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ANTAGONISTIC ACTIVITY OF SELECTED BACTERIA AND FUNGI INHABITING THE SOIL ENVIRONMENT OF SALSIFY (*Tragopogon porrifolius* var. *sativus* (Gaterau) Br.) CULTIVATED AFTER COVER CROPS

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Abstract. The study determined the antagonistic effect of microorganisms of the soil environment of salsify towards the following pathogenic fungi: *A. alternata, F. culmorum*, *F. oxysporum*, *R. solani* and *S. sclerotiorum.* The field experiment considered mulching the soil with such cover crops as oats, phacelia and common vetch. Laboratory tests pointed to oats as the plant which has the best influence on the quantity of antagonistic *Bacillus* spp., *Pseudomonas* spp., *Gliocladium* spp., *Penicillium* spp. and *Trichoderma* spp. These microorganisms reduced the growth of *A. alternata* and *F. culmorum* in the most effective way. Antagonistic fungi inhibited the growth of *F. oxysporum*, *R. solani* and *S. sclerotiorum* in a greater degree than antagonistic bacteria. Mulching the soil with cover crops can reduce the growth and development of soil-borne fungi pathogenic to salsify.

Key words: mulch, antagonistic microorganisms, pathogenic fungi, biotic effect

INTRODUCTION

Tragopogon porrifolius var. *sativus* (Gaterau) Br. is also called goatsbeard. It was used in folk medicine as early as in ancient times. The edible part of this plant is the yellowish or greyish thin taproot with a white pulp and with a taste reminscent that of parsley root [Mencarelli 2007].

Modern horticulture seeks alternative methods of cultivating the land and plants. No-plough or simplified, so-called conservational, cultivations are the most important [Erenstein 2002, Pięta and Kęsik 2007]. They make use of intercrop cover plants that can be left on the surface of the soil in the form of mulch [Błażewicz-Woźniak 2005, Pat-

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kowska and Konopiński 2013a, 2013b]. They improve the soil structure, cause an increase of the organic substance, improve the nitric balance and increase the biological activity of the soil [Błażewicz-Woźniak 2005, Pięta and Kęsik 2007].

The literature includes scarce information concerning cover crops in the formation of the communities of soil microorganisms [Jamiołkowska and Wagner 2003, Patkowska and Konopiński 2008a]. These plants can stimulate the development of saprotrophic microorganisms, especially antagonistic species, what results in reduction of plant diseases [Pięta and Kęsik 2007]. An important role is played by antagonistic bacteria *Pseudomoans* spp., *Bacillus* spp. and fungi *Gliocladium* spp., *Pencillium* spp., *Trichoderma* spp. [Almeida et al. 2007, Muthukumar and Bhaskaran 2007].

Due to the lack of information concerning the cultivated environment of salsify the study was undertaken to establish the antagonistic activity of bacteria and fungi occurring in the soil under the cultivation of *Tragopogon porrifolius* var. *sativus*, after the application of different cover crops.

MATERIAL AND METHODS

The field experiments were conducted in 2007–2008 at the Experimental Station of Felin belonging to the University of Life Science in Lublin. The experimental plots were established on grey brown podzolic soil made of loess formations lying on chalk marls, with the mechanical composition corresponding to that of silty medium loams. The objects of the study were selected soil microorganisms. They were isolated every year in the first 10-day period of June from the depth of 5–6 cm of the plough layer of the soil where salsify cv. 'Mamut' was cultivated. In the cultivation of this plant soil mulching was applied with intercrop cover plants such as oats (*Avena sativa* L.), tansy phacelia (*Phacelia tanacetifolia* B.) and common vetch (*Vicia sativa* L.). Salsify was sown during the first 10 days of May, while cover crops were sown in the first half of August of each year that preceded the experiment. Before winter, oats, phacelia and common vetch formed abundant green manure, which constituted the natural mulch on the surface of the land. The control was the conventional cultivation of salsify, i.e. without any cover crops. The experiment was established in a split-plot scheme in four replications.

The microbiological analysis of the soil of particular experimental combinations was made according to the method described by Martyniuk et al. [1991] and Patkowska [2002]. That analysis served to determine the total population of bacteria (on "Nutrient agar" medium), fungi (on Martin's medium) and the population of bacteria *Bacillus* spp. (on the medium "Tryptic soy agar") and *Pseudomonas* spp. (on the medium "Pseudomonas agar F") in 1g of dry weight of the examined soil samples.

Results concerning the population of bacteria and fungi were statistically analyzed, and the significance of differences was established on the basis of Tukey's confidence intervals [Oktaba 1987].

In each studied year, the obtained isolates of *Bacillus* spp. and *Pseudomonas* spp. bacteria (500 isolates from each genus) as well as all isolates of *Gliocladium* spp., *Penicillium* spp. and *Trichoderma* spp. fungi were used to determine their antagonistic effect towards pathogenic fungi like *Altenaria alternata*, *Fusarium culmorum*, *F. oxysporum*, *Rhizoctonia solani* and *Sclerotinia sclerotiorum*. The pathogenicity of these fungi towards salsify plants was determined in earlier studies conducted in growth chamber [Patkowska and Konopiński 2008b].

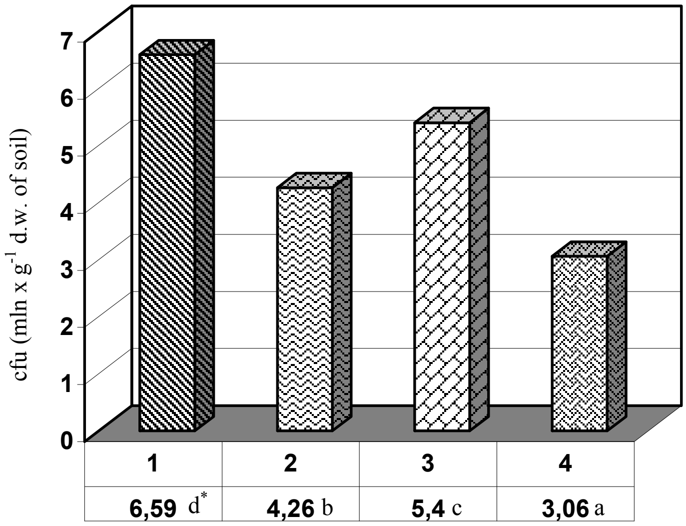
Laboratory tests were conducted and the method and scale described by Martyniuk et al. [1991] was followed to determine the antagonistic effect of bacteria on pathogenic fungi. The scale considering degrees of inhibition of plan pathogen growth provided by Pięta [1999] and Pięta and Kęsik [2007] was applied for the full determination of the effect of bacteria towards the pathogenic fungus. In addition, the activity of all antagonistic isolates of *Bacillus* spp. and *Pseudomonas* spp. towards the studied fungi was established in the cultivation environment of salsify.

Estimation of the effect of *Gliocladium* spp., *Penicillium* spp. and *Trichoderma* spp. towards the studied pathogenic fungi was performed using the method described by Mańka and Mańka [1992]. The individual antagonistic effect was determined on the basis of the scale provided by Mańka and Kowalski [1968]. The total antagonistic effect of *Gliocladium* spp., *Penicillium* spp. and *Trichoderma* spp. from particular experimental combinations on the studied pathogenic fungi made it possible to determine their antagonistic activity [Patkowska 2002, Pięta and Patkowska 2003] in the soil environment of *Tragopogon porrifolius* var. *sativus*.

RESULTS AND DISCUSSION

The microbiological analysis of the soil revealed that the total population of bacteria and the population of *Bacillus* spp. and *Pseudomonas* spp. was the highest when the soil was mulched with oats. A slightly lower population of those microorganisms was found in 1 g d.w. of the soil after using the mulch from common vetch or phacelia. On the other hand, the lowest population of bacteria was obtained as a result of the conventional cultivation of salsify, i.e. without any cover crops. The total population of bacteria in 1 g d.w. ranged from 3.06×10^6 to 6.59×10^6 cfu (fig. 1). The population of *Pseudomonas* spp. obtained from particular experimental combinations was smaller as compared to the population of *Bacillus* spp., and it ranged from 0.30×10^6 to 1.62×10^6 and from 0.89×10^6 to 3.02×10^6 cfu, respectively (fig. 2). A similar relation between the above mentioned bacteria was also obtained using pats, phacelia or common vetch as cover crops in the cultivation of scorzonera and root chicory [Patkowska and Konopiński 2013b]. Similar results concerning *Bacillus* spp. and *Pseudomonas* spp. were obtained using rye or common vetch for soil mulching in the cultivation of onion and scorzonera [Pięta and Kęsik 2007, Patkowska and Konopiński 2013b]. It can be supposed that the ploughed in biomass of oats or common vetch proved to be a good substrate for the development of saprophytic bacteria.

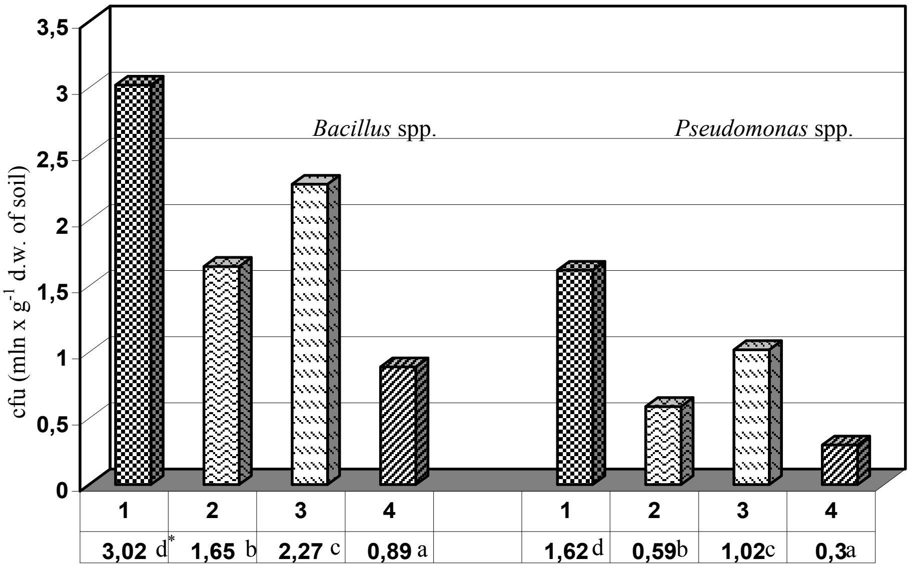
The total population of fungi in 1g d.w. of the soil from particular experimental combinations ranged from 19.21×10^3 to 46.07×10^3 cfu (fig. 3). The population of these microorganisms in the soil after the mulch from oats or common vetch was about twice as small as in the control combination. The total population of fungi in 1 g d.w. of the soil mulched with phacelia was similar to the population of fungi in the conventional cultivation of salsify. The smallest population of fungi in the soil was also recorded using oats as plant mulch in the cultivation of root chicory and scorzonera [Patkowska and Konopiński 2013b]. It can be supposed that the inhibiting effect of oats on the populations of soil-borne fungi is due to avenacine, which accumulates in big quantities in the roots of this plant. As reported by Jamiołkowska [2007], cover crops, especially *Pisum arvense*, considerably decreased the population of fungi (mainly *F. oxysporum* and *R. solani*) in the cultivation of tomato.



* means differ significantly (P < 0.05) if they are not marked with the same letter
1 – soil after oat cultivation, 2 – soil after tansy phacelia cultivation, 3 – soil after spring vetch cultivation, 4 – soil without cover crops cultivation

Fig. 1. Total number of bacteria isolated from the soil of particular experimental combination (means from the years 2007–2008)

Salsify cultivation using cover crops promoted the development of antagonistic bacteria (*Bacillus* spp. and *Pseudomonas* spp.) and fungi (*Gliocladium* spp., *Penicillium* spp. and *Trichoderma* spp.) more than traditional cultivation. Most of antagonistic bacteria *Bacillus* spp. and *Pseudomonas* spp. were found after the oat mulch (50 and 76 isolates, respectively) (fig. 4). Only a slightly less occurred in the soil mulched with common vetch. Independently of the species of cover plant, the number of antagonistic *Gliocladium* spp., *Penicillium* spp. and *Trichoderma* spp. in the soil was much higher than in the traditional cultivation of *Tragopogon porrifolius* var. *sativus* (fig. 5). Like in the case of bacteria, the most of antagonistic fungi were found in the combination with the use of oats as a cover plant. The lowest isolates of antagonistic fungi were obtained as a result of salsify cultivation without cover crops. It should be supposed that the root exudates of cover crops could have exerted a considerable effect on the population of the studied antagonistic microorganisms. As reported by Bending and Lincoln [2000] and Pięta and Patkowska [2001], root exudates, which are a rich source of amino acids,



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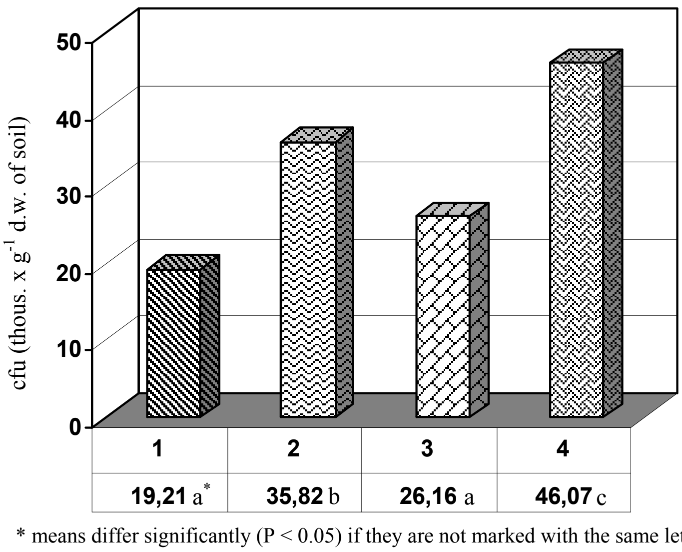
1 – soil after oat cultivation, 2 – soil after tansy phacelia cultivation, 3 – soil after spring vetch cultivation,
4 – soil without cover crops cultivation

Fig. 2. Total number of *Bacillus* spp. and *Pseudomonas* spp. isolated from the soil of particular experimental combination (means from the years 2007–2008)



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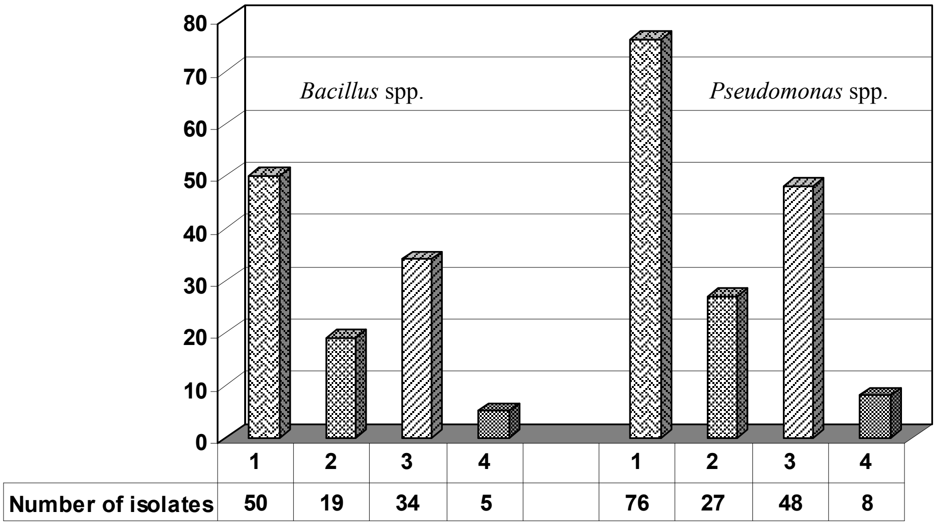
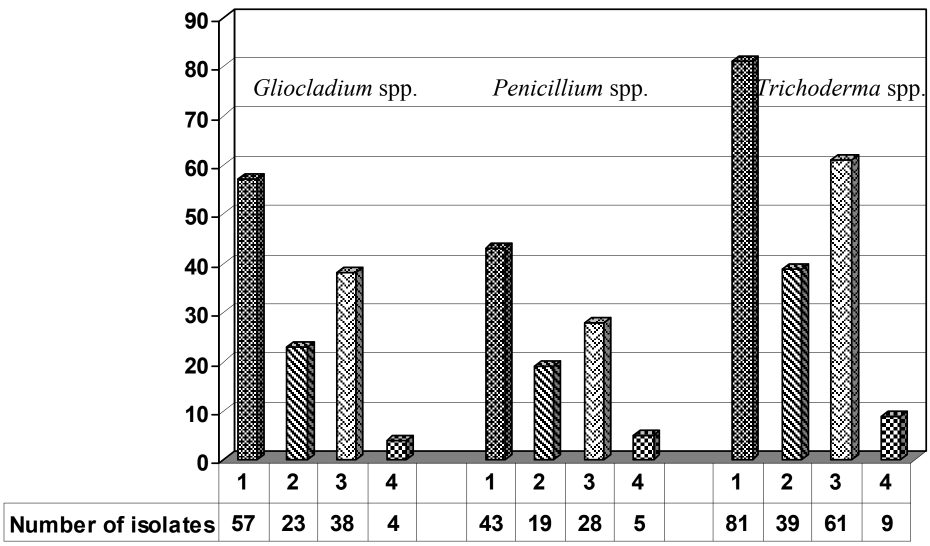
4 – soil without cover crops cultivation

Fig. 3. Total number of fungi isolated from the soil of particular experimental combination (means from the years 2007–2008)



1 – soil after oat cultivation, 2 – soil after tansy phacelia cultivation, 3 – soil after spring vetch cultivation, 4 – soil without cover crops cultivation

Fig. 4. Antagonistic bacteria isolated from the soil of particular experimental combination (sum from the years 2007–2008)



1 – soil after oat cultivation, 2 – soil after tansy phacelia cultivation, 3 – soil after spring vetch cultivation, 4 – soil without cover crops cultivation

Fig. 5. Antagonistic fungi isolated from the soil of particular experimental combination (sum from the years 2007–2008)

organic acids, vitamins, sugars, metal ions, phenolic acids and their derivatives can, for example, inhibit the development of plant pathogens and stimulate the growth and development of antagonistic microorganisms. Essential amino acids occurring in root exudates (tyrosine, phenyloalanine) and alkaline ones (lysine, histidine, arganine) as well as hemicelluloses and celluloses have a negative effect on the growth and development of pathogenic fungi, in this way increasing the population of antagonistic microorganisms [Bending and Lincoln 2000, Pięta and Patkowska 2001]. Pięta and Kęsik [2007] also observed positive effect of spring rye as a mulching plant on the populations of antagonistic bacteria and fungi in the cultivation of onion.

Antagonistic *Bacillus* spp. and *Pseudomonas* spp. exhibited differentiated activity towards the studied fungi pathogenic salsify. The greatest total antagonistic effect of these bacteria towards plant pathogens was observed after oat mulch. It was nearly 12 times higher (+2139) in comparison to control combination (tab. 1). The total antagonistic effect of *Bacillus* spp. and *Pseudomonas* spp. isolated from the soil after the mulch of phacelia was almost four times, and after the mulch of common vetch over twice as small as after oats (tabs 2 and 3). The lowest antagonistic activity of these bacteria was recorded in the traditional cultivation of salsify (tab. 4). Antagonistic bacteria obtained from particular experimental combinations showed the lowest antagonistic activity towards *R. solani* and *S. sclerotiorum.* On the other hand, they much better inhibited the growth and development of fungal pathogens of salsify like *A. alternata*, *F. culmorum* and *F. oxysporum* (tabs 1–4). Antagonistic species of *Pseudomonas* and *Bacillus* have ability to inhibit the growth and development of pathogens through competition, antibiosis and parasitism [Hou et al. 2006, Muthukumar and Bhaskaran 2007]. As reported by Chincholkar et al. [2007], antagonistic activity of *Bacillus* spp. and *Pseudomonas* spp. towards different plant pathogens was due to from their ability to produce HCN, siderophores, lytic enzymes, and to decompose toxins. In addition, differentiated, but similar antagonistic activity of those bacteria towards fungi pathogenic to scorzonera and root chicory cultivated after cover crops was observed in earlier studies [Patkowska and Konopiński 2013b].

The antagonistic activity of different species of *Gliocladium*, *Penicillium* and *Trichoderma* towards studied fungi pathogenic to salsify differed (tabs 5–8). The highest activity of these fungi was observed after mulching the soil with oats it was slightly lower – after common vetch and phacelia as cover crops, while the lowest antagonistic activity was observed for *Gliocladium* spp., *Penicillium* spp. and *Trichoderma* spp. in the case of the conventional cultivation of salsify. These fungi, regardless of the experimental combination, were most effective in inhibiting the growth and development of pathogenic *A. alternata* and *F. culmorum.* They displayed the largest value of the antagonistic effect towards the studied plant pathogens (tabs 5–8). It seems that the positive effect on the activity of *Gliocladium* spp., *Penicillium* spp. and *Trichoderma* spp. in the soil environment of salsify could also have been exerted by the root exudates of cover crops used in the experiment, especially of oats. Hydroxamic acids, which inhibit the development of pathogenic fungi, are present in the root exudates of cereals (mainly rye) [Pięta and Patkowska 2001]. The antagonistic activity of *Gliocladium* spp., *Penicillium* spp. and *Trichoderma* spp. can result from their antibiosis ability, competition and myco-parasitism [Niemi and Lahdenperä 2000, Almeida et al. 2007].

Table 1. Activity of *Bacillus* spp. and *Pseudomonas* spp. isolated from soil after oat cultivation towards pathogenic fungi

Year	Genus of bacteria	Number of antago-nistic isolates	*A. alternata*	*F. culmorum*	*F. oxysporum*	*R. solani*	*S. scle-rotiorum*	Altogether effect of antagonistic activity
			total effect of antagonistic activity					
2007	*Bacillus* spp.	27	+135	+108	+54	+81	+54	+432
	Pseudomonas spp.	47	+235	+141	+141	+188	+141	+846
	Total effect of antagonistic activity		+370	+249	+195	+269	+195	+1278
2008	*Bacillus* spp.	23	+92	+69	+92	+46	+69	+368
	Pseudomonas spp.	29	+145	+58	+116	+87	+87	+493
	Total effect of antagonistic activity		+237	+127	+208	+133	+156	+861
	Altogether effect of antagonistic activity		+607	+376	+403	+402	+351	+2139

Table 2. Activity of *Bacillus* spp. and *Pseudomonas* spp. isolated from soil after tansy phacelia cultivation towards pathogenic fungi

Year	Genus of bacteria	Number of antago-nistic isolates	*A. alternata*	*F. culmorum*	*F. oxysporum*	*R. solani*	*S. scle-rotiorum*	Altogether effect of antagonistic activity
			total effect of antagonistic activity					
2007	*Bacillus* spp.	11	+33	+44	+33	+22	+22	+154
	Pseudomonas spp.	15	+45	+45	+60	+30	+15	+195
	Total effect of antagonistic activity		+78	+89	+93	+52	+37	+349
2008	*Bacillus* spp.	8	+24	+8	+24	+8	+8	+72
	Pseudomonas spp.	12	+48	+24	+36	+24	+12	+144
	Total effect of antagonistic activity		+72	+32	+60	+32	+20	+216
	Altogether effect of antagonistic activity		+150	+121	+153	+84	+57	+565

Table 3. Activity of *Bacillus* spp. and *Pseudomonas* spp. isolated from soil after spring vetch cultivation towards pathogenic fungi

Year	Genus of bacteria	Number of antago-nistic isolates	*A. alternata*	*F. culmorum*	*F. oxysporum*	*R. solani*	*S. scle-rotiorum*	Altogether effect of antagonistic activity
			total effect of antagonistic activity					
2007	*Bacillus* spp.	19	+38	+57	+57	+19	+19	+190
	Pseudomonas spp.	29	+29	+116	+116	+58	+29	+348
	Total effect of antagonistic activity		+67	+173	+173	+77	+48	+538
2008	*Bacillus* spp.	15	+30	+45	+45	+15	+30	+165
	Pseudomonas spp.	19	+57	+38	+57	+38	+38	+228
	Total effect of antagonistic activity		+87	+83	+102	+53	+68	+393
	Altogether effect of antagonistic activity		+154	+256	+275	+130	+116	+931

Table 4. Activity of *Bacillus* spp. and *Pseudomonas* spp. isolated from soil without cover crops cultivation towards pathogenic fungi

Year	Genus of bacteria	Number of antago-nistic isolates	*A. alternata*	*F. culmorum*	*F. oxysporum*	*R. solani*	*S. scle-rotiorum*	Altogether effect of antagonistic activity
			total effect of antagonistic activity					
2007	*Bacillus* spp.	3	+9	+12	+9	+6	+3	+39
	Pseudomonas spp.	4	+16	+16	+16	+8	+8	+64
	Total effect of antagonistic activity		+25	+28	+25	+14	+11	+103
2008	*Bacillus* spp.	2	+4	+8	+8	+4	+1	+25
	Pseudomonas spp.	4	+12	+16	+16	+4	+8	+56
	Total effect of antagonistic activity		+16	+24	+24	+8	+9	+81
	Altogether effect of antagonistic activity		+41	+52	+49	+22	+20	+184

Table 5. Activity of selected saprotrophic fungi isolated from soil after oat cultivation towards pathogenic fungi

Fungus species	Mean number of isolates in 2007–2008	*A. alternata*	*F. culmorum*	*F. oxysporum*	*R. solani*	*S. sclerotiorum*
		GBE – general biotic effect				
Gliocladium catenulatum Gilman et Abbott	20	+120	+140	+100	+80	+60
Gliocladium fimbriatum Gilman et Abbott	20	+80	+100	+80	+60	+80
Gliocladium roseum (Link) Bainier	17	+51	+85	+51	+34	+51
Penicillium janczewskii Zaleski	12	+60	+48	+36	+24	-12
Penicillium janthinellum Biourge	8	+40	+32	+16	+16	+24
Penicillium verrucosum Dierckx var. *cyclopium* (West.) Samson, Stolk et Hadlok	16	+96	+80	+48	+32	+48
Penicillium verrucosum Dierckx var. *verrucosum* Samson, Stolk et Hadlok	7	+35	+28	+21	+14	+7
Trichoderma aureoviride Rifai	16	+128	+96	+96	+80	+96
Trichoderma harzianum Rifai	12	+96	+96	+96	+72	+60
Trichoderma koningii Oud.	34	+272	+272	+272	+204	+204
Trichoderma pseudokoningii Rifai	8	+64	+64	+64	+64	+64
Trichoderma viride Pers. ex. S.F. Gray	11	+88	+88	+88	+66	+66
Number of isolates	181					
Summary biotic effect		+1130	+1129	+968	+746	+748

Table 6. Activity of selected saprotrophic fungi isolated from soil after tansy phacelia cultivation towards pathogenic fungi

Fungus species	Mean number of isolates in 2007–2008	*A. alternata*	*F. culmorum*	*F. oxysporum*	*R. solani*	*S. sclerotiorum*
		GBE – general biotic effect				
Gliocladium catenulatum Gilman et Abbott	13	+78	+52	+52	+26	+39
Gliocladium fimbriatum Gilman et Abbott	10	+50	+50	+40	+30	+20
Penicillium janczewskii Zaleski	4	+20	+16	+12	+8	-8
Penicillium janthinellum Biourge	5	+5	+5	+5	+5	+10
Penicillium verrucosum Dierckx var. *cyclopium* (West.) Samson, Stolk et Hadlok	5	+25	+30	+5	+5	+10
Penicillium verrucosum Dierckx var. *verrucosum* Samson, Stolk et Hadlok	5	+20	+25	+10	+5	+5
Trichoderma koningii Oud.	19	+152	+152	+133	+114	+133
Trichoderma pseudokoningii Rifai	8	+64	+48	+56	+48	+40
Trichoderma viride Pers. ex. S.F. Gray	12	+96	+96	+96	+96	+96
Number of isolates	81					
Summary biotic effect		+510	+474	+409	+337	+345

Table 7. Activity of selected saprotrophic fungi isolated from soil after spring vetch cultivation towards pathogenic fungi

Fungus species	Mean number of isolates in 2007–2008	*A. alternata*	*F. culmorum*	*F. oxysporum*	*R. solani*	*S. sclerotiorum*
		GBE – general biotic effect				
Gliocladium catenulatum Gilman et Abbott	18	+108	+90	+54	+54	+54
Gliocladium fimbriatum Gilman et Abbott	12	+60	+72	+48	+24	+36
Gliocladium roseum (Link) Bainier	8	+32	+32	+40	+32	+32
Penicillium expansum Link ex S. F. Gray	2	-4	+4	+2	-2	-4
Penicillium janczewskii Zaleski	2	124	+10	+6	+4	+4
Penicillium janthinellum Biourge	9	+27	+9	+18	+9	+9
Penicillium verrucosum Dierckx var. *cyclopium* (West.) Samson, Stolk et Hadlok	10	+60	+40	+30	+20	+10
Penicillium verrucosum Dierckx var. *verrucosum* Samson, Stolk et Hadlok	5	+30	+30	+20	+10	+5
Trichoderma aureoviride Rifai	10	+80	+60	+70	+60	+50
Trichoderma harzianum Rifai	14	+112	+112	+112	+84	+70
Trichoderma koningii Oud.	12	+96	+96	+96	+96	+84
Trichoderma pseudokoningii Rifai	10	+80	+80	+70	+60	+60
Trichoderma viride Pers. ex. S.F. Gray	15	+120	+120	+120	+120	+120
Number of isolates	127					
Summary biotic effect		+813	+755	+686	+571	+530

Table 8. Activity of selected saprotrophic fungi isolated from soil without cover crops cultivation towards pathogenic fungi

Fungus species	Mean number of isolates in 2007–2008	*A. alternata*	*F. culmorum*	*F. oxysporum*	*R. solani*	*S. sclerotiorum*
		GBE – general biotic effect				
Gliocladium catenulatum Gilman et Abbott	4	+24	+20	+12	+8	+4
Penicillium lividum Westling	1	+4	+4	+4	+1	+1
Penicillium verrucosum Dierckx var. *cyclopium* (West.) Samson, Stolk et Hadlok	3	+12	+15	+6	+3	+3
Penicillium verrucosum Dierckx var. *verrucosum* Samson, Stolk et Hadlok	1	+5	+4	+2	+1	+1
Trichoderma harzianum Rifai	3	+24	+24	+21	+18	+18
Trichoderma koningii Oud.	4	+32	+28	+28	+24	+24
Trichoderma viride Pers. ex. S.F. Gray	2	+16	+16	+16	+12	+10
Number of isolates	18					
Summary biotic effect		+117	+111	+89	+67	+61

The present studies enable us to state that the use of cover crops (especially oats and common vetch) for soil mulching in the cultivation of *Tragopogon porrifolius* var. *sativus* had a positive effect on the antagonistic activity of soil-borne microorganisms. Trough the increased activity of antagonistic bacteria and fungi the proper species of cover plant can improve the phytosanitary conditions of the soil in a significant way.

CONCLUSIONS

1. Mulching the soil with cover crops can reduce the growth and development of soil-borne fungi pathogenic to salsify.
2. Oats and common vetch are the species favoring the occurrence of antagonistic bacteria and fungi in the soil environment.
3. Oats has the best effect on the antagonistic activity of soil microorganisms in the cultivation of salsify and it can have a positive influence on the healthiness of this plant.

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AKTYWNOŚĆ ANTAGONISTYCZNA WYBRANYCH BAKTERII I GRZYBÓW ŚRODOWISKA GLEBOWEGO SALSEFII (*Tragopogon porrifolius* var. *sativus* (Gaterau) Br.) UPRAWIANEJ PO ROŚLINACH OKRYWOWYCH

Streszczenie. Badania dotyczyły określenia aktywności antagonistycznej mikroorganizmów środowiska glebowego salsefii wobec grzybów patogenicznych: *A. alternata,* *F. culmorum*, *F. oxysporum*, *R. solani* i *S. sclerotiorum.* W doświadczeniu polowym uwzględniono mulczowanie gleby roślinami okrywowymi, takimi jak owies, facelia i wyka siewna. Na podstawie testów laboratoryjnych wskazano owies jako roślinę najkorzystniej wpływającą na liczebność antagonistycznych *Bacillus* spp., *Pseudomonas* spp., *Gliocladium* spp., *Penicillium* spp. i *Trichoderma* spp. Mikroorganizmy te najskuteczniej ograniczały wzrost *A. alternata* i *F. culmorum.* Grzyby antagonistyczne w większym stopniu hamowały wzrost *F. oxysporum*, *R. solani* i *S. sclerotiorum,* aniżeli antagonistyczne bakterie. Mulczowanie gleby roślinami okrywowymi może ograniczać wzrost i rozwój glebowych grzybów patogenicznych dla salsefii.

Słowa kluczowe: mulcz, mikroorganizmy antagonistyczne, grzyby patogeniczne, biotyczne oddziaływanie

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