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CAN SELECTED SOIL FEATURES AND SOIL FUNGAL COMMUNITY INFLUENCE THE OCCURRENCE OF SUGAR BEET SEEDLING DAMPING-OFF?

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Abstract

Thirteen sugar beet fields were investigated in 2001. On three of them (L3, OP, D3) sugar beet was sown as a forecrop, on the others – wheat. Fungi were isolated from diseased seedlings and soil samples. Soils were tested for their infection potential in a laboratory pot test. Some soil features (pH, P, K and Mg content) affected the density of total soil fungi and the frequency of some pathogen groups (*Aphanomyces cochlioides*, *Fusarium* spp., *Rhizoctonia* spp., *Pythium* spp.) in diseased seedlings. Densities of particular soil fungal communities were not correlated with the number of infected seedlings either in the field or in the pot test. The infection rate in the pot test was positively correlated with the infection under field conditions. The field infection was correlated with the incidence of *A. cochlioides* in the field-diseased seedlings, showing that *A. cochlioides* was the main pathogen responsible for the sugar beet damping-off, although other pathogens were also identified.

Key words: sugar beet, *Aphanomyces*, *Pythium*, *Fusarium, Rhizoctonia,* damping-off, soil fungi

Introduction

Sugar beet seeds are precisely sown in March or April, when the soil is dry enough. A population of sugar beets more than 80,000 plants per 1 ha is necessary for the highest yield performance (Märländer et al. 2003), but every year damping-off causes damage in field crop (Harveson et al. 2002, Francis 2003). There are many pathogens responsible for the disease. Many authors have divergent opinion on the main pathogens responsible for sugar beet damping-off. Veverka (1975) announced that near Prague the main fungal pathogens causing sugar beet damp-

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ing-off were *Pythium* spp., *Fusarium* spp., *Phoma betae, Alternaria tenuis* and *Rhizoctonia aderholdi*. Other authors (Osińska 1971, 1984, Szymczak-Nowak 1987, Szymczak-Nowak and Banaszak 1994) reported that the main fungal pathogens were *Aphanomyces cochlioides, Pythium debaryanum* and *P. betae*. According to Szymczak-Nowak and Banaszak (1994) *A. cochlioides* was responsible for about 40% of dead seedlings. *Phoma betae* is dangerous when hyphae penetrate deep layers of seeds (Osińska 1984), especially if they are commonly contaminated with this fungus (Kowalik 1983). In Poland *Rhizoctonia solani* and *Fusarium oxysporum* were very rarely considered serious root rot pathogens (Osińska 1984, Kowalik 1983). In the case of *Fusarium* spp. (particularly *F. oxysporum*) their presence in rotten tissues can be combined with their great saprobic activity and possibility of secondary infections of tissues previously infected with other pathogens (Moliszewska 2000). Poor parasitic activity of many *F. oxysporum* strains, great number of saprobic isolates (Orlikowski 1989) and wide range of host plants for *Fusarium* spp. may confirm this opinion. First serious reports about *R. solani* as pathogen causing damping-off of sugar beet in Poland were published by Kowalik (1983). She pointed out that *R. solani* was becoming an important pathogen of seedlings in Poland. It contributed to about 15–80% of pre-emergence damping-off and a wide range (25–100%) of post-emergence damping-off of sugar beet seedlings depending on pathogenicity/virulence of individual strain and cultivar of *Beta vulgaris* (Kowalik 1983).

The distribution of pathogens in soil varies and depends on many factors, as e.g. chemical and physical properties of soil, crop rotation and soil fungal/microbial community. The crop rotation is of particualar importance especially in the case of soil pathogens, because of reduction of the risk of damping-off outbreak (Beale et al. 2002).

The aim of this work was to examine the main fungal pathogens causing sugar beet damping-off near Opole in Poland and the soil fungal community background, as well as looking for possible relationship between them and some soil properties.

Materials and methods

To avoid the effect of yearly weather changes the research was performed only in 2001, on a broad range of soil and seedlings samples: 13 fields located on the area near Opole (south-west Poland) were examined. Particular samples were taken from: samples L1–L6 – fields around the sugar factory in Lewin Brzeski, D1–D3 – fields in Dobrzeń Wielki, M – field near Prószków, Pp – field near Popielów, Op – field located in Opole Szczepanowice near the road Opole–Racibórz, Z – field near village Złotniki. The forecrop of most of them was wheat, and only a few have had sugar beet as a forecrop (L3, D3, Op).

Samples of soil and seedlings with damping-off symptoms were taken from mid-May to mid-June. In the field the average percentage of diseased seedlings was evaluated for each location. Soil samples were taken randomly from the depth of

2–10 cm. From seedlings with disease symptoms fungi and Oomycetes were isolated in the laboratory, using conventional phytopathological methods (Waller et al. 1998). Parts of particular diseased tissue were also prepared according to the Windels (2000) method for a quick examination of seedlings.

Mycological analysis was conducted also for each soil sample according to the soil plate method by Mańka (1974). Fungi were identified using mycological handbooks, keys and literature (Booth 1966, 1971, Domsch et al. 1980, Sutton 1980, Fassatiova 1983, Nelson et al. 1983, Kwaśna et al. 1991, Moliszewska 2002).

Soil samples were used in laboratory in a pot test to examine their conducive properties. Pots (150 cm^3) were filled with the soil, into each pot 10 non-coated sugar beet seeds cv. 'Janus' were sown and stored at room temperature with 17 h of light-darkness cycle (in three replications). They were watered to keep soil moist. The total number of seedlings and affected young plants were counted every few days in each pot. Finally, seedlings were delicately moved out and then their health condition was evaluated. From each diseased or dead plant fungi were isolated using the same methods described above.

Soil samples were tested for main chemical characteristics (pH, phosphorus, potassium, magnesium, Table 1).

Table 1

Selected characteristics of tested soils

Soil sample	Soil type	pH 1 N KCl	Content per 100 g of soil (mg)		
			P_2O_5	K_2O	Mg
L1	II	7.4	39.1	22.7	2.2
L2	II	7.4	45.0	15.8	3.4
L3	III	6.1	14.6	5.3	8.8
L4	II	7.3	36.0	8.2	3.8
L5	II	5.7	5.0	13.0	4.7
M	II	6.6	41.0	27.5	3.7
D1	III	5.1	8.1	15.6	8.1
D2	III	4.6	9.4	32.7	12.5
D3	III	4.3	7.2	14.4	16.6
L6	II	7.0	39.3	22.8	4.5
Op	II	5.1	2.2	5.4	8.0
Pp	III	4.9	2.8	11.6	8.9
Z	II	5.5	19.7	16.4	5.5

Results

The percentage of infected seedlings ranged from 5 to 80% for fields with sugar beet as a forecrop (L3, Op). These results were convergent with results of the pot tests (Figs. 1, 2). The main pathogens occurring in the diseased seedling tissues differed depending on the field location and in some cases it was difficult to indi-

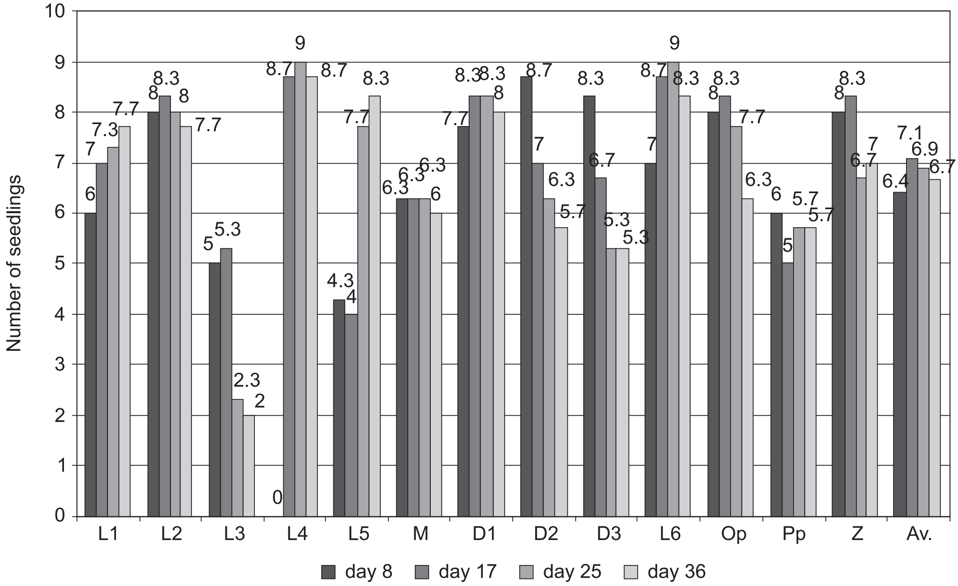

Fig. 1. The average number of sugar beet seedlings in pot test in selected time of observations

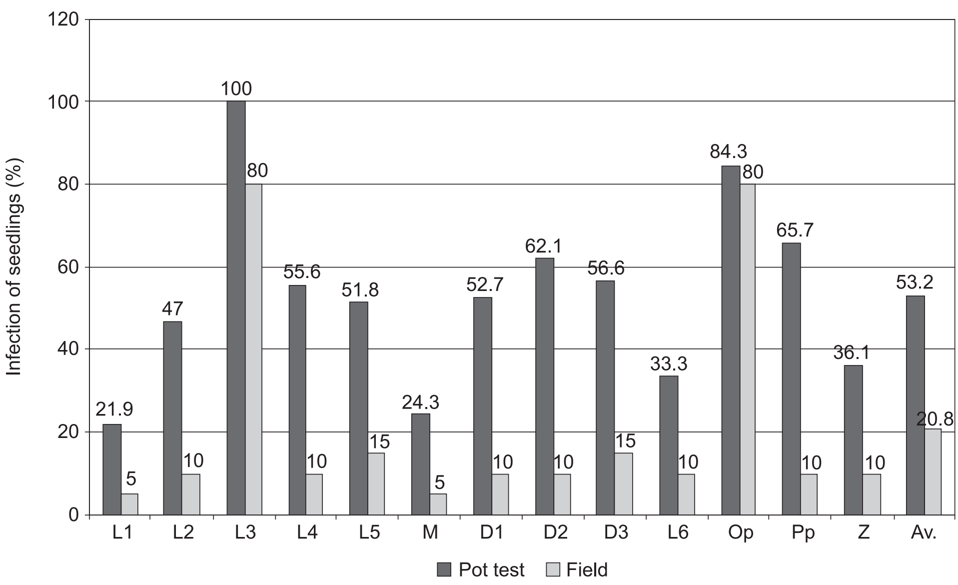

Fig. 2. Percentage of sugar beet seedlings with disease symptoms in the pot test and in the field; Av. – average data for the whole test

cate the main microorganism responsible for the disease. *Aphanomyces cochlioides* was the main pathogen isolated from the seedlings from the fields: L3, L5, M, D2, D3 and Op (Table 2). In the fields L5, D2 and Op it coexisted with *Pythium* spp. *Rhizoctonia* spp. were isolated from seedlings in six locations only. It seems that they were the main pathogens in the fields L1 and L2, and on the other fields but it was noticed together with *A. cochlioides* or with *Pythium* spp. (Table 2). Among *Rhizoctonia* spp. isolates there were mostly: *R. solani* AG 4 HGII, AG 5 as well as some binucleate isolates. Fungi belonging to the genus *Fusarium* were frequently isolated, especially *F. oxysporum* and *F. solani*. The high number of them was obtained for seedlings taken from the fields: M, D2, D3, Op. On field Z they were responsible for the disease together with *A. cochlioides*. Other fungal species were isolated rarely, although *Alternaria alternata* and *Cylindrocarpon didymum* were isolated from seedlings from the field Op more frequently than from the other fields (Table 2). The average number of fungi isolates per one seedling was 1.5. The lowest result was obtained for seedlings Pp (0.7) and the highest one – for D2 (3.9). Totally, 402 fungi and Oomycetes representing 37 species were isolated from 270 seedlings (Table 2).

The results obtained in the laboratory test were not uniform. *Aphanomyces cochlioides* was not a main cause of damping-off as it was noted in the field. It was isolated rarely but *Pythium* spp. were observed more frequently. In the pot tests 18 isolates of *Pythium* spp. were obtained as compared to 20 field isolates (Table 3). *Rhizoctonia* spp. were isolated only from seedlings grown in pots L3 and D2, their AGs were not determined. Among *Fusarium* spp. only *F. oxysporum* was abundant – isolated from eight experimental combinations, the most frequently it was observed on the Op-seedlings. In two cases (L2 and L4) *F. oxysporum* was not isolated either from the field obtained seedlings or from the soil (Tables 2, 3, 4). The genus *Cylindrocarpon* was represented by two species (*C. heteronema* and *C. didymum*), contrary to seedlings sampled from field. The average number of fungi isolates per one seedling in the laboratory test was 1.2. The lowest result was obtained for seedlings L4 and L5 (0.7) and the highest one – for L1 (1.8). In the test 107 seedlings were taken for pathogen isolation; 127 fungal and Oomycetes colonies representing 21 species were obtained (Table 3).

Seeds and seedlings in pots were exposed to pathogens activity, and determination of their effect was easier because seeds and seedlings were not protected (noncoated). The least number of seedlings was obtained in pots filled with soil L3 and all of them showed disease symptoms (Figs. 1, 2). The main pathogen were *Rhizoctonia* spp. as well as *F. oxysporum* and *F. solani*. Probably *P. ultimum* played also an important role in the disease development, especially in pre-emergence damping-off (Table 3). The highest number of seedlings were obtained in the case of soil L4, although 55.6% of them suffered from damping-off.

Seeds showed different pattern of germination, in pots L4 germination was retarded, but in pots L2, D2, D3, Op and Z most sprouts were developed within the first week of the experiment (Fig. 1). In the soil Op post-emergence damping-off was observed, and there was 84.3% of diseased plants (Fig. 2). In soils L1, L2, M,

Table 2

Fungi and Oomycetes isolated from field obtained seedlings

No.	Microorganism	Field location													
		L1	L2	L3	L4	L5	M	D1	D2	D3	L6	Op	Pp	Z	total
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	*Alternaria alternata*				1	2					2	10	2		17
2	*Aphanomyces cochlioides*			31		30	19		5	9		73	3	6	176
3	*Botrytis cinerea*			1								1			2
4	*Cladosporium elatum*				1										1
5	*Cylindrocarpon destructans*											1			1
6	*Cylindrocarpon didymum*			1								6			7
7	*Fusarium avenaceum*						1	1		2		1			5
8	*Fusarium chlamydosporum*											2			2
9	*Fusarium culmorum*	2		1	6	5			11	2				5	32
10	*Fusarium oxysporum*			2			6	2	13	8	1	25	2	7	66
11	*Fusarium poae*									3					3
12	*Fusarium sambucinum*		1		2	3	8	6		6		4	2		32
13	*Fusarium solani*	1	1				24			1		5		12	44
14	*Fusarium sporotrichoides*						1	2		1		1			5
15	*Fusarium tricinctum*					1	1		1	1					4
16	*Geotrichum* sp.											1			1
17	*Gliocladium catenulatum*					2				1					3
18	*Gliocladium roseum*				1	1					1	2			5
19	*Gliocladium solani*				2							1			3
20	*Mucor* sp.	1		1	1	3	4				1	4	1	9	25
21	*Oidiodendron* sp.											1			1
22	*Paecilomyces marquandii*											2			2

Table 2 – cont.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
23	*Penicillium* sp.									2		1			3
24	*Phoma betae*											2			2
25	*Pythium intermedium*											1			1
26	*Pythium irregulare*				5	3					1	2			11
27	*Pythium* sp.					1		3	1		2	1			8
28	*Rhizoctonia* spp.	5	5	4	2	3	1								20
29	*Sclerotinia sclerotiorum*			3		2						2			7
30	*Torula herbarum*				1	1									2
31	*Trichoderma aureoviride*					2									2
32	*Trichoderma hamatum*					1									1
33	*Trichoderma harzianum*		3												3
34	*Trichoderma koningii*												1		1
35	*Trichoderma pilulliferum*										1				1
36	*Trichoderma* sp.		1	1											2
37	*Verticillium dahliae*					1									1
Total number of fungi		**9**	**11**	**45**	**22**	**61**	**65**	**14**	**31**	**36**	**9**	**149**	**11**	**39**	**402**
Number of tested seedlings		**8**	**11**	**32**	**22**	**39**	**22**	**4**	**8**	**10**	**3**	**73**	**15**	**23**	**270**
Average number of fungi per one seedling		**1.1**	**1**	**1.4**	**1**	**1.6**	**2.95**	**3.5**	**3.9**	**3.6**	**3**	**2**	**0.7**	**1.7**	**1.5**

Table 3

Fungi and Oomycetes isolated from seedlings grown in pots

No.	Microorganism	Field location													
		L1	L2	L3	L4	L5	M	D1	D2	D3	L6	Op	Pp	Z	total
1	*Acremonium kiliense*						1								1
2	*Alternaria alternata*				1			1			3	1	2		8
3	*Aphanomyces cochlioides*			1				4		1		3	3		12
4	*Aureobasidium pullulans*				1										1
5	*Cladosporium macrocarpum*		1		1						2				4
6	*Cylindrocarpon didymum*		1	2	1										4
7	*Cylindrocarpon heteronema*											1			1
8	*Fusarium oxysporum*	2		5		4		3	2			9	1	2	28
9	*Fusarium sambucinum*	2					1			2					5
10	*Fusarium solani*			4								2			6
11	*Fusarium sporotrichoides*	1				2				2			2	1	8
12	*Gliocladium roseum*					1			4	1		6			12
13	*Humicola fuscoatra* var. *fuscoatra*							3							3
14	*Mucor* sp.			2			1								3
15	*Penicillium* sp.		1												1
16	*Pythium irregulare*	4		1			3						3	1	10
17	*Pythium rostratum*											2			2
18	*Pythium ultimum*			3					3						6
19	*Rhizoctonia* spp.			5					5						10
20	*Trichoderma pseudokoningii*									1					1
21	White non-sporulating hyphae							1							1
Total number of fungi		**9**	**3**	**23**	**4**	**7**	**6**	**12**	**14**	**7**	**5**	**24**	**11**	**4**	**127**
Number of tested seedlings		**5**	**7**	**14**	**6**	**10**	**4**	**7**	**12**	**9**	**3**	**17**	**9**	**4**	**107**
Average number of fungi per one seedling		**1.8**	**0.4**	**1.6**	**0.7**	**0.7**	**1.5**	**1.7**	**1.2**	**0.8**	**1.7**	**1.4**	**1.2**	**1**	**1.2**

Table 4

Fungi isolated from soil samples

No.	Microorganism	Field location													
		L1	L2	L3	L4	L5	M	D1	D2	D3	L6	Op	Pp	Z	total
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	*Acremonium butyri*													1	1
2	*Acremonium fusidioides*		6	2	1	2		2		1	2		1		17
3	*Acremonium kiliense*								4						4
4	*Acremonium luzulae*				2										2
5	*Acremonium murorum*		2	1	1	1	3								8
6	*Acremonium rutilum*		3	6	3		1			1		2	1		17
7	*Acremonium strictum*						3								3
8	*Acremonium tubakii*			1		4		1	12	2					20
9	*Amorphoteca resinae*													4	4
10	*Aspergillus* sp. 1		2		1		1		1	1	1	4	21		32
11	*Aspergillus* sp. 2			1					6	25					32
12	*Aspergillus sydowii*				1	3	3	4	3	7	1		2		24
13	*Aureobasidium pullulans*		1												1
14	*Chaetomidium fimetii*		4							11	1		2	2	20
15	*Chaetomium funicola*	7					2	2	2				1		14
16	*Chaetomium globosum*						9			4		4			17
17	*Chaetosphaeria vermicularioides*								1	1					2
18	*Chloridium virescens* var *virescens*					1									1
19	*Coniothyrium sporulosum*			1				11	3	25		2		8	50
20	*Cylindrocarpon willcommii*						1								1
21	*Cylindrophora* sp.				1										1
22	*Doratomyces microsporus*					4		2		3			1		10
23	*Emerciellopsis terricola*	8					1			11					20

Table 4 – cont.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
24	*Fusarium culmorum*				1		1				1				3
25	*Fusarium equisetii*			1				1		2					4
26	*Fusarium graminearum*							1			2				3
27	*Fusarium oxysporum*			1		6		6	4	26		5		6	54
28	*Fusarium redolens*								2						2
29	*Fusarium reticulatum*							1							1
30	*Fusarium sambucinum*		2			2								1	5
31	*Fusarium semitectum*										1				1
32	*Fusarium solani*		3	2		3		5	1	4	2	4		10	34
33	*Geotrichum candidum*											1		1	2
34	*Gliocladium roseum*		1	3	1	1		2	3		2	1	2	3	19
35	*Gliocladium solani*		1	1	2				2			1	1	1	9
36	*Gonatobortys* sp.							2						2	4
37	*Gonatorhodiella highlei*			1				1	1						3
38	*Gonytrichum caesium* var. *chloridoides*							1						1	2
39	*Gymnoascus reessii*	1		1			1				1		2		6
40	*Humicola fuscoatra* var. *fuscoatra*	1	17	13		9	1	4	7	8	16		21		97
41	*Humicola grisea* var. *grisea*	8	1	2	3	1		14	6	7	3		5	9	59
42	*Monilia acremonium*		1												1
43	*Monilia grisea*					1									1
44	*Monilia humicola*											1			1
45	*Mortierella alpina*					4	1								5
46	*Mortierella humilis*				5										5
47	*Mucor circinelloides* f. *circinelloides*					11									11
48	*Nectria inventa*	1	3								1				5
49	*Paecilomyces carneus*													1	1

Table 4 – cont.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
50	*Paecilomyces farinosus*			1		1		2		1	1	3		3	12
51	*Paecilomyces liliacinus*			1		1	1		4	3		5			15
52	*Paecilomyces marquandii*	1			1		1	1	1	1		3			9
53	*Paecilomyces variotti*						3	2	5	2			1		13
54	*Penicillium citrinum*							3	4						7
55	*Penicillium expansum*			1						1	1	3	1		7
56	*Penicillium griseofulvum*													1	1
57	*Penicillium* sp. 1	1	2	3		2		6	29	20	5	5	4	2	79
58	*Penicillium* sp. 2			1	1	3				1					6
59	*Penicillium* sp. 3			1		29								39	69
60	*Penicillium* sp. 4											2			2
61	*Penicillium* sp. 5		6							1		2	1		10
62	*Penicillium* sp. 6	13	2			2		4				1		5	27
63	*Penicillium* sp. 7			2		22									24
64	*Penicillium* sp. 8	17				2		3						27	49
65	*Penicillium* sp. 9								2						2
66	*Penicillium* sp. 10				2						6				8
67	*Penicillium* sp. 11	3													3
68	*Phialophora cyclaminis*							3							3
69	*Phoma eupyrena*		2			1	2	6			2				13
70	*Phoma exigua* var. *exigua*						11							9	20
71	*Phoma leveillei*	5			4	2			4	3	1		2		21
72	*Phoma lingam*								1						1
73	*Phoma pomorum*		3												3
74	*Plectosphaerella cucumerina*													2	2
75	*Pseudeurotium zonatum*			1					1						2

Table 4 – cont.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
76	*Pseudogymnoascus roseus*													1	1
77	*Rhizomucor pusillus*	4						9				5			18
78	*Rhizopus nigricans*	4		1	1				2				2	1	11
79	*Saccharomyces* sp.				1										1
80	*Scopulariopsis brumptii*								1				2		3
81	*Scytalidium lignicola*				1	2					2	1			6
82	*Stachybotrys atra*	6	1		1		2	1	1						12
83	*Stachybotrys chartarum*		1												1
84	*Trichocladium opacum*								2						2
85	*Trichoderma aureoviride*	2	2							4		1		2	11
86	*Trichoderma hamatum*	1	2			2	7	3			1	2		9	27
87	*Trichoderma harzianum*	15	5	3				13			4		6	8	54
88	*Trichoderma koningii*	2		8	1	1	1	6		9	4	5	6	14	57
89	*Trichoderma polysporum*			1	3					2		2			8
90	*Trichosporiella cerebriformis*		1												1
91	*Verticillium albo-atrum*					1								1	2
92	*Verticillium dahliae*										1				1
93	*Verticillium nigrescens*									1					1
94	*Wardomyces columbrinus*							2	1						3
95	Orange non-sporulating hyphae			1					1						2
96	Black non-sporulating hyphae					1							1		2
97	Red non-sporulating hyphae				1										1
98	White non-sporulating hyphae							1							1
Total number of fungi		**100**	**74**	**62**	**39**	**125**	**56**	**125**	**117**	**186**	**62**	**65**	**86**	**174**	**1 271**
cfu/g of soil × 10^4		**50**	**37**	**31**	**19.5**	**62.5**	**28**	**62.5**	**58.5**	**93**	**31**	**32.5**	**43**	**87**	**48.8**
The number of species		**19**	**25**	**28**	**23**	**30**	**21**	**33**	**31**	**30**	**24**	**24**	**22**	**29**	**98**

L6 and Z total number of diseased seedlings was lower than the average for the whole test (Fig. 2).

From the soil samples 1271 fungal colonies, representing 98 species, were isolated. The soils were colonized by the fungi to a variable degree, the number of colonies ranged from 39 to 186, the average number of fungal colonies per unit of soil sample (cfu) ranged from 19.5×10^4 to 93×10^4, and the species number ranged from 19 (L1) to 33 (D1) in the experimental soils. Saprobic fungi (*Trichoderma* spp., *Penicillium* spp., *Humicola* spp.) were obtained rarely especially from soil L4 and M (5.0×10^4 and 4.5×10^4 cfu/g of soil respectively), but they were frequent in the fields L1, L5, D1, D2, D3, Pp and Z (more than 20×10^4 cfu/g of soil). *Fusarium* spp. were represented by nine species in the soil samples, *F. oxysporum* and *F. solani* were the most frequent ones (Table 4).

Correlation coefficients were counted as it was shown in Table 5. Significant correlation (0.82) was found between seedling disease observed in the field and in the laboratory test. The relationship between field infection of sugar beet seedlings and the percentage of *A. cochlioides* isolates found in them was significant. This proved that the pathogen was the main one responsible for the seedling damping-off. Significant correlations were found for phosphorus (P), potassium (K) and magnesium (Mg) contents in the soil and the number of infected seedlings in the laboratory test. In the field only potassium content was correlated with the infected seedlings' number. The test showed that the increase of P and K as well as the decrease of Mg content could reduce seedling diseases. The same relationship was found for the total content of fungi in the soil (cfu) and Mg. The correlations betwen soil pH and total fungi content per 1 g of the soil, as well as for infection by *Fusarium* spp. were significant. The correlation was also significant for *Rhizoctonia*

Table 5

Correlation coefficients between some soil properties and selected biological features of fields ($\alpha = 0.05$); bold – data significant

Soil and field feature	pH	P_2O_5	K_2O	Mg	Cfu in soil	Saprobic cfu in soil*	Field infection (%)
Infection in test (%)	–0.44	**–0.64**	**–0.65**	**0.51**	–0.15	–0.24	**0.82**
Field infection (%)	0.18	–0.39	**–0.63**	–0.21	–0.28	–0.25	–
Cfu in soil	**–0.62**	–0.46	0.14	**0.52**	–	n.d.	–0.28
Saprobic cfu in soil*	–0.30	–0.28	0.09	0.07	**0.81**	–	–0.25
*A. cochlioides*** infection (%)	–0.50	–0.49	–0.16	0.49	0.11	–0.16	**0.61**
Fusarium spp.** infection (%)	**–0.54**	–0.23	**0.64**	**0.54**	0.43	0.08	–0.30
Rhizoctonia spp.** infection (%)	**0.66**	**0.57**	0.10	**–0.51**	–0.17	0.02	–0.15
Pythium spp.** infection (%)	0.12	0.13	0.17	–0.12	–0.14	–0.06	–0.20
No. of isolates per one seedling*	–0.49	–0.21	**0.55**	**0.55**	0.37	–0.01	–0.15

*Saprobic fungi: *Trichoderma* spp. + *Penicillium* spp. + *Humicola* spp.
**Data found in the field.
n.d. – no data.

spp. infection of seedlings, but showed the tendency to increase the disease process together with the increase of soil pH, as well as the P content in the soil. The increase of K and Mg contents in the soil could stimulate the infections by *Fusarium* spp. and the number of fungi isolated from one diseased seedling (Table 5).

Discussion

Considering the soil fungal communities, isolated and identified in the work, there were few correlations found for fungal community density and selected soil or disease characteristics, although all tested soils showed great differentiation in the number of species and fungal colonies. The positive correlation was found in the case of total fungal communities and selected saprobic communities (*Trichoderma, Penicillium, Humicola*) as well as for Mg content. The negative correlation was obtained for total fungal density and soil pH. Current research showed that the soil pH decrease can favour fungi development in total as well as the seedling infections by *Fusarium* spp. Soil fertilization gives also some possibilities to suppress or promote development of some groups of fungi. Fertilizers must be used according to plant requirements, soil analysis and give balanced nutrient status. Potassium (K) is the one of the molasseigenic substances with the average demand 330 kg/ha for sugar beet, the demand for Mg is 50 kg/ha and for P – 35 kg/ha to obtain a root yield about 60 t/ha (Märländer et al. 2003). Simultaneously, these elements show some possibilities to affect infection as it was proved in the pot test.

Most of the fields had a wheat as a precrop. The investigations by Pięta et al. (2000) showed the greatest number of antagonistic microorganisms in the soil after winter wheat cultivation, although the number of total fungi colonies was the lowest and the number of soil pathogens was two times smaller comparing to the other crops. This results confirmed that from the point of view of infection threat, wheat was a suitable forecrop for sugar beet (Märländer et al. 2003). Also Kurowski et al. (1990) proved that in sugar beet monocultured soil and in the soil with high fertilization fungal colonies were about 50% more numerous than in the case of standard fertilization and rotation. They found that monoculture resulted in higher level of damping-off (14–43%) and in greater diversity in total fungi isolates from seedlings. The fungi isolated most frequently from seedlings were: *F. oxysporum*, *R. solani* and *Penicillium* spp. (Kurowski et al. 1990). Kowalik (1987) claimed that *A. tenuis*, *F. oxysporum*, *P. betae*, *R. solani*, as well as *F. solani* were fungal pathogens causing sugar beet damping-off. She affirmed lack or poor possibility of soil fungal community to suppress the pathogen activity.

Pythium spp. and *A. cochlioides* were not recorded by Kurowski et al. (1990) and Kowalik (1987) as agents causing sugar beet damping-off. *Pythium* spp. was found both in seedlings taken from the field and in those grown in pots. Species belonging to this genus are known as polyphagous pathogens of early stages of plant development (Payne et al. 1994, Amein 2006). They prefer soils with low pH, but Payne et al. (1994) found no relationship between soil texture and cropping intervals and their occurrence. In current investigations no relationships were found between soil properties and *Pythium* spp. occurrence, although it was more frequent in seedlings originating from acidic soils. *Pythium* spp. was frequently found here together with *A. cochlioides*, similarly as by other researchers (Payne et al. 1994, Piszczek 2004, Amein 2006). Some saprobic fungi, as *Trichoderma* spp. have suppressive properties against soil pathogens (Kuter et al. 1983, Pięta and Patkowska 2003). No relationship was found between total number of isolates and the number of selected saprobic isolates from soil, and 1) infection rate of seedlings in the field or laboratory, and 2) infection caused by particular pathogens (*A. cochlioides, Fusarium* spp., *Rhizoctonia* spp. or *Pythium* spp.). This confirms the findings of Kowalik (1987) and Kurowski et al. (1990). Manici et al. (2003) affirmed that colonization frequency of apple seedlings by pathogens was negatively correlated with total soil fungi while total fungi in soil were highly correlated with growth score of apple seedlings. Zachow et al. (2008) tested microbial communities from the nearest environment of the sugar beet root and showed that indigenous antagonistic potential was influenced by the location of the field and the microenvironment and it was highly specific for each target pathogen, the majority of antagonistic microorganisms suppressed only one pathogen. Only very few isolates harbor a broad antagonistic range (Zachow et al. 2008), this results explain the lack of antagonistic possibilities for broad soil fungal communities in this study.

Significant correlation (0.82) found between seedling disease observed in the field and in the laboratory test confirms the usefulness of the laboratory tests for determination of soil infection potential. Pathogens isolated from field-obtained seedlings and from pot-obtained seedlings were not identical but for two soils, L3 and Op, yet a very high percentage of diseased plants was denoted both in the field and in the pot test. It seems that, if the infection in the pot test is lower than 25% (with the soil in pots more damp than in the field), the soil offers quite safe conditions for growing sugar beet seedlings.

Conclusions

1. Soil fungal communities (total isolates and selected saprobic ones) could not influence the level of field or laboratory infection of sugar beet seedlings or infection caused by particular pathogens, *A. cochlioides, Fusarium* spp., *Rhizoctonia* spp. or *Pythium* spp.

2. The laboratory pot tests are a good method to determine infection potential of soil.

3. The main pathogen responsible for the damping-off of sugar beet in the field was *A. cochlioides*, although *Fusarium* spp., *Rhizoctonia* spp. and *Pythium* spp. were also isolated from the diseased seedlings.

4. The fertilization (P, K, and Mg) and soil pH can affect density of soil fungi communities and the main groups of pathogens (*Aphanomyces cochlioides, Fusarium* spp., *Rhizoctonia* spp., *Pythium* spp.) isolated from the diseased seedlings.

Streszczenie

CZY WYBRANE CECHY GLEBY ORAZ ZBIOROWISKA GRZYBÓW GLEBOWYCH MOGĄ WPŁYWAĆ NA WYSTĘPOWANIE ZGORZELI SIEWEK BURAKA CUKROWEGO?

Badania polowe i laboratoryjne przeprowadzono w 2001 roku na 13 polach, na których uprawiano buraki cukrowe. W trzech przypadkach (L3, OP, D3) przedplon stanowiły buraki, w pozostałych pszenica. Z chorych siewek oraz z gleby izolowano grzyby. Próbki gleby zostały także wykorzystane w teście wazonowym do określenia indywidualnych potencjałów inokulacyjnych tych gleb. Stwierdzono, że pH oraz poziom fosforu, potasu i magnezu mogą oddziaływać na liczebność populacji grzybów glebowych, a także na niektóre grupy patogenów siewek (*Aphanomyces cochlioides*, *Fusarium* spp., *Rhizoctonia* spp., *Pythium* spp.). Liczebność grzybów glebowych nie była skorelowana z porażeniem siewek w polu ani w teście wazonowym. Stwierdzono dodatnią korelację między porażeniem siewek w doświadczeniu laboratoryjnym i polowym. Porażenie siewek w doświadczeniu polowym było dodatnio skorelowane z procentowym udziałem *A. cochlioides* wśród wszystkich patogenów. Dowodzi to, iż ten patogen był głównym sprawcą powschodowej zgorzeli siewek w polu.

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