Occurrence of antagonistic fungi in the soil after cover crops cultivation

E. Patkowska[1], M. Konopiński[2]

[1]*Department of Plant Pathology and Mycology, University of Life Sciences in Lublin, Lublin, Poland*
[2]*Department of Soil Cultivation and Fertilization of Horticultural Plants, University of Life Sciences in Lublin, Lublin, Poland*

ABSTRACT

The purpose of the studies was to determine the species composition of fungi and their antagonistic effect towards soil-borne plant pathogens after the cultivation of oats, spring vetch and tansy phacelia as intercrop cover plants. The total population of fungi in the soil after the cultivation of oats was twice as low as after the cultivation of tansy phacelia. A little smaller fungi population was obtained as a result of mulching the soil with spring vetch in comparison to that after the cultivation of tansy phacelia. The proportion of *Fusarium* spp., *Alternaria alternata*, *Pythium irregulare* and *Thanatephorus cucumeris* isolated from the soil after the cultivation of oats was the lowest one, while being a little higher after the cultivation of spring vetch, and the highest after tansy phacelia. The greatest number of antagonistic fungi occurred in the soil after ploughing in the mulch of oats. Antagonistic fungi isolated from the soil mulched with oats were the most effective in limiting the growth and development of *A. alternata*, *Fusarium culmorum*, *F. oxysporum*, *Haematonectria haematococca*, *P. irregulare* and *T. cucumeris* since the value of their antagonistic effect was the largest. The lowest antagonistic activity of fungi was found out after using tancy phacelia.

Keywords: soil-borne fungi; intercrop plants; antagonistic activity

During vegetation, cultivated plants stimulate or inhibit the development of particular populations of microorganisms in the soil (Patkowska and Konopiński 2013a). Nowadays, the purpose of plant production, especially vegetables, is to obtain good quality of yields without any harmful substances. This became possible thanks to introducing agrotechnical, mechanical and biological methods of plant protection. A special role is played by intercrop cover plants (Borowy 2013, Kołota and Adamczewska-Sowińska 2013, Patkowska and Konopiński 2013a,b). Used as green fertilizers, after ploughing in they provide the organic mass and mineral elements to the soil. Depending on the species, cover crops exert varying effects on the physical properties of the soil, weed infestation, communities of soil-borne microorganisms and plants' healthiness (Lithourgidis et al. 2011, Brainard et al. 2012, Patkowska and Konopiński 2013b).

The organic matter introduced into the soil in the form of roots or green mass, fertilizes the soil, improves the soil aggregated structure, increases the water and sorptive capacity and contributes to increased biological activity of this environment (Hirpa et al. 2009, Błażewicz-Woźniak and Wach 2012). Stimulating the growth of saprotrophic microorganisms, especially those of antagonistic effect on plant pathogens, the organic matter can inhibit the development of pathogens, reduce the occurrence of plant diseases and improve yield quality (Dhimmar 2009, Konopiński et al. 2013, Patkowska and Konopiński 2013a).

The purpose of the studies was to establish the species composition of fungi and their antagonistic

Supported by the Ministry of Science and Higher Education of Poland, Project No. 2 P06 R 01429.

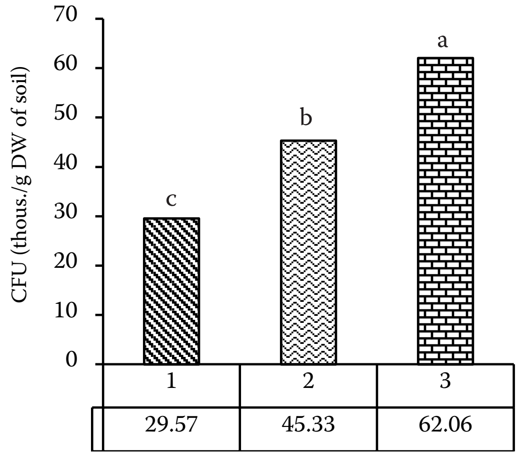


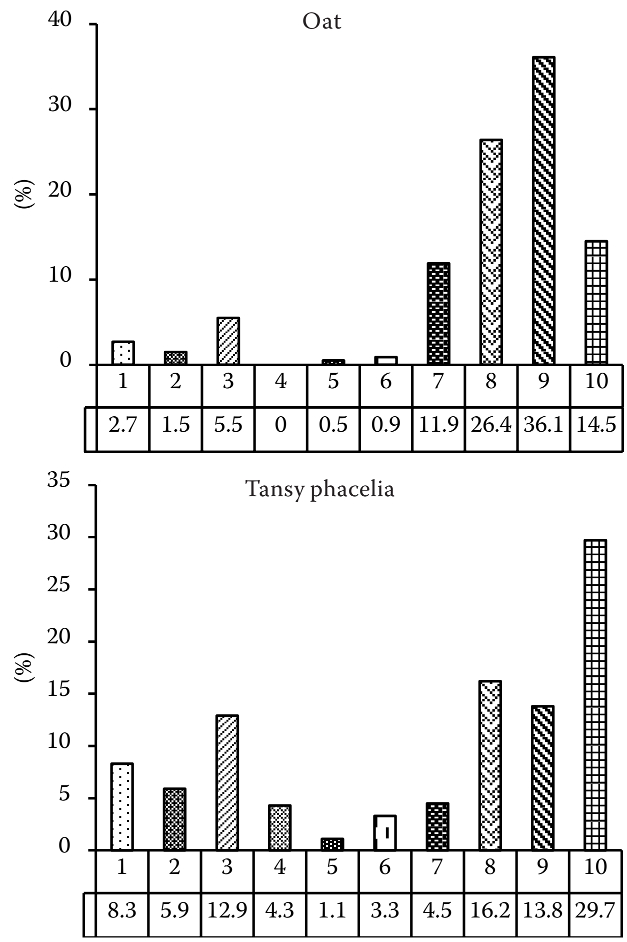
Figure 1. Average number of microorganisms isolated from the soil after oat (1), spring vetch (2) and tansy phacelia (3) cultivation (means from the years 2006–2008). Means differ significantly ($P < 0.05$) if they are not marked with the same letter

effect towards soil-borne plant pathogens after the cultivation of oats, spring vetch and tansy phacelia as mulching cover crops.

MATERIAL AND METHODS

Fieldwork. The studies were conducted in years 2006–2008 in the Felin Experimental Station belonging to the University of Life Sciences in Lublin, district of Lublin (22°56'E, 51°23'N, Central Eastern Poland, 200 m a.s.l.), on a grey-brown podzolic soil. Completely randomized blocks method at four replications was used in the experiment. The object of the studies was the soil sampled every year in the second 10-days' period of June from the depth of 5–6 cm of the plough layer of the field where scorzonera (*Scorzonera hispanica* L.) cv. Duplex was cultivated. Soil mulching with intercrop cover plants such as oats, spring vetch and tansy phacelia were considered in the cultivation of that vegetable.

Laboratory analyses. Microbiological analysis was made according to the method described by Czaban et al. (2007). The soil was sampled from each experimental combination from four randomly chosen places. Martin's medium was used to establish fungi number. After incubation,



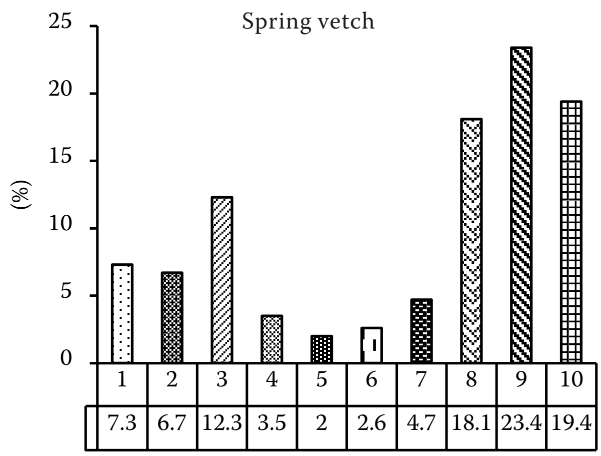


Figure 2. Participation of microorganisms isolated from the soil after oat, spring vetch or tansy phacelia cultivation (total from the years 2006–2008). 1 – *Alternaria alternata*; 2 – *Fusarium culmorum*; 3 – *F. oxysporum*; 4 – *Haematonectaria haematococca*; 5 – *Pythium irregulare*; 6 – *Thanatephorus cucumeris*; 7 – *Clonostachys* spp. and *Myrothecium* spp.; 8 – *Penicillium* spp.; 9 – *Trichoderma* spp.; 10 – other saprotrophic fungi

Table 1. Activity of selected saprotrophic fungi isolated from soil after oat cultivation towards pathogenic microorganisms

Fungus species	Mean number of isolates in 2006–2008	General biotic effect					
		A. alternata	*F. culmorum*	*F. oxysporum*	*H. haematococca*	*P. irregulare*	*T. cucumeris*
Clonostachys compacta Petch	11	44	66	55	55	6	66
Clonostachys rosea (Link) Schroers, Samuels, Seifert et W. Gams	14	56	42	84	70	70	84
Myrothecium verrucaria (Alb. et Schwein) Ditmar	23	69	69	69	92	115	115
Penicillium aurantiogriseum Dierckx	19	57	57	38	38	38	38
Penicillium chermesinum Biourge	3	6	3	3	6	6	3
Penicillium chrysogenum Thom	12	–24	12	12	12	12	24
Penicillium expansum Link ex S. F. Gray	8	8	8	8	16	8	8
Penicillium janczewskii Zalessky	14	42	42	42	56	56	–28
Penicillium simplicissimum (Oudem.) Thom	8	16	8	8	8	8	16
Penicillium lividum Westling	10	–20	–10	–10	10	10	–20
Penicillium verrucosum Dierckx	32	96	96	64	64	32	32
Trichoderma aureoviride Rifai	33	198	198	264	264	231	231
Trichoderma harzianum Rifai	23	161	161	161	184	184	161
Trichoderma koningii Oud.	28	224	224	224	224	224	224
Trichoderma pseudokoningii Rifai	13	104	104	104	104	104	104
Trichoderma piluliferum Webster et Rifai	11	77	77	88	88	88	77
Trichoderma viride Pers.	37	296	296	296	296	296	296
Number of isolates	299						
Summary biotic effect		1410	1453	1530	1587	1548	1431

the number of fungi colonies was converted into 1 g dry weight (DW) of the soil and the obtained isolates were determined.

In each studied year, all fungi isolates from the genera of *Clonostachys*, *Myrothecium*, *Penicillium* and *Trichoderma*, obtained from particular experimental combinations, were used to establish their antagonistic effect towards such fungi and fungal-like as *Alternaria alternata*, *Fusarium culmorum*, *F. oxysporum*, *Haematonectria haematococca*, *Pythium irregulare* and *Thanatephorus cucumeris* (isolated from the infected scorzonera plants). The effect of this saprotrophic fungi on the studied pathogenic microorganism was estimated 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) and the total antagonistic effect was calculated.

Statistical analysis. The total population of fungi was statistically analyzed, and the significance of differences was determined on the basis of the Tukey's confidence intervals ($P < 0.05$). Statistical calculations were carried out using the Statistica program, version 6.0 (StatSoft Inc., Krakow, Poland).

RESULTS AND DISCUSSION

The total fungi population in 1 g DW of the soil after the cultivation of oats was twice as low as in the combination with tansy phacelia, and it was 29.57×10^3 and 62.06×10^3 CFU/g of soil DW. Statistically significantly smaller population of

Table 2. Activity of selected saprotrophic fungi isolated from soil after spring vetch cultivation towards pathogenic microorganism

Fungus species	Mean number of isolates in 2006–2008	General biotic effect					
		A. alternata	*F. culmorum*	*F. oxysporum*	*H. haematococca*	*P. irregulare*	*T. cucumeris*
Clonostachys compacta Petch	8	24	24	40	40	40	40
Clonostachys rosea (Link) Schroers, Samuels, Seifert et W. Gams	6	18	18	24	24	24	12
Myrothecium verrucaria (Alb. et Schwein) Ditmar	2	6	6	6	8	8	8
Penicillium aurantiogriseum Dierckx	13	26	26	13	13	13	13
Penicillium chrysogenum Thom	16	16	16	16	32	16	16
Penicillium expansum Link	1	–2	–1	1	–1	–1	–2
Penicillium janczewskii Zalessky	6	12	12	12	18	18	–12
Penicillium simplicissimum (Oudem.) Thom	1	1	1	1	1	1	1
Penicillium lividum Westling	3	3	3	3	6	3	3
Penicillium verrucosum Dierckx	22	44	44	44	44	22	22
Trichoderma aureoviride Rifai	15	90	90	105	90	90	105
Trichoderma harzianum Rifai	8	48	32	48	64	56	48
Trichoderma koningii Oud.	17	136	136	136	136	136	136
Trichoderma pseudokoningii Rifai	6	48	48	48	48	48	48
Trichoderma piluliferum Webster et Rifai	7	28	42	42	35	42	42
Trichoderma viride Pers.	27	216	216	216	216	216	216
Number of isolates	158						
Summary biotic effect		714	713	755	774	732	696

total fungi as compared to the cultivation of tansy phacelia was obtained as a result of mulching the soil with spring vetch (mean 45.33 × 10^3 CFU/g of soil DW) (Figure 1). The species composition of microorganism communities isolated from the soil after the cultivation of oats, spring vetch or tansy phacelia was similar. The proportion of particular microorganism species differed depending on the species of the cover crops (Figure 2). The number of microorganism obtained from the soil after the cultivation of oats was the smallest, slightly bigger – after the cultivation of spring vetch, and the biggest – after tansy phacelia cultivation.

Antagonistic *Clonostachys* spp., *Myrothecium* spp., *Penicillium* spp. and *Trichoderma* spp. isolated from the soil after oat cultivation were the most effective in inhibiting the growth and development of *H. haematococca*, *F. oxysporum* and *P. irregulare* since the obtained value of antagonistic effect from three-year-long studies was 1587, 1530 and 1548, respectively (Table 1). Antagonistic fungi obtained from this experimental combination proved to be equally effective in inhibiting the growth of *A. alternata*, *F. culmorum* and *T. cucumeris* since the total value of antagonistic effect was 1410, 1453 and 1431, respectively. Within antagonistic fungi isolated from the soil after the cultivation of spring vetch, the smallest antagonistic effect was found out for *T. cucumeris,* its value being 696. Studied fungi isolated from the soil after the cultivation of spring vetch were the most effective in inhibiting the growth and development of *F. oxysporum* and *H. haematococca* since the value of their antagonistic effect was 755 and 774, respectively (Table 2). The number of antagonistic fungi isolated from the soil after tansy phacelia cultivation was the lowest and they were the least effective in inhibiting the growth of *T. cucumeris*

Table 3. Activity of selected saprotrophic fungi isolated from soil after tansy phacelia cultivation towards pathogenic microorganisms

Fungus species	Mean number of isolates in 2006–2008	General biotic effect					
		A. alternata	*F. culmorum*	*F. oxysporum*	*H. haematococca*	*P. irregulare*	*T. cucumeris*
Clonostachys compacta Petch	4	12	12	16	16	16	16
Clonostachys rosea (Link) Schroers, Samuels, Seifert et W. Gams	9	27	27	36	27	36	18
Myrothecium verrucaria (Alb. et Schwein) Ditmar	6	12	12	18	24	18	12
Penicillium aurantiogriseum Dierckx	8	8	16	8	8	8	8
Penicillium chermesinum Biourge	12	12	12	12	–24	–12	–36
Penicillium chrysogenum Thom	5	5	5	5	5	5	10
Penicillium expansum Link	7	–14	–14	7	–7	–7	–14
Penicillium janczewskii Zalessky	7	7	14	7	14	14	–14
Penicillium simplicissimum (Oudem.) Thom	3	3	3	3	3	3	3
Penicillium lividum Westling	2	2	4	4	2	4	2
Penicillium verrucosum Dierckx	25	50	50	50	50	25	25
Trichoderma aureoviride Rifai	6	30	36	36	36	36	36
Trichoderma harzianum Rifai	14	84	56	84	98	84	84
Trichoderma koningii Oud.	12	96	84	96	96	96	96
Trichoderma pseudokoningii Rifai	6	48	42	42	42	48	42
Trichoderma piluliferum Webster et Rifai	4	12	24	24	20	24	24
Trichoderma viride Pers.	17	136	136	136	136	136	136
Number of isolates	147						
Summary biotic effect		530	519	584	546	534	448

colonies (the value of antagonistic effect 448. Those fungi proved to be the most effective in inhibiting the growth of *F. oxysporum* since the value of their antagonistic effect was 584 (Table 3).

Oats used for soil mulching gave the best results in stimulating the development of antagonistic fungi as compared to spring vetch or tansy phacelia. The positive effect of spring rye on the populations of antagonistic fungi in the cultivation of onion was found out by Pięta and Kęsik (2007). The greatest antagonistic effect towards plant pathogens was observed in the species from genus *Trichoderma*. This genus is known for its special competitive abilities, antibiosis and mycoparasitism (Schuster and Schmoll 2010). *Trichoderma* spp. produce a lot of antibiotics and can colonize the organic substance in the soil a very fast as they are characterized with very fast growth and abundant sporulation (Tallapragada and Gudimi 2011).

REFERENCES

Błażewicz-Woźniak M., Wach D. (2012): The fertilizer value of summer catch crops preceeding vegetables and its variation in the changing weather conditions. Acta Scientiarum Polonorum, Hortorum Cultus, *11*: 101–116.

Borowy A. (2013): Growth and yield of ‘Hamburg’ parsley under no-tillage cultivation using white mustard as a cover crop. Acta Scientiarum Polonorum, Hortorum Cultus, *12*: 13–32.

Brainard D.C., Bakker J., Noyes D.C., Myers N. (2012): Rye living mulch effects on soil moisture and weeds in asparagus. Horticultural Science, *47*: 58–63.

Czaban J., Gajda A., Wróblewska B. (2007): The mobility of bacteria from rhizosphere and different zones of winter wheat roots. Polish Journal of Environmental Studies, *16*: 301–308.

Dhimmar S.K. (2009): Effect on growth and yield of *rabi* castor in pulses intercropping under varying planting geometry. American-Eurasian Journal of Scientific Research, *4*: 165–168.

Hirpa T., Gebrekidan H., Tesfaye K., Hailemariam A. (2009): Biomass and nutrient accumulation of green manuring legumes terminated at different growth stages. European Journal of Jewish Studies, *3*: 18–28.

Kołota E., Adamczewska-Sowińska K. (2013): Living mulches in vegetable crops production: Perspectives and limitations (a reviev). Acta Scientiarum Polonorum, Hortorum Cultus, *12*: 127–142.

Konopiński M., Kęsik T., Błażewicz-Woźniak M. (2013): The effect of intercrops and ploughing term on the structure of yield and some qualities of salsify (*Tragopogon porrifolius* L.) roots. Acta Scientiarum Polonorum, Hortorum Cultus, *12*: 35–45.

Lithourgidis A.S., Dordas C.A., Damalas C.A., Vlachostergios D.N. (2011): Annual intercrops: An alternative pathway for sustainable agriculture. Australian Journal of Crop Science, *5*: 396–410.

Mańka K., Kowalski S. (1968): The effect of communities of soil-borne fungi from two forest nurseries (pine and ash) on the development of necrotic fungus (*Fusarium oxysporum* Schl.). Poznańskie Towarzystwo Przyjaciół Nauk, *25*: 197–205. (In Polish)

Mańka K., Mańka M. (1992): A new method for evaluating interaction between soil inhibiting fungi and plant pathogens. New approaches in biological control of soil-borne diseases. Bulletin OILB/SROP, *XV*: 73–75.

Patkowska E., Konopiński M. (2013a): Effect of cover crops on the microorganisms communities in the soil under scorzonera cultivation. Plant, Soil and Environment, *59*: 460–464.

Patkowska E., Konopiński M. (2013b): Harmfulness of soil-borne fungi towards root chicory (*Cichorium intybus* L. var. *sativum* Bisch.) cultivated with the use of cover crops. Acta Scientiarum Polonorum, Hortorum Cultus, *12*: 3–18.

Pięta D., Kęsik T. (2007): The effect of conservation tillage on microorganism communities in the soil under onion cultivation. Electronic Journal of Polish Agricultural Universities, Horticulture, *10*. Available at http://www.ejpau.media.pl/volume10/issue1/art.-21.html

Schuster A., Schmoll M. (2010): Biology and biotechnology of *Trichoderma*. Applied Microbiology and Biotechnology, *87*: 787–799.

Tallapragada P., Gudimi M. (2011): Phosphate solubility and biocontrol activity of *Trichoderma harzianum*. Turkish Journal of Biology, *35*: 593–600.

Received on January 21, 2014
Accepted on April 1, 2014

Corresponding author:

Dr. hab. Elżbieta Patkowska, University of Life Sciences in Lublin, Department of Plant Pathology and Mycology, Leszczyńskiego 7, 20 069 Lublin, Poland
e-mail: elzbieta.patkowska@up.lublin.pl