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RHIZOCTONIA SOLANI AND STREPTOMYCES SCABIES ON SPROUTS AND TUBERS OF POTATO GROWN IN ORGANIC AND INTEGRATED SYSTEMS, AND FUNGAL COMMUNITIES IN THE SOIL HABITAT

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Abstract

The health of sprouts and tubers of six potato cultivars was compared in organic and integrated systems of cultivation in field experiments in 2002–2004. The study included analysis of the structure of fungal communities from both systems. There was much disease in all years. The incidence of sprout rot (*Rhizoctonia solani*) and common scab (*Streptomyces scabies*) was less in the organic than in the integrated system. The incidence of sclerotia of *R. solani* on tubers was similar in the two systems. Analysis of fungal communities showed a greater density of species potentially antagonistic towards pathogens of potato in the organic system.

Key words: antagonism, microorganisms, organic system, integrated system, rhizoplane, rhizosphere, soil

Introduction

Agricultural practices that permit the application of high doses of mineral fertilizers and pesticides cause concerns among many food consumers. Organic food production has received much attention over past few years. Concerns about human health and environmental safety are being raised continually.

The rules of organic farming ban the application of artificially produced chemicals. In this situation the use of natural fertilizers and forage crops instead of mineral fertilizers easily solves the problem of plant nutrition. Disease and pest control is still, however, a major and challenging problem in organic farming. Progress in reducing losses caused by pathogens and insects with environmentally safe methods is being made slowly but continuously. According to Perucci et al.

(1997), Wyczółkowski et al. (1998), Dąbek-Szreniawska et al. (2000), Lahav (Lavian) and Steinberger (2001) and Breza-Boruta (2002), conversion of farming from conventional to organic may help to reduce the risk of disease incidence by promoting the growth of soil saprotrophs. Sadowski et al. (2002, 2004), however, associated disease incidence mostly with weather conditions and reported little impact of farming methods on disease reduction. Alternative approaches to plant disease control have been investigated in the studies of Elad (2000), Weber et al. (2000), Lewis and Lumsden (2001), Baturó (2003), Łukanowski (2003) and Sadowski et al. (2005). Studies that compared the effects of different cultivation techniques, novel cultivars and biopreparations in cereal growing have often been conducted in organic, integrated and conventional systems (Baturó et al. 2002, Łukanowski and Sadowski 2002, Łukanowski et al. 2002, 2003). Yet, works on potato are lacking (Sadowski et al. 2003, 2004).

Growing interest in food produced in organic system will most probably result in increasing the number and area of organic farms, in which estimation of the health status of potato plants during vegetation season and the health status of harvested tubers will be essential. To control the pathogens the recognition of the density and diversity of fungi communities in soil and on roots will be of great importance.

The most important pathogens of potato plants and tubers are *Rhizoctonia solani*, threatening the plants throughout the vegetation season (sprout rot, potato stem canker and black scurf) and *Streptomyces scabies* (common scab).

The objectives of research were:

- 1) to compare the health status of potato tubers of six cultivars grown in organic and integrated systems,
- 2) to determine the occurrence of sprout rot (*R. solani*), black scurf (*R. solani*), common scab (*S. scabies*), and dry rot (*Fusarium* spp.) in the cultivars,
- 3) to determine the composition of fungal communities in the soil, rhizosphere and rhizoplane of plants grown in organic and integrated systems.

Materials and methods

Six potato cultivars: 'Bart' (very early), 'Bila' (early), 'Baszta' (mid-late), 'Wolfram' (mid-late), 'Wawrzyn' (late) and 'Bzura' (late), were planted in Osiny, Institute of Soil Science and Plant Cultivation – National Research Institute in Puławy (51°25'N, 21°58'E) in 2002, 2003 and 2004 in organic and integrated systems. The preceding crops in the organic system included spring barley + clover + forage grasses, clover + forage grasses, clover + forage grasses and winter wheat. The preceding crops in the integrated system included spring barley, faba bean and winter wheat. In the organic system, manure was applied at 320 dt/ha in October, immediately before the winter ploughing, followed by spring planting of potatoes. In the integrated system, ammonium nitrate was applied at 40 kg N per 1 ha in August and organic manure at 300 dt/ha immediately before winter ploughing. Addi-

tional ammonium sulphate was applied at 30 kg N per 1 ha in June for the late cultivars of potatoes. The planting took place in III decade of April.

Copper hydroxide (Funguran-OH 50 WP) was used against fungal diseases and *Bacillus thuringiensis*, with Nowodor 02 S.C. against Colorado beetle (*Leptinotarsa decemlineata*) in the organic system. Cymoxanil + mancozeb (Curzate M 725 WP), dimethomorph + mancozeb (Acrobat MZ 69 WP) and fentin in the form of hydroxide (Brestanid 502 SC) were used against diseases, tiametoxan (Actara 25 WG) against Colorado beetle and linuron + chlomazone (Afalon 450 SC + Command 480 EC) and fluazifop-P-butyl (Fusilade Forte 150 EC) against weeds in the integrated system. Potatoes were harvested from September to October, depending on the cultivar.

At germination sprout rot was assessed. 100 randomly selected plants (25 plants from each of four replicates) were examined, in which all the sprouts were assessed. The disease symptom rating was based on a 0–8° scale (Sadowski et al. 2002). Disease occurrence data were obtained according to the Townsend and Heuberger formula (Wenzel 1948) and presented as disease index (DI).

Samples of soil and roots were taken from plots of cv. 'Bila' grown in both the organic and integrated system, when the plants were at the emergence and flowering stages in 2004. In each system the roots were collected from 100 of randomly chosen plants (4 × 25). Isolation of fungi from rhizosphere and rhizoplane was performed according to Kobus et al. (1993), with additional 10-fold dilutions. In each system the soil was sampled from 20 points from the depth of 5–15 cm (to sterile containers). In the laboratory the 20 soil samples were mixed and 10 g of the mixture was shaken for 30 min in 90 ml of sterile water. Than subsequent 10-fold dilutions were prepared.

For fungi isolation 1 ml of soil 10³ suspension from rhizoplane and 10⁴ suspension from rhizosphere and soil was taken. Onto the suspension in a Petri dish Martin-Johnson medium was poured. Every experimental variant had 30 dishes. The dishes were incubated in room temperature. The appearing colonies were transferred into PDA slants. Fungi were identified on the basis of their morphology in culture (Gilman 1971, Domsch and Gams 1972, Fassatiova 1983, Kwańska et al. 1991).

Density of fungi and diversity of fungal communities in soil rhizosphere, rhizoplane and roots were determined and transformed into number of colonies per 1 g of root weight and air-dry soil according to formula:

for rhizoplane:

$$\text{number of fungi in 1 g} = \frac{\text{number of isolates obtained}}{30} \cdot 1000$$

for rhizosphere and soil:

$$\text{number of fungi in 1 g} = \frac{\text{number of isolates obtained}}{30} \cdot 10000$$

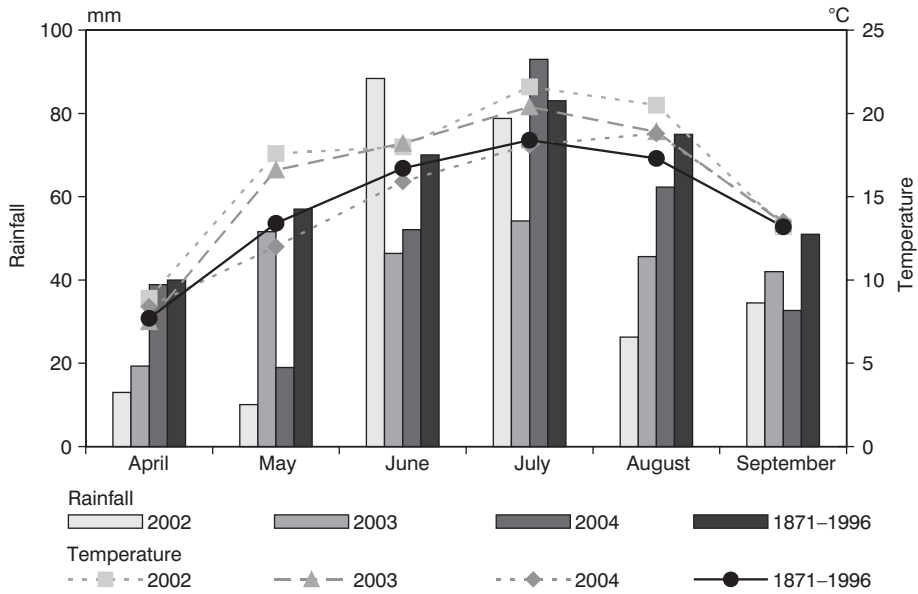


Fig. 1. Weather conditions in Osiny in 2002–2004

Fungal species detected were grouped into: 1) potentially pathogenic to potato, 2) potentially antagonistic to potato pathogens, 3) other species.

The design of the field experiment was a randomized complete block with four replicates, with two factors (the first factor – growing system (I), the second factor – cultivar (II)). The experiment was performed on alfisols formed from loam sand on loam, belonging to good wheat complex of IIIa class. Data were compared by analysis of variance using the general linear model procedure and were separated by Tukey's test at $P = 0.05$.

In order to determine if cropping system significantly affected quantitative and qualitative composition of fungal communities from soil habitat of potato, chi-square test (χ^2) was applied.

The weather data, obtained from Institute of Soil Science and Plant Cultivation – National Research Institute in Puławy are presented in Figure 1. At the emergence stage the precipitation was small in 2002 and 2004, and at the flowering stage – in 2003. The air temperature in 2002 and 2003 was higher than and in 2004 near to the multiyear average.

Results

Sprout health assessment during emergence revealed the occurrence of sprout rot caused by *R. solani*. It was particularly severe in 2003, when high precipitation at emergence favoured the pathogen development. On average, over all cultivars,

Table 1

Occurrence of sprout rot (*Rhizoctonia solani*) in six cultivars of potato grown in organic and integrated systems

Cultivar	Diseased sprouts (%)		DI (%)		LSD _{α=0.05} for DI
	organic system	integrated system	organic system	integrated system	
'Bard'	27.1	51.0	16.5	30.5	I – 0.54 II/I – 1.66 I/II – 1.32
'Bila'	50.4	34.3	39.9	26.1	
'Baszta'	35.3	44.2	26.9	33.0	
'Wolfram'	39.8	44.5	26.1	32.6	
'Wawrzyn'	23.8	23.9	12.0	10.3	
'Bzura'	34.2	47.6	22.1	33.1	
Mean	35.1	40.9	23.9	27.6	

I – cropping system, II – cultivar.

35.1% sprouts were infected in the organic system and 40.9% in the integrated system (Table 1). The disease indices were 23.9 and 27.6, respectively. The highest disease index was found on 'Bila' (early cultivar) in the organic system and 'Baszta' in the integrated system. The smallest number of infected sprouts and lowest disease index was in cultivar 'Wawrzyn' regardless of the system used.

Post-harvest analysis of tubers revealed relatively high occurrence of black scurf caused by *R. solani* and common scab caused by *S. scabies*. On average, over all cultivars, 39.4% (DI = 14.0) and 46.4% (DI = 13.8) of tubers were contaminated by *R. solani* and 74.5% (DI = 16.5) and 84.4% (DI = 28.8) tubers were infected by *S. scabies* in the organic and integrated systems, respectively (Tables 2, 3). The similar average disease indices for black scurf suggest that there was no difference in disease between the organic and integrated systems. The disease index values show more infection by *S. scabies* in the integrated system. There was most infec-

Table 2

Occurrence of black scurf (*Rhizoctonia solani*) in six cultivars of potato grown in organic and integrated systems

Cultivar	Diseased sprouts (%)		DI (%)		LSD _{α=0.05} for DI
	organic system	integrated system	organic system	integrated system	
'Bard'	24.4	37.8	7.4	10.2	I – n.s. II/I – 1.87 I/II – 1.48
'Bila'	66.6	67.6	25.7	23.8	
'Baszta'	27.9	42.0	11.3	11.8	
'Wolfram'	41.0	66.5	16.9	22.1	
'Wawrzyn'	13.9	24.8	4.4	6.0	
'Bzura'	62.8	39.7	18.0	8.7	
Mean	39.4	46.4	14.0	13.8	

I – cropping system, II – cultivar.

n.s. – not significant.

Table 3

Occurrence of common scab (*Streptomyces scabies*) in six cultivars of potato grown in organic and integrated systems

Cultivar	Diseased sprouts (%)		DI (%)		LSD _{$\alpha=0.05$} for DI
	organic system	integrated system	organic system	integrated system	
'Bard'	64.2	74.8	12.7	26.7	
'Bila'	69.5	74.4	13.7	18.9	
'Baszta'	79.4	80.0	18.8	26.6	I – 0.53
'Wolfram'	90.8	96.5	23.3	38.6	II/I – 1.64
'Wawrzyn'	55.2	84.7	9.1	24.5	I/II – 1.30
'Bzura'	87.7	96.1	21.6	37.5	
Mean	74.5	84.4	16.5	28.8	

I – cropping system, II – cultivar.

tion by *R. solani* in cultivar 'Bila' and least in cultivar 'Wawrzyn', regardless of the system. There was most infection by *S. scabies* in cultivar 'Wolfram', least in the organic system in cultivar 'Wawrzyn' and least in the integrated system in cultivars 'Bard' and 'Bila'.

The occurrence of dry rot caused by *Fusarium* species was sporadic (< 0.5%) in 2002 and 2003. The disease was only slightly more prevalent in 2004. The most susceptible cultivar was 'Bzura' grown in the organic system with 2.8% tubers infected. Cultivar 'Wawrzyn' was the most resistant, with no tubers infected regardless of the farming system.

There were 183 fungal isolates obtained from the tuber sprouts. They included 88 and 95 isolates from the organic and integrated systems, respectively. The 15 taxa included the pathogenic *Fusarium* spp., *F. oxysporum* and *F. solani*, and *R. solani* (Table 4). *Fusarium* spp. accounted for 14.8% and 23.2%, and *R. solani* for 21.7% and 33.7% of isolates in the organic and integrated systems, respectively. *Trichoderma*, represented by four species, accounted for 50.1% and 20.1% in the organic and integrated systems, respectively.

The density of fungal communities in the rhizoplane and rhizosphere were greater at the emergence stage than at the flowering stage, and usually greater in the integrated than in the organic system. The density of the fungal community in soil was greater in the organic ecological system (Table 5). Statistical analysis with χ^2 test showed that the number of fungi in integrated system was significantly higher in emergence stage both in rhizoplane and rhizosphere, however, during flowering – in organic system.

There were 191 and 222 fungal isolates obtained from the potato rhizoplane at the emergence stage in the organic and integrated systems, respectively. The numbers decreased to 184 and 182 isolates by the flowering stage. Test χ^2 showed that the number of *F. solani* and *Penicillium* spp. depended on growing system and potato development stage (Table 6). At the emergence stage, the proportion of potato pathogens (*Alternaria* spp., *Fusarium* spp., *Phoma* spp.) in the total number of fungal

Table 4

Fungi isolates obtained from sprouts of potatoes grown in organic and integrated systems (%)

Taxon	Organic system	Integrated system
<i>Botrytis cinerea</i>	2.2	1.0
<i>Cylindrocarpon</i> sp.	–	1.0
<i>Fusarium oxysporum</i>	9.1	11.6
<i>Fusarium solani</i>	5.7	11.6
<i>Gliocladium catenulatum</i>	1.1	1.0
<i>Gliocladium roseum</i>	–	1.0
<i>Mucor</i> spp.	5.7	8.4
<i>Penicillium</i> spp.	–	4.2
<i>Rhizoctonia solani</i>	21.7	33.7
<i>Rhizopus</i> spp.	2.2	6.4
<i>Trichoderma hamatum</i>	2.2	–
<i>Trichoderma harzianum</i>	12.6	3.2
<i>Trichoderma koningii</i>	13.6	13.7
<i>Trichoderma viride</i>	21.7	3.2
<i>Zygorhynchus</i> sp.	2.2	–
Total	100	100

isolates in rhizoplane was similar in the organic and integrated systems. The number of potential fungal antagonists (genera *Trichoderma* and *Gliocladium*) was, however, greater in the organic system. By the flowering stage, the number of both groups, pathogens and antagonists, increased in the organic system and decreased in the integrated system, and accounted respectively 72 (39.1%) and 20 (11.0%) pathogens and 39 (21.2%) and 5 (2.7%) antagonists.

Table 5

Density of fungal communities in rhizoplane, rhizosphere and soil of potato grown in organic and integrated systems

Habitat	Phase of potato development	Organic system	Integrated system	χ^2
Rhizoplane	emergence	6 367	7 400	***
	flowering	6 133	6 066	
Rhizosphere	emergence	99 333	102 667	***
	flowering	74 333	45 667	
Soil	emergence	–	–	–
	flowering	77 333	60 000	

***Significance level P = 0.005.

Table 6

Fungi isolates obtained from rhizoplane of potato cultivar 'Bila' grown in organic and integrated systems

Taxon	Emergence phase		Flowering phase		χ^2
	organic system	integrated system	organic system	integrated system	
<i>Alternaria alternata</i>	6	2	–	–	–
<i>Arthrinium phaeospermum</i>	–	–	2	–	–
<i>Chaetomium</i> sp.	1	–	–	–	–
<i>Chrysosporium pannorum</i>	15	7	–	–	–
<i>Coniothyrium fuckelii</i>	5	–	3	1	–
<i>Cylindrocarpon radicum</i>	–	1	–	–	–
<i>Dendryphion nanum</i>	–	–	1	–	–
<i>Fusarium avenaceum</i>	–	12	–	–	–
<i>Fusarium culmorum</i>	–	2	–	–	–
<i>Fusarium equiseti</i>	10	–	4	–	–
<i>Fusarium oxysporum</i>	–	3	29	12	–
<i>Fusarium solani</i>	25	28	30	8	***
<i>Fusarium tricinctum</i>	–	1	–	–	–
<i>Gliocladium catenulatum</i>	3	–	7	1	–
<i>Gliocladium roseum</i>	–	6	28	1	–
<i>Gymnoascus reessii</i>	–	–	–	1	–
<i>Humicola grisea</i>	–	4	–	1	–
<i>Monocillium indicum</i>	–	–	–	1	–
<i>Mucor mucedo</i>	–	5	3	–	–
<i>Mucor</i> spp.	–	2	–	3	–
<i>Myrothecium</i> sp.	–	–	8	8	–
<i>Paecilomyces lilacinus</i>	–	1	–	–	–
<i>Penicillium</i> spp.	100	147	43	139	***
<i>Phoma eupyrena</i>	1	–	–	–	–
<i>Phoma</i> sp.	5	1	9	–	–
<i>Rhizopus nigricans</i>	–	–	–	1	–
<i>Sporotrichum carnis</i>	–	–	6	–	–
<i>Torula</i> spp.	–	–	6	5	–
<i>Trichoderma koningii</i>	19	–	–	–	–
<i>Trichoderma viride</i>	–	–	4	–	–
Nonsporulating colonies	1	–	1	–	–
Total	191	222	184	182	–

***Significance level P = 0.005.

Table 6a

Effect of cultivation system and potato development phase on rhizoplane fungi

Fungi	Organic system		Integrated system		χ^2 for system
	number	%	number	%	
Emergence phase					
Potentially pathogenic (<i>Fusarium</i> spp., <i>Alternaria</i> spp., <i>Phoma</i> spp.)	47	24.6	49	22.1	**
Potentially antagonistic (<i>Trichoderma</i> spp., <i>Gliocladium</i> spp.)	22	11.5	6	2.7	
Flowering phase					
Potentially pathogenic (<i>Fusarium</i> spp., <i>Alternaria</i> spp., <i>Phoma</i> spp.)	72	39.1	20	11.0	-
Potentially antagonistic (<i>Trichoderma</i> spp., <i>Gliocladium</i> spp.)	39	21.2	5	2.7	
χ^2 for growth phases in system	-		-		

**Significance level P = 0.01.

There were 298 and 308 fungal isolates obtained from the potato rhizosphere at the emergence phase in the ecological and integrated system. These numbers decreased to 223 and 137 isolates by the flowering phase. Test χ^2 showed that the number of *F. oxysporum*, *F. solani* and *G. roseum* depended on the growing system and potato development stage (Table 7).

At the emergence phase, the rhizosphere of potatoes grown in the ecological system was colonized mostly by antagonists which amounted to 129 (43.3%) of total number of isolates. Pathogens accounted only for 12 (4.0%) of isolates. The numbers for antagonists and pathogens in the integrated system were 105 (34.1%) and 56 (18.2%), respectively.

By the flowering phase the contribution of pathogens increased to a similar level of more than 22% and antagonists decreased to 36.8% and 30.7% in the ecological and integrated system.

Test χ^2 showed that the number of potentially pathogenic fungi both in rhizoplane and rhizosphere was significantly higher in integrated system and potentially antagonistic – in organic one. Such relation was not noted in flowering phase (Tables 6a, 7a).

There were 232 and 180 fungal isolates obtained from soil of the organic and integrated systems, respectively, at the flowering stage (Table 8). More pathogens than antagonists were isolated from soil of both systems. The contribution of pathogens was 30.2% and 32.2%, and antagonists 25.9% and 16.7% in the organic and integrated system, respectively (Table 8a). The density of pathogens was 4.3% and 15.6% more than antagonists in the organic and integrated system, respectively. There was no correlation between cropping system and number of potentially pathogenic and antagonistic fungi (Table 8a).

Table 7

Fungi isolates obtained from rhizosphere of potato cultivar 'Bila' grown in organic and integrated systems

Taxon	Emergence phase		Flowering phase		χ^2
	organic system	integrated system	organic system	integrated system	
<i>Alternaria alternata</i>	–	–	–	1	–
<i>Arthrimum phaeospermum</i>	2	2	–	–	–
<i>Chaetomium</i> sp.	–	–	2	–	–
<i>Cladosporium herbarum</i>	–	–	–	1	–
<i>Coniothyrium fuckelii</i>	2	–	5	1	–
<i>Cylindrocarpon</i> sp.	1	–	–	–	–
<i>Fusarium equiseti</i>	–	–	8	–	–
<i>Fusarium oxysporum</i>	5	35	22	20	***
<i>Fusarium solani</i>	4	10	16	7	*
<i>Gliocladium catenulatum</i>	1	8	19	22	–
<i>Gliocladium roseum</i>	15	48	40	13	***
<i>Gymnoascus reessii</i>	2	28	1	–	–
<i>Monocillium indicum</i>	2	9	–	–	–
<i>Mortierella</i> sp.	–	–	–	4	–
<i>Mucor mucedo</i>	–	–	–	1	–
<i>Mucor</i> spp.	–	7	13	–	–
<i>Myrothecium roridum</i>	–	–	–	2	–
<i>Myrothecium</i> sp.	–	–	6	–	–
<i>Oidiodendron</i> sp.	–	–	–	1	–
<i>Paecilomyces</i> sp.	–	15	–	–	–
<i>Penicillium</i> spp.	148	83	64	38	–
<i>Phoma</i> sp.	3	11	4	3	–
<i>Rhizopus nigricans</i>	–	–	–	13	–
<i>Stemphylium</i> sp.	–	–	–	1	–
<i>Torula</i> spp.	–	1	–	–	–
<i>Trichocladium asperum</i>	–	–	–	1	–
<i>Trichoderma harzianum</i>	–	–	3	1	–
<i>Trichoderma koningii</i>	65	35	8	2	–
<i>Trichoderma polysporum</i>	2	7	3	–	–
<i>Trichoderma pseudokoningii</i>	–	–	–	1	–
<i>Trichoderma viride</i>	46	7	9	3	–
<i>Zygorhynchus</i> sp.	–	2	–	–	–
Nonsporulating colonies	–	–	–	1	–
Total	298	308	223	137	

*Significance level $P = 0.05$, ***significance level $P = 0.005$.

Table 7a

Effect of cultivation system and potato development phase on rhizosphere fungi

Fungi	Organic system		Integrated system		χ^2 for system
	number	%	number	%	
Emergence phase					
Potentially pathogenic (<i>Fusarium</i> spp., <i>Alternaria</i> spp., <i>Phoma</i> spp.)	12	4.0	56	18.2	***
Potentially antagonistic (<i>Trichoderma</i> spp., <i>Gliocladium</i> spp.)	129	43.3	105	34.1	
Flowering phase					
Potentially pathogenic (<i>Fusarium</i> spp., <i>Alternaria</i> spp., <i>Phoma</i> spp.)	50	22.4	31	22.6	-
Potentially antagonistic (<i>Trichoderma</i> spp., <i>Gliocladium</i> spp.)	82	36.8	42	30.7	
χ^2 for growth phases in system	***		-		

***Significance level P = 0.005.

Discussion

Sprout rot, black scurf and common scab occurred on the six cultivars of potato throughout the period of the experiments. The amount of disease depended first on the weather during plant growth, which was clear with sprout rot. The most favourable weather for pathogenic fungi occurred in 2003. Relatively low temperatures and high soil moisture during the emergence stage favours sprout rot (Weber 1976, Osowski 2002). Dry soil, particularly during tuber development, creates the most favourable conditions for *S. scabies* (Gawińska-Urbanowicz 2000) while the moisture in the soil at the time of tuber maturation favours the development of sclerotia of *R. solani* (Weber 1976, Sadowski et al. 2003).

The occurrence of sprout rot and common scab on potatoes grown in the organic system was significantly less than in the integrated system. The lower incidence of sprout rot was associated with greater colonization of sprouts by *Trichoderma* and of soil by *Gliocladium* spp. in the organic system. Cultivation system did not effect the level of tuber contamination by sclerotia of *R. solani*. This agrees with Sadowski et al. (2002), who reported that contamination of potato tubers by *R. solani* was similar in organic and conventional systems.

Infection of sprouts and contamination of tubers of individual cultivars of potato by *R. solani* differed among the years of study and ranged from high to low. Similar differences in reaction to pathogen were observed by Sadowski et al. (2004), Kućmierz et al. (1993) and Bogucka (1993). According to Chrzanowska (2002), there are no cultivars entirely resistant to *R. solani* and there is only some differentiation between cultivars in their susceptibility.

Table 8

Fungi isolates obtained from soil under potato cultivar 'Bila'
grown in organic and integrated systems

Taxon	Organic system	Integrated system
<i>Acremonium strictum</i>	1	–
<i>Arthrinium phaeospermum</i>	5	–
<i>Chaetomium</i> sp.	2	4
<i>Chrysosporium pannorum</i>	–	4
<i>Fusarium equiseti</i>	12	2
<i>Fusarium oxysporum</i>	19	21
<i>Fusarium solani</i>	17	29
<i>Fusarium tricinctum</i>	2	–
<i>Gliocladium catenulatum</i>	12	–
<i>Gliocladium roseum</i>	33	2
<i>Gymnoascus reessii</i>	1	–
<i>Humicola grisea</i>	5	9
<i>Monocillium indicum</i>	–	5
<i>Mucor</i> spp.	5	5
<i>Paecilomyces lilacinus</i>	1	–
<i>Paecilomyces</i> sp.	6	–
<i>Penicillium</i> spp.	72	62
<i>Phoma</i> sp.	20	6
<i>Rhizopus nigricans</i>	–	2
<i>Trichocladium asperum</i>	1	–
<i>Trichoderma hamatum</i>	2	–
<i>Trichoderma harzianum</i>	–	4
<i>Trichoderma koningii</i>	5	3
<i>Trichoderma polysporum</i>	2	–
<i>Trichoderma viride</i>	6	21
<i>Trichotecium roseum</i>	1	–
Nonsporulating colonies	2	1
Total	232	180

Table 8a

Effect of cropping system occurrence of fungi in soil at flowering phase

Fungi	Organic system		Integrated system		χ^2 for system
	number	%	number	%	
Potentially pathogenic (<i>Fusarium</i> spp., <i>Alternaria</i> spp., <i>Phoma</i> spp.)	70	30.2	58	32.2	–
Potentially antagonistic (<i>Trichoderma</i> spp., <i>Gliocladium</i> spp.)	60	25.9	30	16.7	P = 0.1

Results on occurrence of common scab on the potato cultivars used here often disagree with resistance data for the commercially used cultivars towards *S. scabies* given by COBORU ("Lista..." 2004). In our study, least infection by *S. scabies* was observed on cv. 'Wawrzyn', which, according to COBORU, is considered to be the most susceptible. The cv. 'Bila', according to COBORU, is considered highly resistant. It was, however, infected to a moderate extent in our studies. Most infection occurred on 'Wolfram', which was the most susceptible to *S. scabies* in both the organic and integrated system.

Differences in the density and diversity of communities of soil fungi in the two cultivation systems probably result from the differences in fertilization, agronomic procedures and chemical control (Myśkow et al. 1996). Other factors common to both systems, i.e. the crop species, crop cultivar and development stage, temperature and moisture had more general effects and influences on the basic structure and character of the fungal communities (Choroszewski 1989, Kurzawińska 1994, Wyczółkowski et al. 1999, Pięta and Patkowska 2001).

In both systems the most notable antagonistic fungi recorded were *Trichoderma* and *Gliocladium* species. The former was among the predominant fungi in the emergence stage. The latter was among the predominant fungi in the rhizosphere during both the emergence and flowering stages. The increase in their density during early plant growth is in agreement with Kurzawińska (1994) who, while studying the fungal communities in soil under potatoes fertilized with different amounts of nitrogen, recorded an increase in density of *Trichoderma* species in the spring. Among the pathogens the most frequently isolated were *Fusarium* species, particularly *F. solani* and *F. oxysporum*, in agreement with the results of Pięta and Patkowska (2001).

The results on the structure of fungal communities in soil growing potato crops habitat suggest beneficial effects of the organic cultivation system on the development of the microorganisms antagonistic towards pathogens. The pathogen:antagonist ratio shows that the organic system of cultivation favours not only their growth but also their activity. In the earlier investigations (one season only) in the same field in Osiny and in the region of Tuchola (54°N, 18°E) the changes of soil fungi community diversity were not favourable enough to protect the plants against the pathogens (Lenc et al. 2005).

The occurrence of larger communities of active and efficient antagonists is an indication of their importance in the natural biological control of pathogens (Łacicowa 1988, Mańka 1990, Moliszewska 1997).

Streszczenie

RHIZOCTONIA SOLANI I STREPTOMYCES SCABIES NA KIEŁKACH I BULWACH ZIEMNIAKA UPRAWIANEGO W SYSTEMIE EKOLOGICZNYM I INTEGROWANYM ORAZ ZBIOROWISKA GRZYBÓW ŚRODOWISKA GLEBOWEGO

W latach 2002–2004 w doświadczeniu polowym porównano zdrowotność kielków i bulw sześciu odmian ziemniaka uprawianego w systemie ekologicznym i integrowanym. Dokonano też analizy składu zbiorowisk grzybów środowiska glebowego w obydwu systemach. We wszystkich latach objawy chorobowe wystąpiły w znacznym nasileniu. W systemie ekologicznym było istotnie mniej zgnilizny kielków (*Rhizoctonia solani*) aniżeli w integrowanym. Na bulwach zebranych z uprawy w systemie ekologicznym było mniej objawów parcha zwykłego (*Streptomyces scabies*). Zanieczyszczenia bulw sklerocjami *R. solani* w obydwu systemach uprawy były na tym samym poziomie. Analiza mikologiczna zbiorowisk grzybów wykazała, że w systemie ekologicznym liczniej występowały gatunki potencjalnie antagonistyczne.

Literature

- Baturo A., 2003: Effect of chitosan on *Bipolaris sorokiniana* (Sacc. in Sorok) Shoemaker growth and spring barley infection. Bull. Pol. Acad. Sci. 51, Biol. Sci. Plant Prot. 2: 95–102.
- Baturo A., Sadowski Cz., Kuś J., 2002: Zdrowotność korzeni jęczmienia jarego i zasiedlające je grzyby w ekologicznym, integrowanym i konwencjonalnym systemie uprawy. Acta Agrobot. 55, 1: 17–26.
- Bogucka H., 1993: Rizoktonioza ziemniaka. Ziemn. Pol. 2: 18–20.
- Breza-Boruta B., 2002: Właściwości antagonistyczne promieniowców z rodzaju *Streptomyces* w stosunku do wybranych mikroorganizmów w uprawie ziemniaka. Typescript. University of Technology and Life Sciences, Bydgoszcz.
- Choroszewski P., 1989: Mikroflora zbiorowiska glebowego pól ziemniaczanych. Zesz. Probl. Post. Nauk Roln. 374: 104–118.
- Chrzanowska M., 2002: Wykorzystanie odporności odmian na choroby w ekologicznej uprawie ziemniaka. Zesz. Probl. Post. Nauk Roln. 489: 21–32.
- Dąbek-Szreniawska M., Wyczółkowski A.I., Jończyk K., Kuś J., 2000: Współzależności między systemem uprawy, wodoodpornością agregatów glebowych a liczebnością drobnoustrojów. Acta Agrophys. 38: 47–57.
- Domsch K.H., Gams W., 1972: Fungi in agricultural soils. Longman, London.
- Elad Y., 2000: Biological control of foliar pathogens by means of *Trichoderma harzianum* and potential model of action. Crop Prot. 19: 709–714.
- Fassatiova O., 1983: Grzyby mikroskopowe w mikrobiologii technicznej. WN-T, Warszawa.
- Gawińska-Urbanowicz H., 2000: Występowanie parcha zwykłego (*Streptomyces* sp.) na wybranych odmianach ziemniaka w różnych warunkach środowiska. Roczn. AR Pozn. 321, Ogród. 30: 33–38.
- Gilman J.C., 1971: A manual of soil fungi. The Iowa State University Press, Ames, Iowa.
- Kobus J., Czaban J., Gajda A., Masiak D., Książniak A., 1993: Wheat rhizosphere microflora and its effect on plant nutrition and some pathogenic fungi. Part I. Changes of rhizobacterial populations with development of winter wheat. Roczn. Glebozn. 44, 3/4: 45–53.

- Kućmierz J., Kurzawińska H., Wesołowska J., 1993: Wpływ terminu i gęstości sadzenia na występowanie rizoktoniozy (*Rhizoctonia solani*) na kilku odmianach ziemniaka. Zesz. Nauk. AR Krak. 287, Ogród. 21: 105–114.
- Kurzawińska H., 1994: Zbiorowiska grzybów środowiska glebowego z uprawy ziemniaka i ich wpływ na sprawców suchej zgnilizny bulw w zależności od nawożenia azotowego. Zesz. Nauk. AR Krak. Rozpr. 192.
- Kwaśna H., Chełkowski J., Zajkowski P., 1991: Grzyby (*Mycota*). T. 12. PAN, Warszawa.
- Lahav (Lavian) I., Steinberger Y., 2001: Soil bacterial functional diversity in a potato field. Eur. J. Soil Biol. 37: 59–67.
- Lenc L., Pańka D., Sadowski Cz., 2005: Zbiorowiska grzybów środowiska glebowego ziemniaka (*Solanum tuberosum* L.) uprawianego w systemie ekologicznym i integrowanym. In: Obieg pierwiastków w przyrodzie. Ed. B. Gworek. T. III. Instytut Ochrony Środowiska, Warszawa: 788–793.
- Lewis J.A., Lumsden D.L., 2001: Biocontrol of damping-off of greenhouse-grown crops caused by *Rhizoctonia solani* with formulation of *Trichoderma* spp. Crop Prot. 20: 49–56.
- Lista opisowa odmian, rośliny rolnicze. Cz. 2. 2004. COBORU, Słupia Wielka.
- Łacicowa B., 1988: Niektóre aspekty wykorzystania grzybów z rodzaju *Trichoderma* i *Gliocladium* w biologicznej ochronie roślin. Ochr. Rośl. 3: 8–10.
- Łukanowski A., 2003: Effect of chitosan on winter wheat infection by *Fusarium avenaceum*, *Fusarium culmorum* and *Fusarium graminearum* and on growth of these fungi. Bull. Pol. Acad. Sci. 51, Biol. Sci. Plant Prot. 2: 117–122.
- Łukanowski A., Baturó A., Sadowski Cz., 2002: Healthiness of winter wheat and spring barley farmed under different systems. Plant Prot. Sci. 38, 2: 662–666.
- Łukanowski A., Sadowski Cz., 2002: Occurrence of *Fusarium* on grain and heads of winter wheat cultivated in organic, integrated, conventional systems and monoculture. J. Appl. Genet. 43A: 103–110.
- Łukanowski A., Żary E., Sadowski Cz., 2003: Head healthiness of wheat cultivated under organic, integrated, conventional conditions and monoculture with a special respect to mycotoxinogenic pathogens from genus *Fusarium*. In: Obieg pierwiastków w przyrodzie. Ed. B. Gworek. T. II. Instytut Ochrony Środowiska, Warszawa: 687–690.
- Mańka K., 1990: Saprofityczna mikroflora środowiska glebowego a zdrowotność roślin. Phytopathol. Pol. 11: 122–134.
- Moliszewska E.B., 1997: The protective activity of *Trichoderma hamatum* (Bonord.) Bain., *Gliocladium catenulatum* Gilm. & Abbot and *G. roseum* Bain against sugar beet damping-off under the influence of herbicides. In: *Trichoderma* spp., other microorganisms and plant extracts in plant diseases control. VIII Conference of the Section for Biological Control of Plant Diseases of The Polish Phytopathological Society, Research Institute of Pomology and Floriculture, April 21–22, 1997, Skierniewice, Poland. Eds. L.B. Orlikowski, Cz. Skrzypczak. Research Institute of Pomology and Floriculture, Skierniewice: 106–111.
- Mysłow W., Stachyra A., Zięba S., Masiak D., 1996: Aktywność biologiczna gleby jako wskaźnik jej żyzności i urodzajności. Roczn. Glebozn. 47, 1/2: 89–99.
- Osowski J., 2002: Przyczyny braku wschodów na plantacji ziemniaka. Ziemi. Pol. 1: 13–17.
- Perucci P., Bonciarelli U., Santiloschi R., Bianchi A.A., 1997: Effect rotation, nitrogen fertilization and management of crop residues on some chemical, microbiological and biochemical properties of soil. Biol. Fertil. Soils 24: 311–316.
- Pięta D., Patkowska E., 2001: Wpływ wydzielin korzeniowych różnych roślin uprawnych na skład populacji bakterii i grzybów ze szczególnym uwzględnieniem grzybów patogenicznych przeżywających w glebie. Acta Agrobot. 54, 1: 95–102.
- Sadowski Cz., Klepin J., Baturó A., Lenc L., 2002: Zdrowotność bulw i kielków ziemniaka uprawianego w systemie ekologicznym i konwencjonalnym. Zesz. Probl. Post. Nauk Roln. 489: 95–102.
- Sadowski Cz., Korpál W., Lenc L., Kawalec A., 2003: Health status of tubers of potato cultivated under organic and integrated conditions. In: Obieg pierwiastków w przyrodzie. Ed. B. Gworek. T. II. Instytut Ochrony Środowiska, Warszawa: 682–686.
- Sadowski Cz., Pańka D., Lenc L., 2004: Porównanie zdrowotności bulw i kielków wybranych odmian ziemniaka uprawianych w systemie ekologicznym. Zesz. Probl. Post. Nauk Roln. 500: 373–381.

- Sadowski Cz., Pańka D., Lenc L., Domoradzki M., 2005: Badania nad możliwością wykorzystania biopreparatów do otoczkowania nasion warzyw ekologicznych. *Progr. Plant Prot. / Post. Ochr. Rośl.* 45, 2: 1054–1057.
- Weber Z., 1976: Wpływ przedplonu i innych czynników na występowanie rizoktoniozy ziemniaka (*Rhizoctonia solani* Kühn). *Rocz. Nauk Roln. Ser. E* 6, 2: 45–65.
- Weber Z., Werner M., Frużyńska-Jóźwiak D., 2000: Wpływ terminu wprowadzania do ziemi grzybów z rodzaju *Trichoderma* na skuteczność ochrony roślin przed *Fusarium oxysporum* Schlecht. *Rocz. AR Pozn.* 321, *Ogrodn.* 30: 171–176.
- Wenzel H., 1948: Zur Erfassung des Schadenausmasses in Pflanzenschutzversuchen. *Pflanzenschutzberichte* 15: 81–84.
- Wyczółkowski A.I., Dąbek-Szreniawska M., Kucwaj T., Księżopolska A., Stawiński J., Jończyk K., Kuś J., 1998: Zespoły wybranych mikroorganizmów gleby w zależności od sposobu jej uprawy. In: 33. Sympozjum Mikrobiologiczne „Ekologiczne aspekty mikrobiologii gleby”, Poznań Kiekrz, 6–9.09.1998. 357–363.
- Wyczółkowski A.I., Dąbek-Szreniawska M., Wyczółkowska M., Kuś J., 1999: Powiązanie między sposobem nawożenia pszenicy ozimej a liczebnością wybranych mikroorganizmów cyklu azotowego. *Acta Agrophys.* 23: 185–197.

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