

PATHOGENIC SOILBORNE FUNGI OF ONION CULTIVATED AFTER COVER CROPS: SPRING RYE AND COMMON VETCH

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Abstract. The purpose of the studies was to determine the occurrence of soilborne fungi pathogenic towards onion cultivated after spring rye and common vetch. The objects of the studies were the seedlings of onion 'Wolska' cv and the isolates of the following fungi: *Fusarium culmorum*, *F. oxysporum*, *F. solani*, *Penicillium verrucosum* var. *cyclopium*, *P. verrucosum* var. *verrucosum* and *Pythium irregulare*. As a result of the growth chamber studies it turned out that the fungi used in the experiment were pathogenic towards onion. The harmfulness of the studied fungi varied both between the species and between the isolates within the species. *P. verrucosum* var. *cyclopium* and *F. culmorum* proved to be the most harmful since the smallest number of onion plants grew in those experimental combinations and they were the least infected. The most onion plants with the smallest proportion of the infected ones were found in the combination with *F. oxysporum*.

Key words: pathogenic fungi, onion, spring rye, common vetch

INTRODUCTION

Common onion (*Allium cepa* L.) is threatened with infection caused by different pathogenic microorganisms. As early as in the growth phase it can be infected by pathogenic fungi belonging to *Botrytis* spp., *Fusarium* spp., *Penicillium* spp. and *Pythium* spp. [Abawi and Lorbeer 1971, Bruckart and Lorbeer 1982, Schwartz and Mohan 1996, Lorbeer 1997, Pięta et al. 2004]. The main place where these pathogens colonize is the soil [Booth 1971, Nelson et al. 1983, Raper et al. 1968, Ramirez 1982]. It follows from earlier studies conducted by Pięta and Kęsik [2005] that the soil after spring rye and common vetch was colonized by antagonistic microorganisms. The populations of

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those microorganisms were represented by *Bacillus* spp., *Pseudomonas* spp. and the isolates of *Trichoderma hamatum* and *T. koningii*. On the other hand, there is no information on the occurrence of pathogens in the soil and their harmfulness towards common onion cultivated after spring rye and spring vetch. Hence, the authors undertook the studies signaled in the title.

MATERIAL AND METHODS

The objects of the studies conducted in the years 2004-2005 were such fungi as *Fusarium culmorum*, *F. oxysporum*, *F. solani*, *Penicillium verrucosum* var. *cyclopium*, *P. verrucosum* var. *verrucosum* and *Pythium irregulare* isolated from the plough layer of the soil. The enumerated species were obtained from the soil samples taken from the plots where onion was cultivated in different combinations, i.e. after spring rye and common vetch as cover plants. Those plants were in the experimental combinations presented in table 1.

Table 1. Fungi isolated from the soil (total from the years 2004 and 2005)
Tabela 1. Gatunki grzybów wyizolowane z gleby (ogółem z lat 2004 i 2005)

Fungus species Gatunek grzyba	Kombinacje doświadczenia – Experimental combination							Total number Razem liczba (%)
	1	2	3	4	5	6	7	
<i>Fusarium culmorum</i> (W.G.Sm.) Sacc.	3	5	3	4	7	2	9	33 (6.0)
<i>Fusarium oxysporum</i> Schl.	31	17	25	24	27	28	19	189 (34.7)
<i>Fusarium solani</i> (Mart.) Sacc.	5	5	1	4	3	20	6	44 (8.1)
<i>Penicillium verrucosum</i> Dierckx var. <i>cyclopium</i> (West.) Samson, Stolk et Hadlok	15	50	5	35	5	10	10	130 (23.8)
<i>Penicillium verrucosum</i> Dierckx var. <i>verrucosum</i> Samson, Stolk et Hadlok	6	5	5	60	5	3	15	99 (18.2)
<i>Pythium irregulare</i> Baisman	5	4	9	8	9	5	4	50 (9.2)
Total – Razem	65	86	48	135	56	92	63	545 (100.0)

1 – mulch of spring rye + direct onion sowing, 2 – mulch of spring rye + disc harrowing in spring and onion sowing, 3 – mulch of spring rye + disc harrowing in autumn and onion sowing, 4 – mulch of common vetch + direct onion sowing, 5 – mulch of common vetch + disc harrowing in spring and onion sowing, 6 – mulch of common vetch + disc harrowing in autumn and onion sowing, 7 – traditional cultivation

1 – mulcz żyta jarego + bezpośredni siew cebuli, 2 – mulcz żyta jarego + talerzowanie wiosną i siew cebuli, 3 – mulcz żyta jarego + talerzowanie jesienią i siew cebuli, 4 – mulcz wyki siewnej + bezpośredni siew cebuli, 5 – mulcz wyki siewnej + talerzowanie wiosną i siew cebuli, 6 – mulcz wyki siewnej + talerzowanie jesienią i siew cebuli, 7 – uprawa tradycyjna

In order to determine the pathogenicity of the aforementioned species, 15 isolates from each species were considered (tab. 1). The experiment was conducted in the conditions of a growth chamber, where the temperature of the day, which lasted 16 hours,

was 22–24°C (with light intensity of 2000 Lux) and the temperature at night was 18–20°C. The relative humidity of the air ranged from 70 to 85%. ‘Wolska’ cv. onion seeds were sown into pots filled with the soil overgrown with the mycelium of a single isolate of a given species. The infection mixture was prepared according to the method by Noll [Łacicowa 1969]. Each fungus isolate was examined in four replications (four pots). Onion seedlings grew from the seeds sown to sterile soil constituted the control. One hundred seeds were sown into each pot. Four weeks after setting the experiment the number of the grown seedlings was established, and after they were removed from the pots their healthiness was determined applying a five-degree infection scale, i.e. 0° – no disease symptoms, 1° – necrosis up to 10% of the root and the cotyledons area, 2° – necrosis up to 25% of the root and the cotyledons area, 3° – necrosis up to 50% of the root and the cotyledons area, 4° – necrosis on more than 50% of the root and the cotyledons area. The disease index was established on the basis of the degree of infection for each isolate of the studied fungi species according to McKinney’s formula given by Łacicowa [1969].

RESULTS AND DISCUSSION

Results of the mycological analysis of the soil showed that numerous fungi used for the growth chamber studies were obtained from all samples (tab. 1). *F. oxysporum* was the most numerous since its isolates constituted 34.7% of all the colonies. This fungus is commonly found in the soil due to its considerable tolerance to the environmental conditions and big competitive properties towards other microorganisms [Booth 1971, Ramsey and Lorbeer 1980]. Other *Fusarium* spp. such as *F. culmorum* and *F. solani* were also obtained from the examined soil samples. The colonies of those fungi constituted 6.0% and 8.1% of all isolates, respectively (tab. 1). Earlier studies conducted by Pięta et al. [1998] showed that those species not only colonized the soil more rarely but they also had a smaller share in the infection of bulb onion and shallot as compared to *Fusarium oxysporum*.

Besides, *Penicillium verrucosum* var. *cyclopium* (syn. *P. cyclopium*) and *Penicillium verrucosum* var. *verrucosum* (syn. *P. verrucosum*) were also frequently isolated from the soil where onion was cultivated (in the combinations after spring rye or common vetch) (tab. 1). According to Łacicowa [1978], *Penicillium* spp. constituted a considerable threat not only for onion but for all onion plants as well. Both *Fusarium* spp. and *Penicillium* spp. infected onion during the plants’ growth and during the storage [Saaltink 1971, Schwartz and Mohan 1996, Pięta et al. 1998]. Besides, *Pythium irregulare*, which is especially harmful to the sprouting seeds and the young onion plants, was isolated from the soil [Schwartz and Mohan 1996].

Results obtained from the growth chamber experiment pointed to varying harmfulness of both the studied species and particular isolates of those fungi. The harmfulness was established on the basis of the number of the grown plants and their healthiness (tab. 2, 3, 4). Healthy seedlings were obtained from the control combination from all onion seedlings. Generally, the smallest number, on average 79.6 onion seedlings, grew from the experimental combination where the soil overgrown with *P. verrucosum* var.

cyclopium was used (tab. 2). On the other hand, the highest number, which was on average 89.9 seedlings, grew in the combination with *F. oxysporum*.

Table 2. Mean of number seedlings onion growing in particular experiments combination
Tabela 2. Średnia liczba siewek cebuli wyrosłych w poszczególnych kombinacjach doświadczenia

Number of isolates Numer izolatu	Fungus species – Gatunek grzyba						mean średnia
	<i>F. culmorum</i>	<i>F. oxysporum</i>	<i>F. solani</i>	<i>P. verrucosum</i> var. <i>cyclopium</i>	<i>P. verrucosum</i> var. <i>verrucosum</i>	<i>P. irregulare</i>	
1	81.5	75.0	85.5	90.0	90.0	78.5	83.4
2	84.0	90.0	84.5	80.0	91.0	82.0	85.2
3	91.0	89.5	86.0	71.5	89.5	80.0	84.6
4	96.0	96.0	93.0	78.5	87.0	88.5	89.8
5	72.5	98.0	86.5	89.0	86.0	84.0	86.0
6	68.5	89.0	92.0	88.0	94.0	82.5	85.7
7	76.5	90.0	93.0	88.0	90.0	87.5	87.5
8	90.0	95.5	90.5	85.5	91.5	78.5	88.6
9	60.5	90.5	89.5	85.0	90.5	76.5	82.1
10	98.0	93.0	91.0	83.0	80.5	83.0	88.1
11	72.5	97.0	88.0	72.5	86.5	78.0	82.4
12	56.5	88.5	80.5	80.0	87.0	79.5	78.7
13	98.0	95.0	89.0	65.5	79.0	85.0	85.2
14	70.5	92.5	65.5	70.0	75.5	71.0	74.2
15	90.0	69.5	60.5	67.5	67.5	84.0	73.2
Mean – Średnia	80.4	89.9	85.0	79.6	85.7	81.2	83.6

Table 3. Mean of number seedlings disease onion growing in particular experiments combination
Tabela 3. Średnia liczba porażonych siewek cebuli wyrosłych w poszczególnych kombinacjach doświadczenia

Number of isolates Numer izolatu	Fungus species – Gatunek grzyba						mean średnia
	<i>F. culmorum</i>	<i>F. oxysporum</i>	<i>F. solani</i>	<i>P. verrucosum</i> var. <i>cyclopium</i>	<i>P. verrucosum</i> var. <i>verrucosum</i>	<i>P. irregulare</i>	
1	4.5	18.0	4.5	17.5	13.5	12.0	9.7
2	11.5	8.0	8.5	15.5	14.0	9.0	11.1
3	16.5	9.5	7.0	7.5	15.0	5.5	10.2
4	9.0	5.5	3.0	6.0	17.5	5.0	7.8
5	2.5	1.5	5.0	21.5	15.5	6.5	8.8
6	3.5	9.5	2.0	31.0	3.5	7.0	9.4
7	2.5	11.0	2.5	20.5	9.0	5.5	8.5
8	3.5	3.5	2.5	8.5	5.5	20.5	7.3
9	5.5	12.0	4.5	40.5	16.0	15.0	15.6
10	7.5	6.5	3.5	2.5	4.5	5.5	5.0
11	12.0	4.5	6.5	19.5	16.5	14.0	12.2
12	7.0	9.0	12.5	39.5	4.0	14.5	14.4
13	17.5	7.5	7.5	2.5	6.5	6.0	8.0
14	14.0	3.0	20.0	32.5	15.0	7.5	15.3
15	15.0	15.5	18.0	8.0	22.5	7.0	14.3
Mean – Średnia	8.8	8.3	6.5	18.2	11.9	9.4	10.5

Table 4. Disease index of plants

Tabela 4. Indeks porażenia roślin

Number of isolates Numer izolatu	Fungus species – Gatunek grzyba						mean średnia
	<i>F. culmorum</i>	<i>F. oxysporum</i>	<i>F. solani</i>	<i>P. verrucosum</i> var. <i>cyclopium</i>	<i>P. verrucosum</i> var. <i>verrucosum</i>	<i>P. irregulare</i>	
1	26.3	32.3	18.7	14.7	13.1	36.5	23.6
2	21.7	14.1	24.5	28.3	16.4	12.3	19.5
3	11.4	17.8	20.3	45.3	17.3	24.5	22.7
4	7.9	8.8	8.4	20.4	28.9	7.3	13.6
5	32.1	3.5	17.2	6.8	32.4	18.8	18.5
6	43.5	19.3	4.8	11.9	8.1	23.6	18.5
7	36.8	28.4	5.8	8.3	19.1	8.7	17.8
8	12.4	6.1	7.9	17.6	7.3	41.5	15.5
9	53.7	31.7	19.1	18.9	28.1	36.7	31.4
10	4.8	12.1	16.4	28.7	4.8	18.5	14.2
11	37.8	7.2	28.7	41.2	21.3	38.4	29.1
12	55.8	19.8	39.9	28.9	9.1	40.1	32.3
13	3.4	27.3	24.5	53.6	17.9	17.2	24.0
14	48.3	9.1	48.7	39.7	32.6	32.9	35.2
15	16.9	40.3	54.9	48.7	45.8	28.3	39.2
Mean – Średnia	27.5	18.5	22.7	27.5	20.1	25.7	23.7

Analyzing particular isolates of the studied fungi species it can be stated that from 56.5 to 98.0 seedlings grew from the combination with *F. culmorum*, from 75.0 to 98.0 from the combination with *F. oxysporum* and from 60.5 to 93.0 onion seedlings – from the combination with *F. solani* (tab. 2). In the case of *P. verrucosum* var. *cyclopium* and *P. verrucosum* var. *verrucosum*, the number of the seedlings that grew ranged from 65.5 to 91.5, while in the experimental combination with *P. irregulare* the number ranged from 71.0 to 88.5 seedlings. According to Schwartz and Mohan [1996], this fungus is especially harmful towards onion seedlings. After four weeks' growth of plants in each combination there occurred seedlings with necrotic symptoms on the roots and the cotyledons (phot. 1, 2, 3). The necrosis was the same in all experimental combinations. The highest average number, namely 1.8 diseased seedlings, was found in the combination with *P. verrucosum* var. *cyclopium*, while the lowest – 6.5 diseased seedlings – in the combination with *F. solani* (tab. 3). The mean numbers of diseased seedlings in the case of *F. culmorum* and *F. oxysporum* were similar and they were 8.8 and 8.3, respectively. The calculated disease index considering the degrees of root and cotyledons infection was differentiated both between the species and between the isolates within a species. The most visible necrosis was found in the combinations with *F. culmorum* and *P. verrucosum* var. *cyclopium*, since the mean disease index was the highest and it was 27.5 (tab. 4). The lowest value of the disease index was observed in onion seedlings in the combination with *F. oxysporum*.

Results of laboratory tests showed that the studied species proved to be less or more pathogenic towards onion seedlings. It should be supposed that with repeated cultivation of onion in the field where those fungi occur greater infection of onion can occur. According to Pięta et al. [1998], Schwartz and Mohan [1996], *F. culmorum*, *F. oxysporum*, *F. solani*, *P. verrucosum* var. *cyclopium* and *P. verrucosum* var. *verrucosum* develop in the infected onion tissues both during the growth period and during the storage, causing great losses.



Photo 1. Damping-off of the onion germs after artificial inoculation by *Penicillium* spp.
Fot. 1. Zgorzel kielków cebuli w wyniku sztucznej inokulacji *Penicillium* spp.



Photo 2. The necrosis of onion seedlings roots after artificial inoculation by *Fusarium* spp.
Fot. 2. Nekroza korzeni siewek cebuli w wyniku sztucznej inokulacji *Fusarium* spp.



Photo 3. The onion seedlings infected by soilborne fungi
Fot. 3. Siewki cebuli porażone przez grzyby przeżywające w glebie

Antagonistic microorganisms such as *Bacillus* spp., *Pseudomonas* spp. and *Trichoderma* spp. occurred in the soil after the cultivation of spring rye and common vetch [Pięta and Kęsik 2005]. It should be expected that the activity of those antagonists in the soil will limit the development of onion pathogens.

CONCLUSIONS

Fungi *Fusarium culmorum*, *F. oxysporum*, *F. solani*, *Penicillium verrucosum* var. *cyclopium*, *P. verrucosum* var. *verrucosum* and *Pythium irregulare* caused worse emergences and healthiness of onion seedlings.

The disease symptoms in the form of necrosis of the root and the cotyledons caused by the studied fungi were similar.

Penicillium verrucosum var. *cyclopium* and *Fusarium culmorum* proved to be the most harmful towards four-week-old seedlings, while *F. oxysporum* – the least.

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GRZYBY PATOGENICZNE DLA CEBULI ZASIEDLAJĄCE GLEBĘ PO UPRAWIE ROŚLIN OKRYWOWYCH – ŻYTA JAREGO I WYKI JAREJ

Streszczenie. Celem badań było określenie występowania w glebie grzybów patogenicznych dla cebuli uprawianej po życie jarym i wyce siewnej. Przedmiotem badań były siewki cebuli odm. 'Wolska' oraz izolaty grzybów *Fusarium culmorum*, *F. oxysporum*, *F. solani*, *Penicillium verrucosum* var. *cyclopium*, *P. verrucosum* var. *verrucosum* i *Pythium irregulare*. W wyniku przeprowadzonych badań w fitotronie okazało się, że użyte do doświadczenia grzyby były patogeniczne dla cebuli. Szkodliwość badanych grzybów była różna zarówno między gatunkami, jak i między izolatami w obrębie gatunku. Najbardziej szkodliwym okazał się *P. verrucosum* var. *cyclopium* i *F. culmorum*, w tych bowiem kombinacjach doświadczenia wyrosło najmniej roślin cebuli i były najbardziej porażone. Najwięcej roślin cebuli z najmniejszym udziałem porażonych było w kombinacji z *F. oxysporum*

Słowa kluczowe: grzyby patogeniczne, cebula, żyto jare, wyka siewna

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