8% (Bohun) to 56.1% (Sam).

Table 2

Air temperature and rainfalls in the growing season of oat in 2002 – 2004

Month	Mean for the years 1971-1995		Difference of air temperatures as compared with means for the years 1971 - 1995 [°C]			Difference of rainfalls as compared with means for the years 1971 - 1995 [mm]		
			Years					
	Air temp. [°C]	Rainfalls [mm]	2002	2003	2004	2002	2003	2004
April	7.3	43	+ 1.9	+ 0.8	+ 2.3	-15	-37	0
May	13.1	62	+ 4.6	+ 4.9	+ 0.4	+26	+51	-12
June	16.4	81	+ 1.9	+ 2.5	+ 1.7	+56	-28	-46
July	17.9	91	+ 4.3	+ 3.0	+ 1.5	+3	-27	+53
August	17.0	81	+ 3.8	+ 3.0	+ 1.0	-64	-30	+1

The temperature in Zamość in the vegetation season of 2002 was higher as compared to the long-term means from 1.9°C to 4.6°C. On the other hand, the rainfalls exceeded the means of long-term in May, June and July, respectively, by 26 mm, 56 mm and 3 mm. The lowest rainfalls occurred in August of that year – only 17mm. In 2003 the air temperature between April and August was higher than long-term means by 0.8°C to 4.9°C. The rainfalls exceeded long-term means only in April – by 51mm, while in the other months of that vegetation season the rainfalls did not exceed long-term means. In 2004 the temperature of many years was higher than long-term means by 0.4°C to 2.3°C. On the other hand, the rainfalls exceeded long-term means in July and August, respectively, by 53 mm and 1 mm. The lowest amount of rainfall was observed in June of 2004 – 35 mm (Table 2).

DISCUSSION

Various methods of inoculation are used to determine the susceptibility of plant genotypes to pathogens (Łacicowa, Pięta 1998, Kiecana, Kocyłak 1999, Strausbaugh *et al.* 2004). In the presented field studies the germination of the grain took place in the presence of the inoculum of *F. crookwellense* introduced on the surface of the glume and into the soil environment in the form of an infection mixture. In this way a strict contact of the pathogen with the plants of particular oat genotypes was ensured. The application of this method turned

out to be effective. The occurrence of pre-emergence damping off and the infection of older plants were observed on all plots with inoculation of the grain. The reduction of panicle numbers and grain yield from a plot were observed too. However in the case of some genotypes in 2002 yield on plots with inoculation did not differ from that on control plots due to higher number of spikelets filled with grains of higher weight in panicles.

The studies conducted on experimental plots showed considerable agressiveness of *F. crookwellense* to oat, especially as a pathogen causing pre - and post – emergence damping off. High pathogenicity of this fungus to oat seedlings, established in the conditions of a plot experiment, with inoculation grain and soil, is confirmed in the studies by Kiecana and Kocyłak (1999), where *F. crookwellense* showed similar pathogenicity towards oat seedlings to *F. culmorum.* On the other hand, in the studies by Mańka (1989) this fungus proved to be more pathogenic towards the seedlings of five species of cereals: wheat, rye, barley, triticale and oat, as compared to *F. culmorum. F. crookwellense* exhibited similar pathogenicity to wheat seedlings in the studies by van Wyk *et al.* (1986).

The present studies showed that the losses of number plants on the plots did not result only from seedlings damping off, but also of infection plants during their further growth; hence the differences occurring between the number of plants established in the two observations. These findings are confirmed by the results of studies by Kiecana and Mielniczuk (2001) and Kiecana *et al.* (2003), pointing to the importance of *F. crookwellense* in infecting both the seedlings and older plants. The infection of roots and stem base of wheat by this species is reported by Linddell (1985, according to Burgess *et al.* 1988), while Strausbaugh *et al.* (2004) write about the infection of wheat and barley roots.

Besides, the examined species showed high pathogenicity related to barley and oat in strict field experiments with inoculation of the heads and panicles (Perkowski, Kiecana 1998, Mielniczuk *et al.* 2004). In the conditions of natural infection of wheat heads, *F. crookwellense* was considered as the main pathogen causing the fusarium head blight (scab) of this cereal cultivated in Japan, whereas in New South Wales it took the third place after *F. graminearum* and *F. culmorum* in infecting wheat heads, and in Poland it occupied the fifth place after *F. avenaceum, F. poae, F. sporotrichioides* and *F. culmorum* in infecting the panicles of oat (Sugiura *et al.* 1993, Mielniczuk 2001, Tan *et al.* 2004).

If one considers as the criterion of evaluation a 53% decrease of the seedling numbers and a 68% loss of plants before the harvest as well as a 60% reduction of the number of panicles and a 56% reduction of the yield as compared to the control, then cv. Sam was the most sensitive to the infection by *F. crookwellense.* On the other hand, cv. Bohun was regarded as the least susceptible to the infection by this pathogen.

Analyzing the vegetation periods when the studies were conducted, the weather conditions in 2004 turned out to be the most favourable to plant infec-

tion by *F. crookwellense*, and April when the growth of plants in the presence of the infection material

began in that vegetation season was characterized by high humidity and warm weather. Similar weather conditions in 1998 and 2000 were favour the infection of oat seedlings by *Fusarium culmorum* (Kiecana and Mielniczuk 2001).

CONCLUSIONS

High pathogenicity of *F. crookwellense* in field experiments with inoculation of grain and soil suggests that this fungus frequently can cause seedling blight and foot-rot of oat.

Among the tested oat genotypes, did not observe completely resistant to grain inoculation by *F. crookwellense*.

It seems that cultivar Bohun should be recommended for cultivation in the Lublin province, as it is highly resistance to seedling infection by *F. crokwellense* in the cultivation conditions of this part of Poland.

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