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AN INTERACTION OF POTATO CROP SOIL FUNGI POPULATION ON FUNGI RESPONSIBLE FOR TUBER SUPERFICIAL DISEASES

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Abstract: A biotic interaction between fungi from soil within and outside the rhizosphere of potato and fungi responsible for black scurf – *Rhizoctonia solani* Kühn and silver scurf – *Helminthosporium solani* (Dur., Mont.). It was found that fungi population connected with crop environment under investigation promoted the growth of *Rhizoctonia solani*, thus indicating no resistance of this environment to this pathogen. These fungi, however, inhibited the growth of *Helminthosporium solani*.

Key words: biotic effect, *Rhizoctonia solani*, *Helminthosporium solani*, potato, soil, rhizosphere

INTRODUCTION

The potato tuber superficial diseases, that in Poland include mainly rhizoctonia (black scurf) and silver scurf, are very common and lead to crop losses. In addition, they deteriorate the potato market, seed and processing values (Kurzawińska et al. 2001; Lutomirska 1999).

Rhizoctonia solani colonizes soil practically over the entire potato crop area. A number of authors (Bogucka 1983; Kućmierz et al. 1993; Kurzawińska 1997; Weber 1987) state that environmental conditions have a major effect on the occurrence of this soil fungus and the degree of infection.

Silver scurf caused by *Helminthosporium solani* is a common disease in the entire territory of Poland. Young tubers are infected in the early stage of tuberization, by the mid of July, at earliest. The disease develops during harvesting and storage (Cayley et al. 1983; Kurzawińska 1990).

The knowledge of soil environment where plants grow, plays a considerable role in providing its advantageous features to assure satisfactory health state of plants, thus enhancing potato crops. This goal can be achieved only if ecological conditions of agricultural crops are more deeply understood. According to Mańka (1990), the

microflora present in soil environment plays a multifunctional role, including that highly connected with health state of cultivated plants.

MATERIALS AND METHODS

The two-year field experiments were carried out at the Agricultural Experimental Station at the Agricultural University in Prusy near Cracow. An effect of soil fungi on the growth of *Rhizoctonia solani* and *Helminthosporium solani* was investigated. The experiments were carried out on degraded black-earth with loess subsoil of high culture. In both years of experiments winter wheat was a forecrop. The autumn organic fertilizing at amount of 30 t/ha of farmyard manure was carried out. Before potato seeding phosphorus fertilizing was carried out in the form of 120 kg/ha of superphosphate, 180 kg/ha K_2O in potash salt, and nitrogen at amount of 150 kg/ha in ammonium nitrate. The treatment of the experiment fields made during the vegetation period complied with commonly accepted practices.

The mycological soil examinations for crops of the potato cultivar Mila were carried out in compliance with the sand method (Mańka 1974). The fungi were isolated from the soil within and outside the rhizosphere during the potato sprouting period.

To recognize biotic functions of soil fungi populations to *R. solani* and *H. solani* the saprophytic species being the most common among all colonies (75–80%) were insulated as environment representatives. During experiments the method of series was employed – see Mańka (1974).

RESULTS

In both years of experiments the examination of saprobiotic fungi populations from soil within and outside the rhizosphere of potato crop showed no ability to inhibit the growth of *R. solani*. This led to negative overall biotic effect equal to –322; –431 (Table 1) and –388; –269 (Table 2), in the year 1 and year 2, respectively.

During two years of experiments the examined fungi populations taken both within and outside the rhizosphere of potato demonstrated higher resistance to *H. solani*, as estimated from positive values of overall biotic effect to this pathogen. The figures of such effect were +127; +51 (Table 3) and +98; +172 (Table 4) for year 1 and year 2, accordingly.

One may conclude from the analysis of biotic relations between saprobiotic fungi populations predominating in crop environment under investigation and its pathogens that the fungi higher resistance to *H. solani* than to *R. solani*.

The highest individual biotic effects to the examined pathogens were found for the following saprobiotic fungi species: *Trichoderma viride, T. polysporum, T. hamatum, T. harzianum, T. koningii, Mucor circinelloides f. circinelloides, M. hiemalis f. hiemalis.* (Table 1–4). In addition, the fungus *R. solani* showed a strong antagonistic activity to *H. solani* (Table 4).

Table 1. The effect of fungal communities isolated from the soil outside the rhizosphere and from the potato rhizosphere on the growth of *Rhizoctonia solani* Kühn (first year of studies)

Species of fungus	Frequency	Biotic effect	
		IBE	GBE
Soil			
Fusarium oxysporum (Schlecht.) Snyd. et Hans.	16	–4	–64
Penicillium waksmanii Zaleski	16	–6	–96
Trichoderma viride Pers. ex Gray	15	+8	+120
Aspergillus niger van Tiegh.	14	–4	–56
Cladosporium herbarum (Pers.) Link ex Gray	14	–3	–42
Aspergillus clavatus Desm.	13	–3	–39
Alternaria alternata (Fr.) Keissl.	12	–3	–36
Penicillium expansum (Link ex Gray) Thom	12	–4	–48
Torula graminis Desm.	12	–4	–48
Coniothyrium fuckelii Sacc.	11	–7	–77
Mucor circinelloides van Tiegh *f. circinelloides*	10	+7	+70
Trichoderma koningii Oudem.	10	+6	+60
Trichoderma polysporum (Link ex Pers.) Rifai	10	+6	+60
Scopulariopsis brumptii Salvanet-Duval	9	–6	–54
Penicillium canescens Sopp	8	–6	–48
Sordaria fimicola (Roberge) Ces. et de Not.	8	–3	–24
Number of isolates	190		
Summary biotic effect			–322
Rhizosphere			
Penicillium waksmanii Zaleski	21	–6	–126
Fusarium oxysporum (Schlecht.) Snyd. et Hans.	20	–4	–80
Trichoderma viride Pers. ex Gray	14	+8	+112
Torula graminis Desm.	13	–4	–52
Coniothyrium fuckelii Sacc.	12	–7	–84
Aspergillus clavatus Desm.	11	–3	–33
Penicillium chrysogeum Thom	11	–4	–44
Phoma exigua v. exigua Desm.	11	–6	–66
Trichoderma koningii Oudem.	11	+6	+66
Penicillium expansum (Link ex Gray) Thom	10	–4	–40
Trichoderma harzianum Rifai	10	+6	+60
Aspergillus flavus Link ex Gray	9	–4	–36
Mucor hiemalis f. hiemalis Wehmer	9	+6	+54
Penicillium canescens Sopp	9	–6	–54
Penicillium frequentans Westling	9	–6	–54
Penicillium spinulosum Thom	9	–6	–54
Number of isolates	189		
Summary biotic effect			–431

IBE – individual biotic effect, GBE – general biotic effect

Table 2. The effect of fungal communities isolated from the soil outside the rhizosphere and from the potato rhizosphere on the growth of *Rhizoctonia solani* Kühn (second year of studies)

Species of fungus	Frequency	Biotic effect	
		IBE	GBE
Soil			
Coniothyrium fuckelii Sacc.	18	–7	–126
Penicillium restrictum Galman et Abbott	16	–6	–96
Cladosporium cladosporioides (Fres.) de Vries	15	–3	–45
Fusarium oxysporum (Schlecht.) Snyd. et Hans.	15	–4	–60
Penicillium verrucosum Dierckx *v. verrucosum* Samson	15	–6	–90
Trichoderma viride Pers. ex Gray	15	+8	+120
Phoma eupyrena Sacc.	13	–5	–65
Alternaria alternata (Fr.) Keissl.	12	–3	–36
Sordaria fimicola (Roberge) Ces. et de Not.	12	–3	–36
Penicillium waksmanii Zaleski	11	–6	–66
Trichoderma polysporum (Link ex Pers.) Rifai	11	+6	+66
Mucor hiemalis Wehmer *f. hiemalis*	9	+6	+54
Rhizoctonia solani Kühn	9	0	0
Acremoniium butyri (van Beyma) W. Gams	8	–7	–56
Trichoderma harzianum Rifai	8	+6	+48
Number of isolates	187		
Summary biotic effect			–388
Rhizosphere			
Trichoderma viride Pers. ex Gray	19	+8	+152
Mucor hiemalis Wehmer *f. hiemalis*	16	+6	+96
Rhizoctonia solani Kühn	14	0	0
Trichoderma hamatum (Bon.) Bain.	14	+6	+84
Fusarium oxysporum (Schlecht.) Snyd. et Hans.	13	–4	–52
Mortierella vinacea Nixon–Stewart	12	–7	–84
Penicillium spinulosum Thom	12	–6	–72
Penicillium restrictum Gilman et Abbott	11	–6	–66
Penicillium verrucosum Dierckx *v. verrucosum* Samson	11	–6	–66
Penicillium canescens Sopp	10	–6	–60
Penicillium frequentans Westling	10	–6	–60
Penicillium waksmanii Zaleski	10	–6	–60
Cladosporium cladosporioides (Fres.) de Vries	9	–3	–27
Penicillium chrysogeum Thom	9	–6	–54
Penicillium vermiculatum Dangeard	9	–6	–54
Trichoderma koningii Oudem.	9	+6	+54
Number of isolates	188		
Summary biotic effect			–269

IBE – individual biotic effect, GBE – general biotic effect

Table 3. The effect of fungal communities isolated from the soil outside the rhizosphere and from the potato rhizosphere on the growth of *Helminthosporium solani* Dur. Mont. (first year of studies)

Species of fungus	Frequency	Biotic effect	
		IBE	GBE
Soil			
Fusarium oxysporum (Schlecht.) Snyd. et Hans.	16	+3	+48
Penicillium waksmanii Zaleski	16	–4	–64
Trichoderma viride Pers. ex Gray	15	+8	+120
Aspergillus niger van Tiegh.	14	–2	–28
Cladosporium herbarum (Pers.) Link ex Gray	14	–2	–28
Aspergillus clavatus Desm.	13	–1	–13
Alternaria alternata (Fr.) Keissl.	12	+1	+12
Penicillium expansum (Link ex Gray) Thom	12	–2	–24
Torula graminis Desm.	12	–2	–24
Coniothyrium fuckelii Sacc.	11	–3	–33
Mucor circinelloides van Tiegh. *f. circinelloides*	10	+7	+70
Trichoderma koningii Oudem.	10	+7	+70
Trichoderma polysporum (Link ex Pers.) Rifai	10	+8	+80
Scopulariopsis brumptii Salvanet-Duval	9	–3	–27
Penicillium canescens Sopp	8	–3	–24
Sordaria fimicola (Roberge) Ces. et de Not.	8	–1	–8
Number of isolates	190		
Summary biotic effect			+127
Rhizosphere			
Penicillium waksmanii Zaleski	21	–4	–84
Fusarium oxysporum (Schlecht.) Snyd. et Hans.	20	+3	+60
Trichoderma viride Pers. ex Gray	14	+8	+112
Torula graminis Desm.	13	–2	–26
Coniothyrium fuckelii Sacc.	12	–3	–36
Aspergillus clavatus Desm.	11	–1	–11
Penicillium chrysogenum Thom	11	–2	–22
Phoma exigua Desm. *v. exigua*	11	–3	–33
Trichoderma koningii Oudem.	11	+7	+77
Penicillium expansum (Link ex Gray) Thom	10	–2	–20
Trichoderma harzianum Rifai	10	+7	+70
Aspergillus flavus Link ex Gray	9	–2	–18
Mucor hiemalis Wehmer *f. hiemalis*	9	+7	+63
Penicillium canescens Sopp	9	–3	–27
Penicillium frequentans Westling	9	–3	–27
Penicillium spinulosum Thom	9	–3	–27
Number of isolates	189		
Summary biotic effect			+51

IBE – individual biotic effect, GBE – general biotic effect

Table 4. The effect of fungal communities isolated from the soil outside the rhizosphere and from the potato rhizosphere on the growth of *Helminthosporium solani* Dur. Mont. (second year of studies)

Species of fungus	Frequency	Biotic effect	
		IBE	GBE
Soil			
Coniothyrium fuckelii Sacc.	18	–3	–54
Penicillium restrictum Gilman et Abbott	16	–4	–64
Cladosporium cladosporioides (Fres.) de Vries	15	–2	–30
Fusarium oxysporum (Schlecht.) Snyd. et Hans.	15	+3	+45
Penicillium verrucosum Dierckx *v. verrucosum* Samson	15	–4	–60
Trichoderma viride Pers. ex Gray	15	+8	+120
Phoma eupyrena Sacc.	13	–4	–52
Alternaria alternata (Fr.) Keissl.	12	+1	+12
Sordaria fimicola (Roberge) Ces. et de Not.	12	–1	–12
Penicillium waksmanii Zaleski	11	–4	–44
Trichoderma polysporum (Link ex Pers.) Rifai	11	+8	+88
Mucor hiemalis Wehmer *f. hiemalis*	9	+7	+63
Rhizoctonia solani Kühn	9	+6	+54
Acremoniium butyri (van Beyma) W. Gams	8	–3	–24
Trichoderma harzianum Rifai	8	+7	+56
Number of isolates	187		
Summary biotic effect			+98
Rhizosphere			
Trichoderma viride Pers. ex Gray	19	+8	+152
Mucor hiemalis Wehmer *f. hiemalis*	16	+7	+112
Rhizoctonia solani Kühn	14	+6	+84
Trichoderma hamatum (Bon.) Bain.	14	+7	+98
Fusarium oxysporum (Schlecht.) Snyd. et Hans.	13	+3	+39
Mortierella vinacea Nixon–Stewart	12	–5	–60
Penicillium spinulosum Thom	12	–3	–36
Penicillium restrictum Gilman et Abbott	11	–4	–44
Penicillium verrucosum Dierckx *v. verrucosum* Samson	11	–4	–44
Penicillium canescens Sopp	10	–4	–40
Penicillium frequentans Westling	10	–4	–40
Penicillium waksmanii Zaleski	10	–4	–40
Cladosporium cladosporioides (Fres.) de Vries	9	–2	–18
Penicillium chrysogenum Thom	9	–2	–18
Penicillium vermiculatum Dangeard	9	–4	–36
Trichoderma koningii Oudem.	9	+7	+63
Number of isolates	188		
Summary biotic effect			+172

IBE – individual biotic effect, GBE – general biotic effect

DISCUSSION

It was found that the examined fungi populations were highly diversified and comprised a wide variety of species. According to Alexander (1975) biocenoses of large number of species are more stable and less vulnerable to destructive impacts than poorly diversified environments. The stability of soil fungi populations enhanced by flora is reported by many authors (Choroszewski 1989; Dorenda 1986; Kurzawińska 1994; Kutrzeba 1983; Wagner 1990).

Saprobiotic fungi populations from soil within and outside the rhizosphera of potato crop showed no ability to inhibit the growth of *R. solani.* The same conclusion was drawn from previous papers Kurzawińska (1979, 1994). Also other authors (Shan-da Liu and Baker 1980) proved that the pathogen *R. solani* encountered no strong enough antagonists in the soil environments.

An inhibiting effect on the growth of pathogen depend mainly on the proportion of antagonistic fungi in the soil environment under consideration.

A strong antagonistic effect of the fungi *Trichoderma* to the pathogens of cultivated plants was proven by Kurzawińska (1994), Levis and Papavizas (1983), Mańka (1990).

The research studies on non-pathogenic fungi present in the host plant environment are of crucial importance for establishing micro-environmental conditions for plant pathogen occurrence, thus also for developing non-chemical (pro-ecological) plant protection methods (Mańka and Mańka 1993).

CONCLUSIONS

1. The fungi taken both within and outside the rhizosphere of potato has shown a growth inhibiting effect on *H. solani.* This pathogen appeared to be a weak competitor in a struggle for existence with saprophytic fungi, as was proven by positive overall biotic effects.
2. An investigation of biotic relations indicated that fungi populations related to cultivation environment under examination promoted the growth of *R. solani.*
3. The fungi *Trichoderma* belonged to the most antagonistic species to both pathogens under investigation.
4. Mycological examinations of fungi populations present in potato crop environment may explain an effect of agrotechnical factors on health state of this plant.

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POLISH SUMMARY

ODDZIAŁYWANIE ZBIOROWISK GRZYBÓW ŚRODOWISKA GLEBOWEGO Z UPRAWY ZIEMNIAKA NA GRZYBOWYCH SPRAWCÓW CHORÓB SKÓRKI BULW

Scharakteryzowano oddziaływanie biotyczne między grzybami z gleby pozaryzosferowej i ryzosfery ziemniaka a sprawcą ospowatości bulw – *Rhizoctonia solani* Kűhn i parcha srebrzystego – *Helminthosporium solani* (Dur., Mont.). Stwierdzono, że zbiorowiska grzybów związane z analizowanym środowiskiem uprawnym sprzyjały wzrostowi *R. solani*, co wskazuje na brak oporu środowiska w stosunku do tego patogena. Natomiast grzyby te ograniczały wzrost *H. solani.*