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Fungi occurrence on seeds of field pea

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Seeds of four edible cultivars of *Pisum sativum* and three fodder harvested in 2004-2006 from eight localities, scattered in all region suitable for pea production in Poland, were evaluated for fungi occurrence on CN agar medium in Petri plates. The highest number (27) of species was isolated in 2004, while the lowest (16) in 2006. Number of fungi inhabiting seeds was influenced mainly by environmental conditions of locality and years. *Alternaria alternata* dominated in each sample of 450 seeds. Species of *Penicillium* contaminated seeds as the next and infection by *Stemphylium botryosum* was at similar level. *Fusarium poae* was the most often occurring species of this genera. Pea specific pathogens: *Mycosphaerella pinodes, Phoma pinodella* and *Ascochyta pisi* infected more seeds in 2004 and 2005 than 2006, and at the last season only *A. pisi* was noted. In general, level of infection by those pathogens was low, reaching on an average only 2.56%, with the highest for *A. pisi*, and the lowest for *M. pinodes.*

Key words: different fungi, occurrence, intensity, *ascochyta* blight, pea cultivars

INTRODUCTION

Studies concern fungi transmission by *Pisum sativum* L. seeds were conducted in different countries, like Australia (Bretag et al. 1995), Canada (Xue et al. 1997; Morrall et al. 2005), France (Roger et al. 1999; Fougereux et al. 2006), Poland (Grzelak, Iłłakowicz 1973; Filipowicz 1976; Marcinkowska 1997), but mainly for incidence of *ascochyta* blight fungi. Some reports (Skolko et al. 1954; Czyżewska 1976; Filipowicz 1976; Marcinkowska 1997; 1998) were also performed for saprobic fungi, since they could had been able to cause seed destruction and thus decreased plant stands of peas (Filipowicz 1976), soybean (Marcinkowska, Schollenberger 1979), or parsley (Nowicki 1997). Saprobic fungi are also important because some of them may produce secondary metabolites harmful for people and animals (Kozakiewicz 1990; 1992).

Fungi inhabiting pea seeds in Poland were already described, but on genotypes issued earlier. Now the increasing importance of dry pea seed production for edible and animal feeding (fodder) purposes caused breeders interest in releasing new cultivars of field pea. Seeds of recently introduced cultivars were the objective for evaluation of any fungi occurring on them.

MATERIALS AND METHODS

Seeds of four edible and three fodder cultivars, six bred in Poland and one in Czech, registered between 1995-2006, were tested for fungi occurrence (Tab. 1). Seeds for evaluation were harvested in 2004, 2005 and 2006 from plants cultivated in fields of 14 localities situated in seven different regions of Poland, suitable for pea production. Cultivars of each type were planted in eight localities, six different and two the same, since at Cicibór (C) and Kawęczyn (KA) were tested edible cultivars requiring better soils for cultivation and also fodder one of light soil requirements.

A sample of 450 seeds of each cultivar, collected at 8 localities were studied every year. Surface sterilized seeds (Marcinkowska, Boros, in print) were placed on Coon's (CN) agar medium into a Petri plate (Pp) 10 cm in diameter. A plate contained 15 seeds. Evaluation was done in two equal series (15 Pp x 15 seeds equals 225), first started in late December, second by the end of February. The same incubation conditions were provided for seeds of both series (Marcinkowska 1997). Identification of fungi was done following different keys (Marcinkowska 1998; 2003). List of fungi occurred on seeds was given in table 2. Data were taken on the eight day since plating.

Number of identified species was counted together for both series and changed for percent of a sample. For statistical evaluation percentage data were transformed according to Bliss (TP) and used in Statgraphics Plus programme. Majority of occurring fungi (Tabs 3, 4), that means nine common species and 4 genera of more than one species (*Aspergillus, Cladosporium, Fusarium, Penicillium*), were covered by statistical analyses. Statistical analysis were also done for comparison of frequency of three species responsible for *ascochyta* blight and *Alternaria alternata* on tested seeds

Table 1
Names of cultivars and origin of tested seeds

No	Cultivar	R.Y.	Locality of planting cultivars		Part of Poland
			edible	fodder	
	edible		Krzyżewo (K)		North-East
1.	Ramrod	1995		Marianowo (MR)	North-East
2.	Set	2000	Cicibór (C)	Cicibór (C)	Central-East
3.	Tarchalska	2004	Kawęczyn (KA)	Kawęczyn (KA)	Central
4.	Terno	2006 [cz]	Kościelna W. (KW)		Central
				Masłowice (M)	Central
	fodder		Sulejów (S)		Central
1.	Hubal	2005		Lubinicko (L)	Central-West
2.	Sokolik	2001	Chrząstowo (CH)		Central-North
3.	Zagłoba	2000	Radostowo (R)		Central-North
				Bobrowniki (B)	North-West
			Rarwino (RR)		North-West
				Wyczechy (W)	North-West
				Tomaszów B. (TB)	South-West

Abbreviations: R. Y. – year of cultivar registration; [cz] – cultivar bred in Czech Republic

(Tabs 5, 6). Incidence of fungi on seeds was evaluated according to Fisher's least significant difference (LSD) procedure, the method used to discriminate among the means at the 95% confidence level.

RESULTS

On evaluated seeds of 7 cultivars, 4 edible and 3 fodder, 27 species of fungi were identified in 2004, 22 in 2005 and 16 in 2006 (Tab. 2).

Statistical analysis of data concern majority of species occurring on seeds indicated that number of fungi inhabiting edible cultivars and fodder ones depended significantly on their species and year (Tab. 3). Significance of differences between locality and cultivar was various for both groups of cultivars.

The most often isolated fungus from seeds, over cultivars, localities and years, was *A. alternata*, as often as *Penicillium* spp. from fodder cultivars, but for edible one the next was *S. botryosum* and *Penicillium* spp., both of homogenous group, of lower intensity, to which partly belonged also *A. pisi* (Tab. 4). The other species responsible

Table 2

Fungi found on seeds of tested cultivars during 2004-2006

No	Species	Years		
		2004	2005	2006
1	*Alternaria alternata* (Fr.) Keissler	+	+	+
2	*Ascochyta pisi* Libert	+	+	+
3	*Aspergillus flavus* Link	+	+	–
4	*Aspergillus niger* Tieg.	+	+	+
5	*Botrytis cinerea* Pers.: Fr.	+	+	+
6	*Chaetomium globosum* Kunze: Fr	+	+	–
7	*Cladosporium cladosporioides* Fres.	+	+	+
8	*Cladosporium herbarum* (Pers.: Fr.) Link	+	+	–
9	*Epicoccum purpurascens* Link	–	+	–
10	*Fusarium avenaceum* (Corda: Fr.) Sacc.	+	+	–
11	*Fusarium equiseti* (Corda) Sacc.	+	–	–
12	*Fusarium oxysporum* Schlecht.	+	+	+
13	*Fusarium poae* (Peck) Woll.	+	+	+
14	*Fusarium solani* (Mart.) Sacc.	+	+	–
15	*Fusarium* sp.	+	+	+
16	*Mucor hiemalis* Wehm.	+	–	+
17	*Mycosphaerella pinodes* (Berk. et Blox.) Vesterg.	+	+	–
18	*Papulaspora* sp.	+	+	–
19	*Penicillium claviformae* Bainier	+	–	+
20	*Penicillium expansum* Link: Fr.	+	+	+
21	*Phoma pinodella* (L.K.Jones) Morgan-Jones et Burch	+	+	–
22	*Rhizoctonia solani* Kühn	+	+	+
23	*Rhizopus stolonifer* (Ehrenb.: Fr.) Vuill. var. stolonifer	+	+	+
24	*Sclerotinia sclerotiorum* (Lib.) de Bary	+	+	+
25	*Stemphylium botryosum* Wallr.	+	+	+
26	*Trichocladium asperum* Harz	+	–	–
27	*Trichothecium roseum* Link	+	–	–
28	*Ulocladium atrum* Preuss	+	+	+
29	Non-sporulating fungi	+	+	+

Abbreviations: (+) a fungus occurred; (-) not occurred

Table 3
Analysis of variance for seed contamination of edible and fodder cultivars by majority of fungi species occurring over cultivars, localities and years

Source of variation	Four edible				Three fodder cultivars			
	D.f.	P-value (level of significans)		H. ns	D.f.	P-value (level of significans)		H. ns
Fungus	12	0.0000	significant	5	12	0.0000	significant	3
Locality	7	0.0000	significant	3	7	0.2249	non-significant	1
Cultivar	3	0.7071	non-significant	1	2	0.0003	significant	2
Year	2	0.0557	significant	2	2	0.0000	significant	3

Abbreviations: D. f. – degrees of freedom; H. ns– number of homogenous groups

Table 4
Multiple range test for different fungi species occurrence on seeds of both types of cultivars (a mean over cultivars, localities and years)

Fungi species	Cultivars			
	Four edible		Three fodder	
	percent (TP)	H. gr (5)	percent (TP)	H. gr (3)
Botrytis cinerea	1.34	a	3.94	a b
Rhizoctonia solani	1.84	a b	3.18	a
Fusarium solani	2.15	a b	2.00	a
Mycosphaerella pinodes	2.84	a b	2.82	a
Aspergillus spp.	2.88	a b	3.31	a
Fusarium spp.	3.12	a b	3.43	a
Phoma pinodella	3.19	a b	4.38	a b
Cladosporium spp.	4.06	b c	3.48	a
Fusarium poae	4.27	b c	3.97	a b
Ascochyta pisi	5.81	c d	4.22	a b
Penicillium spp.	6.79	d	7.81	c
Stemphylium botryosum	7.42	d	5.02	b
Alternaria alternata	10.92	e	8.49	c

Abbreviation: H.gr – homogenous groups

for *ascochyta* blight, *P. pinodella* and *M. pinodes,* occurred less frequently, being on similar level for both cultivar types, with lower percentage on edible for the first fungus. *Fusarium* spp. represented by *F. avenaceum, F. equiseti* and *F. oxysporum* inhabited less seeds compared to *F. poae* but more than *F. solani.* Infection by the last fungus was the lowest for fodder cultivars, while by *B. cinerea* for edible one.

When statistical analysis was done only for *A. alternata*, the species most often inhabiting seeds, and the specific pea pathogens, *M. pinodes* (syn. *Didymella pinodes* (Berk. et Blox.) Petrak) anamorph *Ascochyta pinodes* L. K. Jones)*, A. pisi* and *P. pinodella,* significant differences were found again for fungi occurring on seeds of both cultivar groups, and for edible – on localities, but for fodder – in years (Tab. 5).

A. alternata dominated, reaching respectively 10.29 and 8.33 percent, on edible and fodder cultivar seeds compared to species responsible for *ascochyta* blight, which were covered by second homogenous group (Tab. 6).

Localities influenced also seed contamination but statistically proved differences were noted only for edible cultivars both when majority of fungi and only

Table 5

Analysis of variance for seed contamination by *ascochyta* blight fungi and *Alternaria alternata* occurring on edible and fodder cultivars over cultivars, localities and years

Source of variation	Type of cultivars					
	Four edible			Three fodder		
	D.f.	P-value (level of significans)	H. ns	D.f.	P-value (level of significans)	H. ns
Fungus	3	0.0000 significant	2	3	0.0000 significant	2
Locality	7	0.0000 significant	4	7	0.3694 non-significant	1
Cultivar	3	0.8108 non-significant	1	2	0.2038 non-significant	1
Year	2	0.5157 non-significant	1	2	0.0096 significant	2

Table 6

Multiple range test for *ascochyta* blight fungi and *Alternaria alternata* frequency occurrence on both cultivar types independently on cultivar, locality and year

Species of fungi	Edible		Fodder	
	cultivars			
	Percent (TP)	H. gr	percent (TP)	H. gr
M. pinodes	1.23	a	2.40	a
P. pinodella	1.55	a	4.00	a
A. pisi	4.29	a	3.69	a
A. alternata	10.29	b	8.33	b

Table 7

Multiple range test for incidence of all fungi contaminating seeds and 4 species of fungi on four edible cultivars in 8 localities (a mean from fungi, cultivars and years)

Locality	Contamination by			
	all fungi		four fungi	
	Percent (TP)	H. gr (3)	Percent (TP)	H. gr (4)
Sulejów	2.21	a	0	a
Kościelna W.	2.61	a	0.98	a b
Chrząstowo	2.68	a b	0	a
Kawęczyn	3.59	a b	3.50	a b
Cicibór	4.29	b	4.71	b c
Rarwino	6.03	c	7.61	c d
Krzyżewo	6.31	c	8.61	d
Radostowo	7.11	c	10.51	d

A. alternata and *ascochyta* blight species were considered, being the highest at Radostowo, Krzyżewo and Rarwino (Tab. 7). At Sulejów and Chrząstowo no infection by fungi responsible for *ascochyta* blight was found.

Frequency of majority of fungi incidence on seeds of edible cultivars was statistically documented between years 2004 and 2005 compare to lower one, of hot and dry season 2006 (Tab. 8). Significant differences were also found for fodder cultivars both contaminated by all fungi with the highest in 2005 and the lowest in 2006, and also *A. alternata* and *ascochyta* blight species occurring more frequently in cooler and more humid seasons of 2004 and 2005 than in 2006.

Table 8

Multiple range test for incidence of fungi contaminating seeds of edible and fodder cultivars during years 2004-2006 (a mean from fungi, cultivars and localities)

Year	Cultivars					
	Edible		Fodder			
	all fungi		all fungi		four species	
	percent (TP)	H. gr (2)	percent (TP)	H. gr (3)	percent (TP)	H. gr (2)
2006	3.60	a	3.11	a	2.56	a
2004	4.73	b	4.28	b	5.21	b
2005	4.73	b	5.55	c	6.09	b

Table 9

Multiple range test for incidence of all fungi on 3 fodder cultivars (a mean from locality, year and fungal species)

Cultivar	Percent (TP)	H. gr
Sokolik	3.80	a
Zagłoba	4.00	a
Hubal	5.14	b

When inhabitance of cultivars over fungi, localities and years was analyzed statistically documented differences were only reported for fodder one (Tab. 3). Sokolik and Zagłoba were less contaminated by all fungi compare to Hubal (Tab. 9).

There were no significant differences between occurrence each of *ascochyta* blight fungi on seeds of both types of cultivars independently on cultivar, year and locality (Tab.6) but when separately the factors were considered Terno showed the highest infection in 3 out of 8 localities, reaching respectively, 20.22 percent in Cici-

Table 10

Occurrence frequency of *ascochyta* blight fungi on seeds of edible and fodder cultivars during 2004-2006 at different localities (full names are in table 1)

Infection percent of seeds in different localities and years																
Edible cultivars and their location								year	Fodder cultivars and their location							
C	KA	KW	K	R	RR	S	CH		C	KA	B	L	MR	M	TB	W
1.Ramrod									1. Hubal							
0.44	0.22	0	6.44	0.44	2.89	0	0	2004	1.78	0.22	0	0	1.11	0	2.22	0.22
0.22	0	0	0.66	0.44	2.99	0	0	2005	0	0.22	0	2.67	1.56	0	5.78	3.33
0	0	0	0	0.22	0	0	0	2006	0	0	0	0	0	0	0	0
2.Set								0.89	2.Sokolik							
1.33	0.89	0	17.56	5.11	0.67	0	0	2004	1.56	0	0	0	0.22	0	1.56	0
0	0.22	0	0	0	1.56	0	0	2005	0	0	0	0	1.11	0.88	2.0	1.11
0	0	0	0	0.22	0	0	0	2006	0	0	0	0	0	0	0	0
3. Tarchalska								0	3.Zagłoba							
0.67	0.44	0	7.11	0	0.22	0	0	2004	7.99	0	0.22	0.22	1.56	0	1.11	0
0	0	0.22	0	0.22	0	0	0	2005	0	0	0	1.11	0.88	0	0.66	2.22
0	0	0	0	0	0	0	0	2006	0	0	0	0	0	0	0	0
4. Terno								0.22								
20.22	2,89	2.44	19.11	12.4	0	0	0	2004								
0	0	0	0	0	3.12	0	0	2005								
0	0.22	0	0.22	0.22	0	0	0	2006								

bór, 19.11 in Krzyżewo and 12.4 in Radostowo (Tab. 10). Data were given as a sum of seed percent infected by *M. pinodes*, *A. pisi* and *P. pinodella.*

The second stronger infected was Set in Krzyżewo (17.56) and Radostowo (5.11). Such high infection was only observed on seeds harvested in 2004, but those of 2006 were almost clean, since only from single ones of Terno, Set and Ramrod fungi responsible for *ascochyta* blight were isolated. During three years no infection was noted on seeds from Chrząstowo and Sulejów, but the highest was found at Krzyżewo, Radostowo, Cicibór and Rarwino.

Seed infection of fodder cultivars by *M. pinodes*, *A. pisi* and *P. pinodella* was higher in 2004 than in 2005, and not observed in 2006 (Tab. 10). In general these cultivars were less infected to edible once, reaching on Zagłoba from 0.22 % in Bobrowniki and Lubinicko to 7.99 % in Cicibór. The highest percentage (5.78) of Hubal infection was noted in 2005 at Tomaszów B., the locality where *ascochyta* blight fungi occurred in 2004 and 2005, like similarly at Marianowo. These fungi were isolated only once from seeds harvested in Bobrowniki and Masłowice.

In the period of studies (2004-2006) seed infection by fungi responsible for *ascochyta* blight was very low (Fig. 1). *A. pisi* was isolated most often, independently on cultivars, years and localities totally 1.54 % of seeds, from 1.46 % in 2004 to 0.02 % in 2006 were infected. This species was the only one noted on seeds harvested in 2006. It dominated on seeds harvested in 2004, but in the next year *P. pinodella* was the most often isolated species.

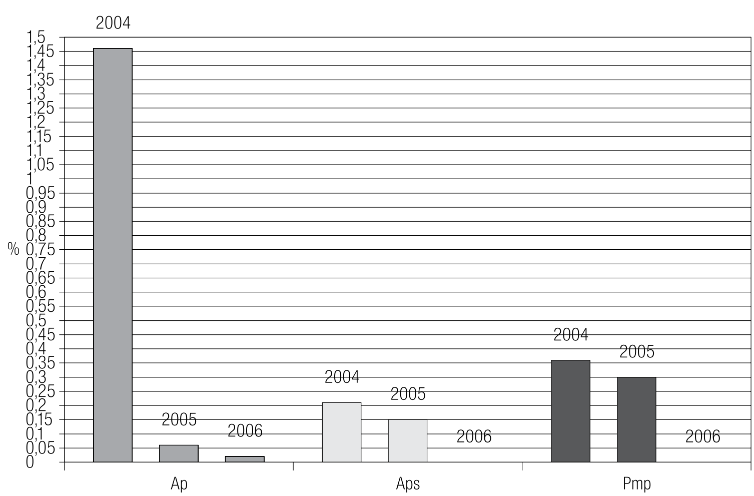

Fig. 1. Occurrence frequency (%) of *Ascochyta pisi* (Ap), *Mycosphaerella pinodes* (Aps) and *Phoma pinodella* (Pmp) on seeds over cultivars and localities from 2004-2006.

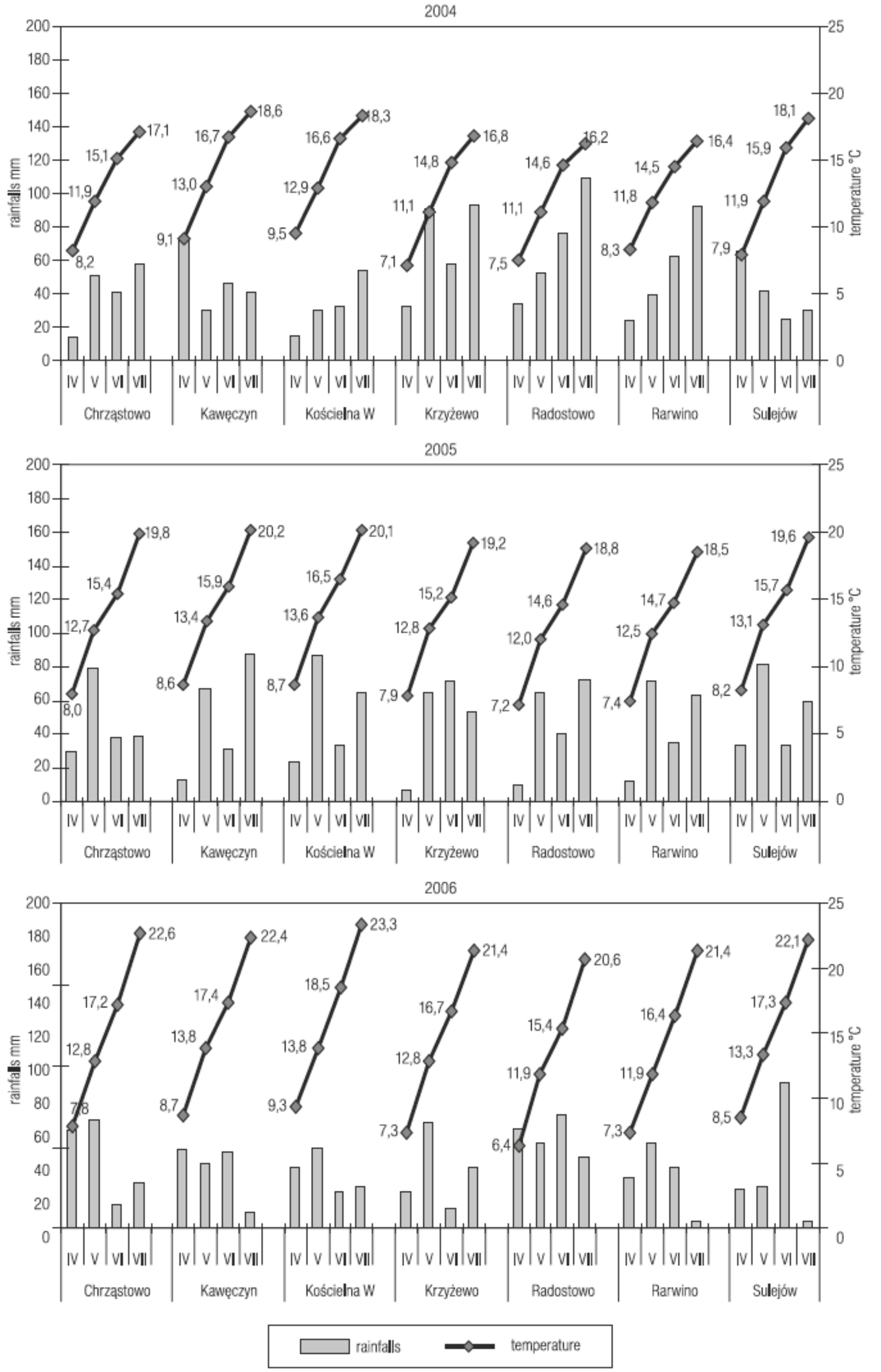

Fig. 2. Meteorological data at different localities, where edible cultivars were planted during 2004-2006 from April to July.

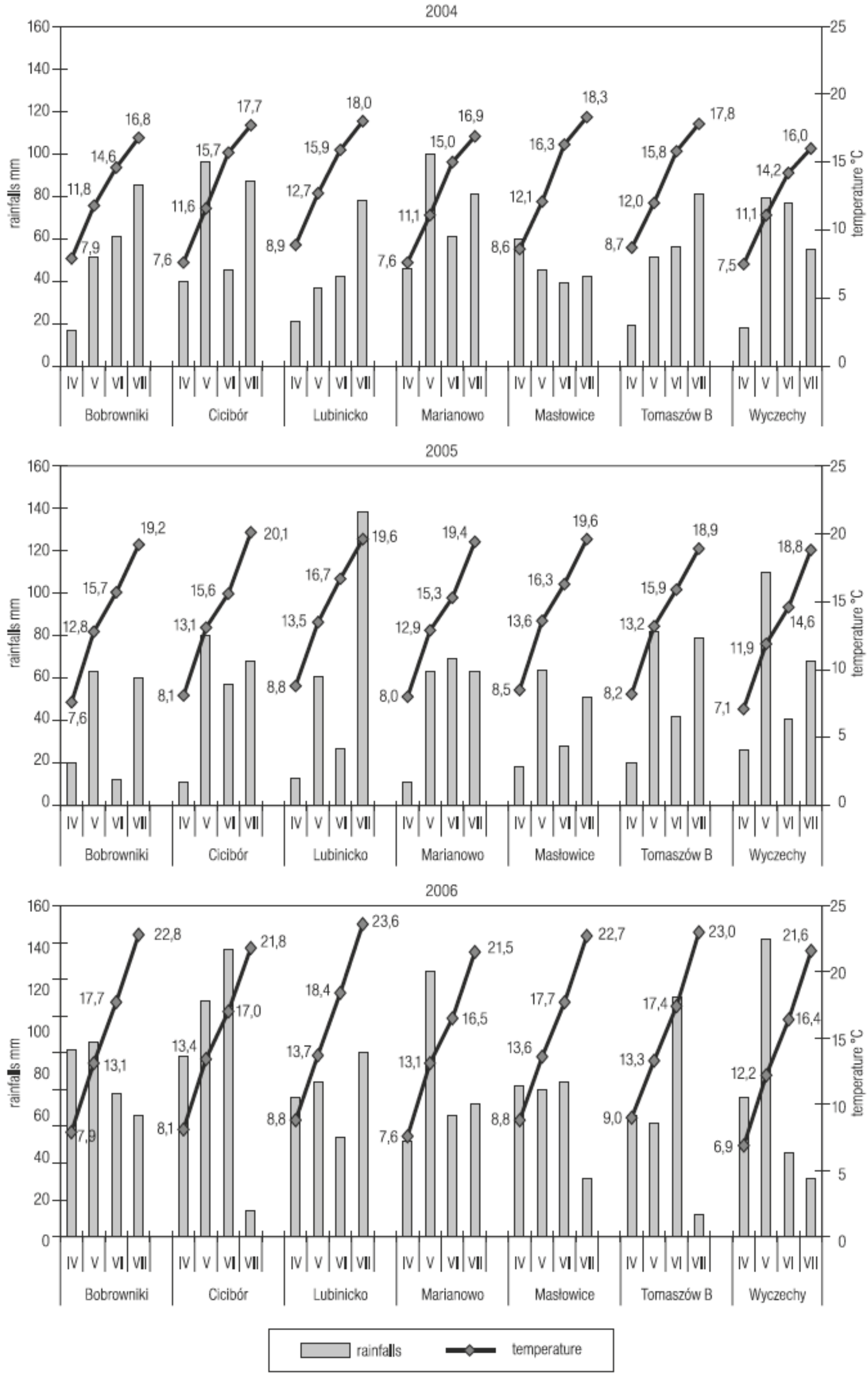

Fig. 3. Meteorological data at different localities, where fodder cultivars were planted during 2004-2006 from April to July.

DISCUSSION

Occurrence frequency of fungi inhabiting pea seeds was first of all depended on species. Seeds of all sample transmitted *A. alternata* and this species dominated among other fungi. The presented results supported the earlier obtained for field pea by Filipowicz (1976) and Marcinkowska (1997), green pea (Czyżewska 1976) and dry edible pea (Marcinkowska 1998). The next in this study were species of *Penicillium* with *P. expansum,* occurring in majority, but also *P. claviforme* contaminated many seeds. Filipowicz (1976) reported even more often *Penicillium* sp. than *A. tenuis* Nees (syn. *A. alternata*). Also Marcinkowska (1998) noted in 1992 common occurrence of *Penicillium* sp. Frequency of *Stemphylium botryosum,* weak polyphagous pathogen, the third more often inhabiting species, was similar to reported earlier (Grzelak, Iłłakowicz 1973; Marcinkowska 1997, 1998). It was important to notice that seeds were contaminated not only by *Penicillium* spp. but also *Aspergillus* spp., of which genera some species, like *A. flavus* and so *P. expansum* could be able to produce mycotoxins (Kozakiewicz 1990, 1992). So one had to realize the presence of those species on seeds as dangerous, but on the other hand not all isolates, even of harmful species could produce mycotoxins, and their amount might be also changeable depend on different factors, like temperature or light of environment.

Number of isolated species differed for various studies, Filipowicz (1976) reported the highest (30), the lowest (8) Grzelak and Iłłakowicz (1973), but in presented work were isolated 27, in 2004 - slightly cooler and of higher rainfalls, and 16 in 2006 of wormer and drier vegetation season (Figs 4, 5). Not only the number but also composition of species inhabiting seeds was influenced by weather conditions, particularly pea pathogenic fungi for which development a drop of water is necessary to infect a plant. Specific pathogens of peas, *ascochyta* complex fungi, were noted each season less frequently to common saprobe, *A. alternata,* like it happened for dry seeds in early 90.ties (Marcinkowska 1998). While on fall-planted Austrian winter pea, even *A. alternata* occurred very often, *P. pinodella* dominated in Poland on seeds in 1994 and *M. pinodes* in 1993 (Marcinkowska 1997), like in Canada (Morrall et al. 2005) and France in recent years (Fougereux et al. 2006). In Poland also Grzelak and Iłłakowicz (1973) and Filipowicz (1976) reported common occurrence of fungi responsible for *ascochyta* blight, but with the highest for *A. pisi.* These earlier results concern the last species frequency were supported by the recent data from Canada (Morrall et al. 2005) and the presented one, even level of seeds infected by *ascochyta* complex fungi was very low. *A. pisi*, took first place and was the only one out of three, however very sporadic, in the warmest growing season of 2006. On the other hand no significant differences were found between frequency of *M. pinodes, P. pinodella* and *A. pisi*, when they were compared to *A. alternata.* The level of seed infection by *M. pinodes* and *P. pinodella* in case of majority of species inhabiting was similar for both groups of cultivars, and lower comparing to *A. pisi.* The last species infected significantly more seeds of edible cultivars to fodder one. Even more to *F. poae,* the saprobic species of *Fusarium* inhabiting pea seeds most often. This domination was already proved by Filipowicz (1976) and Marcinkowska (1993, 1997, 1998). The number of isolated *Fusarium* species was lower to obtained by Filipowicz (1976) but the same as Marcinkowska (1993, 1997), however the prevalence of species varied between reports. Among pathogenic species Czyżewska (1976) and Filipowicz (1976) noted more often *F. oxysporum.* In this study was also found *F. solani* reported earlier on seeds of winter pea (Marcinkowska 1997).

Variability of mycobiota was influenced, besides fungal species and weather conditions of the growing season, also by characters of cultivars and environmental conditions of localities. The last factor was combined with local weather or even microclimate of field where peas were growing in different years. Particularly rainfalls increased frequency of fungi inhabiting seeds, so for locality characterized by higher precipitation and usually lower temperatures (Figs. 4 and 5) many more fungi were isolated. The influence of weather was also reported from other studies (Bathgate et al. 1989; Xue et al. 1997; Roger et al. 1999; Marcinkowska 1998, 2002; Morrall et al. 2005; Fougereux et al. 2006). Presented data supported positive (2005 and 2004) or negative (2006) influence of weather on seed infection by plant pathogens but also their inhabitance by saprobic species, especially on cultivars suitable for light soil.

Influence of cultivars on fungal species occurrence was proved by several authors (Filipowicz 1993; Fougeroux et al. 2006; Marcinkowska 1997, 1998, 2002; Xue et al. 1996). These data reported only such dependence considered all fungi on fodder cultivars. The obtained results supported the earlier reports cited here, done by different researches in various countries, that incidence of *ascochyta* blight fungi was influenced by many factors, changeable in between studies. According to Fougereux et al. (2006) and Morrall et al. (2006) these were mainly years, production area (localities) and type of crop (winter or spring pea).

CONCLUSIONS

1. Many more seeds were inhabited by saprobic fungi than plant pathogenic. Number of fungi occurring on edible and fodder cultivars depended mainly on fungal species and year.
2. *Alternaria alternate* was the most often occurring species on both types of cultivars, next was *Penicillium* spp.
3. *Stemphylium botryosum,* the weak pathogen, was isolated most often from seeds of both cultivar types compare to all other pathogenic fungi.
4. Fungi responsible for *ascochyta* blight infected seeds sporadically. They were recovered with various intensity from seeds of both types of cultivars. *Ascochyta pisi* was most often isolated.
5. No clear response of tested pea cultivars to *ascochyta* blight fungi occurrence on their seeds was found since host-plant reaction was strongly influenced by environmental conditions (locality and year).
6. Differences in seed contamination by any fungi species were only found for fodder cultivars.

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Występowanie grzybów na nasionach grochu polnego

Streszczenie

Zasiedlenie nasion 7 odmian grochu polnego przez różne gatunki grzybów oceniano w latach 2004-2006. Odmiany polskie: Ramrod, Set i Tarchalska, oraz czeska – Terno, wymagają do uprawy gleb żyźniejszych w porównaniu do paszowych: Hubala, Sokolika i Zagłoby, odpowiednich do uprawy na glebach lżejszych. Stąd każda z grup odmian uprawiana była w 8 miejscowościach, reprezentujących rejony uprawy grochu w Polsce, przy tym w 6 różnych, jedynie w Ciciborze i Kawęczynie były obydwa doświadczenia. Ze 168 próbek, każda 450 nasion, odkażonych powierzchniowo wyizolowano w teście szalkowym na pożywce Coon'a (CN), 27 gatunków w 2004, 22 w 2005 oraz 16 w 2006 roku. *Alternaria alternata* uzyskano z nasion wszystkich próbek, w największej liczbie. Kolejnym był *Stemphylium botryosum,* słaby patogen, gatunki rodzaju *Penicillium,* a zwłaszcza *P. expansum, Ascochyta pisi, Fusarium poae, Cladosporium* spp. Z gatunków chorobotwórczych najrzadziej infekował *Botrytis cinerea, Rhizoctonia solani, F. solani, Sclerotinia sclerotiorum.* Sprawcy zgorzelowej plamistości grochu, zwłaszcza *Mycosphaerella pinodes* (0.36%) i *Phoma pinodella* (0.66%) zainfekowały nieliczne nasiona, przy tym tylko *A. pisi* wystąpił we wszystkie 3 lata, osiągając średni najwyższy procent

porażenia (1.54) bez względu na odmiany i miejscowości. Te trzy gatunki w sumie porażały najsilniej odmianę Terno, zasiedlając najliczniej nasiona z Krzyżewa, Radostowa, Ciciboru i Rarwina. W Chrząstowie i Sulejowie w ogóle nie zanotowano sprawców askochytozy. Z odmian uprawianych na glebach lżejszych, Zagłoba wykazała najsilniejsze porażenie. Najwięcej sprawców zgorzelowej plamistości grochu izolowano z nasion zebranych w Tomaszowie Bolesławickim i Marianowie. Grzyby te nie poraziły nasion w 2006, najbardziej suchym i gorącym w okresie badań. Częstotliwość występowania grzybów zależała nie tylko od ich gatunku, co udowodniono statystycznie, ale w znacznej mierze od warunków otoczenia, na które wpływały warunki atmosferyczne pola uprawnego, a więc wskazane wyżej różnice dla miejscowości i lat, również często istotne. Najsilniej zasiedlone przez grzyby były nasiona zebrane w roku 2004, jak również w tym sezonie gatunki wystąpiły najliczniej. Cechy odmian, udowodnione tylko dla trzech o mniejszych wymaganiach glebowych, nie pozostawały bez wpływu na występowanie grzybów. Uzyskane wyniki wskazały, iż różne czynniki, ale w niejednakowym stopniu, zmieniały zasiedlenie nasion przez gatunki grzybów, tak porażających je jak i jedynie zanieczyszczających.