JOURNAL OF PLANT PROTECTION RESEARCH
Vol. 41, No. 2 2001

COMMUNITIES OF FUNGI AND BACTERIA IN THE RHIZOSPHERE OF POTATO AND THEIR EFFECT ON PHYTOPATHOGENS

DANUTA PIĘTA, ELŻBIETA PATKOWSKA, ALINA PASTUCHA

AGRICULTURAL UNIVERSITY, DEPARTMENT OF PHYTOPATHOLOGY,
LESZCZYŃSKIEGO 7, 20-069 LUBLIN, POLAND
e-mail: dpieta@consus.ar.lublin.pl

Abstract. The purpose of the studies carried out in the years 1996-1998 was to establish the composition of bacteria and fungi communities in the potato rhizosphere and non-rhizosphere soil. Besides, in the examined samples the studies established the proportion of bacteria and fungi antagonistic towards soilborne pathogens. The microbiological analysis of 1 g of dry weight of soil coming from the rhizosphere of potato revealed from 3.96×10^6 to 7.26×10^6 bacteria colonies and from 51.38×10^3 to 69.96×10^3 fungi colonies. In the case of non-rhizosphere soil of 1 g of dry weight of soil revealed from 3.50×10^6 to 4.75×10^6 bacteria colonies and from 16.16×10^3 to 34.10×10^3 fungi colonies. Moreover, potato cultivation had a positive effect on the increase of numbers of antagonistic bacteria (*Bacillus* spp. and *Pseudomonas* spp.) and fungi (*Gliocladium* spp., *Penicillium* spp., *Trichoderma* spp.). A larger number of the communities of bacteria and fungi, including antagonistic ones, in the root area of potato, indicates considerable biological activity, which contributes to a better phytosanitary condition of the soil.

Key words: potato, rhizopshere, pathogenic fungi, antagonistic microorganisms

I. INTRODUCTION

Rhizopshere is characterized by the largest biological activity. The compounds exudated by roots and the flaking root cells (Funck-Jensen and Hockenhull 1984; Huber and Watson 1970; Rovira 1965; 1969; Schroth and Hildebrand 1964) and the remaining roots (Batalin 1962) are the main stimulators of microorganisms development in the period of vegetation. Root exudates are a rich source of amino-acids, sugars, organic acids, vitamins, metal ions, phenol acids and their derivatives (Funck-Jensen and Hockenhull 1984; Pięta 1988; Sytnik et al. 1977). Among the enumerated compounds, sugars soluble in water and acidic amino-acids stimulate, while phenol acids, aromatic and alkaline amino-acids inhibit the growth of pathogenic fungi (Milczak and Piotrowski 1980; Pięta 1988; Piotrowski and Milczak 1982). Particular attention should be paid to the stimulating effect of root exudates on the development of bacteria and fungi antagonistic towards soilborne pathogenic fungi. Among bacteria, the largest ability of antagonistic effect towards phytopathogens was found in the representatives of *Bacillus* spp. and *Pseudomonas* spp. (Defago and Haas 1990; Keel 1992), while in the case of fungi in *Trichoderma* spp. and *Gliocladium* spp. (Hwang and Chakravarty 1993; Lorito et al. 1993; Marois et al. 1981; Papavizas 1985). Representatives of these genera of antagonistic bacteria and fungi are distinguished by remarkable ability to inhibit the growth of pathogens and to shorten their life in the soil through competition, antybiosis and parasitism (Ahl et al. 1986; Dowling and O'Gara 1994; Kloepper et al. 1999; Lin et al. 1994; Mukherjee et al. 1995; Pietr and Sobiczewski 1993). Considering the

effect of microorganisms on plants, studies were undertaken to determine the quantitative and qualitative composition of bacteria and fungi populations in the potato rhizosphere and non-rhizosphere soil. Besides, in the examined samples the studies established the proportion of bacteria and fungi antagonistic towards soilborne pathogens.

II. MATERIAL AND METHODS

The studies were carried out on the experimental field belonging to the Department of Plant and Soil Cultivation of the University of Agriculture in Lublin in the years 1996-1998. The field is localized in the Experimental Farm of Czesławice near Nałęczów. The object of the research was the rhizosphere soil of potato of cv. Bronka, and the non-rhizosphere soil. In the present experiment potato was cultivated after soybean.

The experiment was established according to randomised block design with three replications, on grey brown podzolic soil formed from loesses, that belonged to the second, good wheat complex. In each year, the rhizosphere soil was sampled at anthesis of potato. Samples of non-rhizosphere soil were taken from the fallow ground. The manner of sampling the rhizosphere soil, and next conducting the laboratory microbiological analysis corresponded with the methods described by Martyniuk et al. (1991). The rhizosphere soil of potato and the non-rhizosphere soil (from the depth of 5-10 cm) was taken to sterile Petri dishes. Afterwards, in sterile laboratory conditions a soil solution in the dilution ranging from 10^{-1} to 10^{-7} was prepared.

The total number of bacteria in 1g of soil dry weight was determined on "Nutrient agar" from the soil solutions with the dilutions of 10^{-5}, 10^{-6}, 10^{-7}. "Triptic soy agar" and dilutions 10^{-4}, 10^{-5}, 10^{-6} were used for the bacteria from *Bacillus* spp., while "Pseudomonas agar F" and dilutions of 10^{-2}, 10^{-3}, 10^{-4} were used for *Pseudomonas* spp. The total number of fungi in 1 g of soil dry weight was determined on Martin nutrient medium (1950) with the dilutions of 10^{-2}, 10^{-3}, 10^{-4}.

The results concerning the numbers of bacteria and fungi were statistically analysed and the significance of differences was determined on the basis of Tukey confidence intervals (Oktaba 1987).

In each year, the obtained bacteria isolates (200 isolates of *Bacillus* spp. and 200 isolates of *Pseudomonas* spp.) together with all the isolates of saprophytic fungi of *Gliocladium* spp. and *Trichoderma* spp. as well as 5 isolates from each species from *Penicillium* spp. were used in order to determine their antagonistic effect towards such pathogenic fungi as *Fusarium culmorum, F. oxysporum, F. solani, Pythium irregulare* and *Rhizoctonia solani.* To establish the antagonistic effect of the examined bacteria on pathogenic fungi a five-degree scale described by Martyniuk et al. (1991) and the degrees of inhibition of phytopathogen growth provided by Pięta (1999) were used. An estimation of the effect of saprophytic fungi on the studied pathogenic fungi was performed by means of the method of biotic rows (Mańka 1974; Mańka and Mańka 1992), and the individual effect of antagonistic effect was determined on the basis of the scale provided by Mańka and Kowalski (1968).

III. RESULTS

The differences in the numbers of particular populations of microorganisms were found out on the basis of the mycological analysis of the potato rhizosphere and non-rhizosphere soil (Tab.1). During the studies the total number of bacteria in 1 g of dry weight of the rhizosphere soil of potato ranged from 3.96×10^6 to 7.26×10^6 bacteria colonies, while in the case of non-rhizosphere soil it was from 3.50×10^6 to 4.75×10^6 bacteria colonies. In the three years of studies the mean number of bacteria from *Bacillus* spp. in 1 g of dry weight of the potato rhizosphere soil was 1.80×10^6, while in non-rhizosphere soil it was 1.91×10^6 colonies (Tab.1). In the case of bacteria from *Pseudomonas* spp. on the average three times more colonies were isolated from the potato rhizosphere soil than from non-

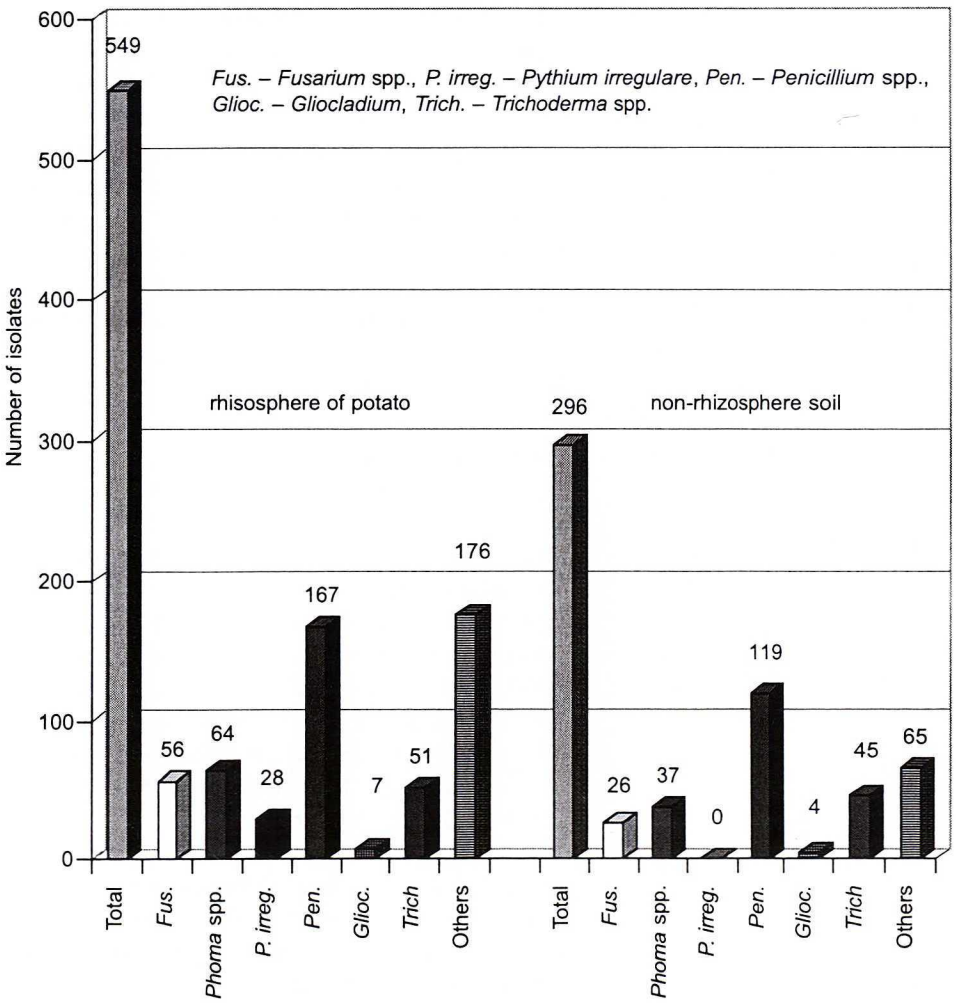


Fig. 1. Fungi isolated from the studied samples of soil in 1996-1998

Table 1

The number of bacteria and fungi in the plant rhizosphere

Type of soil	Total number of bacteria (mln/1g d. m. of soil)				Number of bacteria of *Bacillus* genus (mln/1g d. m. of soil)				Number of bacteria of *Pseudomonas* genus (mln/1g d. m. of soil)				Total number of fungi (thous./1g d. m. of soil)			
	1996	1997	1998	mean	1996	1997	1998	mean	1996	1997	1998	mean	1996	1997	1998	mean
Rhizosphere of potato	6,69*^{a}	3,96^{a}	7,26^{b}	5,97^{a}	3,00^{a}	1,23^{a}	1,19^{a}	1,80^{a}	1,91^{b}	0,96^{a}	2,03^{b}	1,63^{b}	59,90^{b}	51,38^{b}	69,96^{b}	60,13^{b}
Soil of non- rhizosphere	4,75^{a}	4,47^{a}	3,50^{a}	4,24^{a}	2,33^{a}	1,17^{a}	2,25^{b}	1,91^{a}	0,19^{a}	1,03^{a}	0,44^{a}	0,55^{a}	34,10^{a}	27,37^{a}	16,16^{a}	25,88^{a}

* Means in columns differ significantly (P = 0.05), if they are not marked with the same letter

rhizosphere soil. The total number of fungi in 1 g of dry weight of the potato rhizosphere soil ranged from 51.38×10^3 to 69.96×10^3, while in non-rhizosphere soil it was from 16.16×10^3 to 34.10×10^3 colonies (Tab.1).

The mycological analyses of the rhizosphere potato soil separated 549 isolates, and from non-rhizosphere soil 296 fungi isolates (Fig. 1). Among the obtained fungi the following were included in the pathogenic species: *Fusarium culmorum, F. oxysporum, F. solani, Phoma exigua* and *Pythium irregulare.* The last one was not isolated from non-rhizosphere soil, while the others were much more frequently isolated from the rhizosphere potato soil than from non-rhizosphere soil (Fig. 1). A similar relation was observed for such saprophytic fungi as *Penicillium* spp., *Gliocladium* spp. and *Trichoderma* spp. Besides, the species from *Acremonium* spp., *Aspergillus* spp., *Chaetomium* spp., *Cladosporium* spp., *Mucor* spp., *Rhizopus* spp. were obtained in small numbers both from the rhizosphere and non-rhizosphere soil. The number of isolates of those fungi obtained from the three years of mycological analysis of the examined soil samples is shown in the chart as others (Fig. 1).

Within *Bacillus* spp., *Pseudomonas* spp., *Gliocladium* spp., *Penicillium* spp. and *Trichoderma* spp. the studies separated the isolates, which were characterized by antagonistic effect towards the tested pathogenic fungi. Totally, 71 *Bacillus* spp. isolates and 99 *Pseudomonas* spp. isolates were separated from the rhizosphere potato soil, and correspondingly 18 and 34 isolates were separated from non-rhizosphere soil which were distinguished by their antagonistic effect. Those bacteria genera from the rhizosphere of potato were effective in limiting the growth of *Pythium irregulare* colonies. On the other hand, those bacteria obtained from non-rhizosphere soil efficiently reduced *F. oxysporum* (Tabs. 3, 4). Bacteria of *Bacillus* spp. and *Pseudomonas* spp. obtained from the rhizosphere of potato showed little effectiveness in limiting the growth of *F. oxysporum* (+ 215) and *F. solani.* (+ 247), and their effect was the smallest towards *R. solani* (+ 28 the total antagonistic effect). The stud-

Table 2

Activity of bacteria *Bacillus* spp. and *Pseudomonas* spp. isolated from the rhizosphere of potato towards pathogenic fungi

Genus of bacteria	The number of isolates	*F. culmorum*		*F. oxysporum*		*F. solani*		*P. irregulare*		*R. solani*		Altogether effect of antagonistic activity
		1	2	1	2	1	2	1	2	1	2	
Bacillus spp.	19	0	0	+1	+19	+2	+38	+2	+38	0	0	+152
Pseudomonas spp.	20	+1	+20	+1	+20	+1	+20	+3	+60	0	0	+140
Together effect of antagonistic activity			+20		+39		+58		+98		0	+292
Bacillus spp.	24	+1	+24	+1	+24	+2	+48	+3	+72	0	0	+240
Pseudomonas spp.	45	0	0	+2	+90	+1	+45	+4	+180	0	0	+360
Together effect of antagonistic activity			+24		+114		+93		+252		0	+600
Bacillus spp.	28	+1	+28	+1	+28	+1	+28	+5	+140	+1	+28	+504
Pseudomonas spp.	34	0	0	+1	+34	+2	+68	+3,5	+119	0	0	+255
Together effect of antagonistic activity			+28		+62		+96		+259		+28	+759
Altogether effect of antagonistic activity			+72		+215		+247		+609		+28	+1,651

1 – individual effect of antagonistic activity; 2 – total effect of antagonistic activity

Table 3

Activity of bacteria *Bacillus* spp. and *Pseudomonas* spp. isolated from the non-rhizosphere soil towards pathogenic fungi

Genus of bacteria	The number of isolates	*F. culmorum*		*F. oxysporum*		*F. solani*		*P. irregulare*		*R. solani*		Altogether effect of antagonistic activity
		1	2	1	2	1	2	1	2	1	2	
Bacillus spp.	6	+1	+6	+1	+6	+1	+6	+1	+6	0	0	+42
Pseudomonas spp.	11	0	0	+1	+11	+1	+11	0	0	0	0	+33
Together effect of antagonistic activity			+6		+17		+17		+6		0	+75
Bacillus spp.	3	0	0	+2	+6	+2	+6	+1	+3	+1	+3	+30
Pseudomonas spp.	13	0	0	+2	+26	+1	+13	+1	+13	+1	+13	+117
Together effect of antagonistic activity			0		+32		+19		+16		+16	+147
Bacillus spp.	9	+1	+9	+1	+9	0	0	+3	+27	+1	+9	+126
Pseudomonas spp.	10	0	0	+1	+10	0	0	+1	+10	0	0	+40
Together effect of antagonistic activity			+9		+19		0		+37		+9	+166
Altogether effect of antagonistic activity			+15		+68		+36		+59		+25	+388

1 – individual effect of antagonistic activity; 2 – total effect of antagonistic activity

Table 4

Activity of saprophitic fungi isolated from the rhizosphere of potato towards pathogenic fungi

Fungus species	Mean of isolates in 1996-1998	*F. culmorum*		*F. oxysporum*		*F. solani*		*P. irregulare*		*R. solani*	
		1	2	1	2	1	2	1	2	1	2
Gliocladium catenulatum	4	+4	+16	+4	+16	+6	+24	+6	+24	+2	+8
Gliocladium roseum	3	+4	+12	+6	+18	+8	+24	+7	+21	+5	+15
Penicillium brevi-compactum	116	+3	+348	+4	+464	+4	+464	+5	+580	–2	–232
Penicillium decumbens	6	+2	+12	+3	+18	+4	+24	+4	+24	+1	+6
Penicillium janthinellum	12	–2	–24	+2	+24	+3	+36	–2	–24	–5	–60
Penicillium meleagrinum	2	+1	+2	+3	+6	+3	+6	–2	–4	–5	–10
Penicillium nigricans	18	+1	+18	+2	+36	+4	+72	–2	–36	–5	–90
Penicillium purpurogenum	1	+2	+2	+3	+3	+3	+3	+3	+3	+2	+2
Penicillium roseo-purpureum	1	+1	+1	+3	+3	+2	+2	+3	+3	+2	+2
Penicillium verrucosum var. *cyclopium*	2	+7	+14	+7	+14	+5	+10	+2	+4	0	0
Penicillium verrucosum var. *verrucosum*	8	+3	+24	+4	+32	+4	+32	+2	+16	+1	+8
Torula herbarum	4	+1	+4	0	0	–1	–4	+2	+8	–2	–8
Trichoderma harzianum	20	+8	+160	+8	+160	+8	+160	+8	+160	+8	+160
Trichoderma koningii	27	+8	+216	+8	+216	+8	+216	+8	+216	+8	+216
Trichoderma pseudokoningii	4	+8	+32	+8	+32	+8	+32	+8	+32	+8	+32
Together effect of antagonistic activity	228		+837		+1042		+1101		+1027		+49

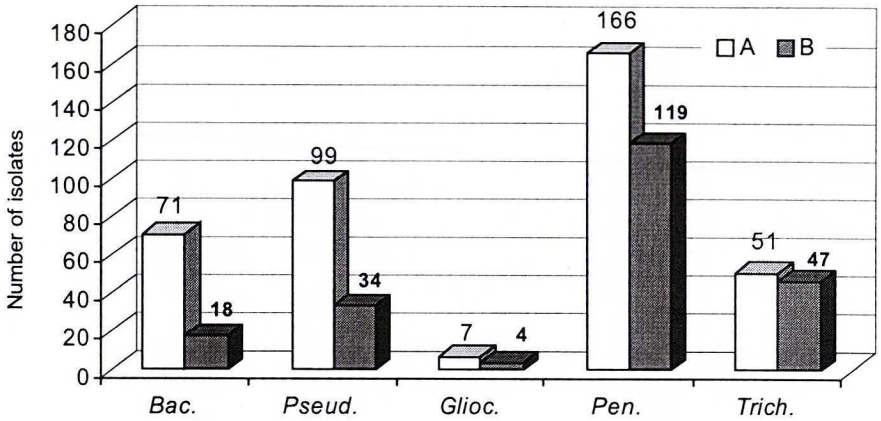
1 – individual effect of antagonistic activity; 2 – total effect of antagonistic activity

Table 5

Activity of saprophitic fungi isolated from the non-rhizosphere soil towards pathogenic fungi

Fungus species	Mean of isolates in 1996-1998	*F. culmorum*		*F. oxysporum*		*F. solani*		*P. irregulare*		*R. solani*	
		1	2	1	2	1	2	1	2	1	2
Gliocladium roseum	4	+6	+24	+6	+24	+7	+28	+7	+28	+4	+16
Penicillium chrysogenum	34	+1	+34	+2	+68	+5	+170	+4	+136	-4	-136
Penicillium funiculosum	33	+1	+33	+1	+33	+1	+33	+1	+33	-3	-99
Penicillium nigricans	6	0	0	+1	+6	+2	+12	0	0	-4	-24
Penicillium purpurogenum	12	0	0	+2	+24	+2	+24	+1	+12	-1	-12
Penicillium roseo-purpureum	4	0	0	+1	+4	+3	+12	+1	+4	+1	+4
Penicillium verrucosum var. *verrucosum*	30	+1	+30	+2	+60	+1	+30	+1	+30	0	0
Torula herbarum	5	0	0	+1	+5	+1	+5	0	0	-3	-15
Trichoderma hamatum	2	+6	+12	+8	+16	+8	+16	+8	+16	+6	+12
Trichoderma harzianum	2	+8	+16	+8	+16	+8	+16	+8	+16	+7	+14
Trichoderma koningii	8	+7	+56	+8	+64	+8	+64	+8	+64	+7	+56
Trichoderma pseudokoningii	23	+7	+161	+8	+184	+8	+184	+8	+184	+7	+161
Trichoderma viride	12	+8	+96	+8	+96	+8	+96	+8	+96	+8	+96
Verticillium tenerum	7	+1	+7	+2	+14	+3	+21	+2	+14	+1	+7
Together effect of antagonistic activity	182		+469		+614		+711		+633		+80

1 – individual effect of antagonistic activity; 2 – total effect of antagonistic activity



Bac. – *Bacillus* spp., *Pseud.* – *Pseudomonas* spp., *Glioc.* – *Gliocladium* spp., *Pen.* – *Penicillium* spp., *Trich.* – *Trichoderma* spp.

Fig. 2. Occurrence of antagonistic microorganisms in the rhizosphere of potato (A) and non-rhizosphere soil (B)

ied bacteria genera from non-rhizosphere soil inhibited the growth of *F. culmorum* in the smallest degree (Tab. 3).

Among the saprophytic fungi isolated from the rhizosphere soil of potato the studies separated 228 isolates of antagonistic effect (*Gliocladium* spp. – 7, *Penicillium* spp. – 166, *Trichoderma* spp. – 51, and *Torula herbarum* – 4 colonies) (Tab. 4). Antagonistic fungi inhibited the growth of *R. solani* in the smallest degree (+49), while inhibiting *F. oxysporum* (+1042) and *P. irregulare* (+1027 – total antagonistic effect) the most.

Non-rhizosphere soil included 182 fungi isolates, which were distinguished by their antagonistic effect, and they belonged to *Penicillium* spp. – 119 and *Trichoderma* spp. – 47 colonies, and the species of *Gliocladium roseum* – 4, *Torula herbarum* – 5 and *Verticillium tenerum* – 7 colonies (Tab. 5). The antagonistic fungi enumerated here inhibited the growth of *R. solani* the least (+ 80), and the growth of *F. solani* the most (+ 711 total antagonistic effect) (Tab. 5).

IV. DISCUSSION

On the basis of the studies it was found out that potato cultivation had a stimulating effect on the development of microorganisms in the soil. The increase of the number of microorganisms, especially in the rhizosphere potato soil, could have occurred under the effect of root exudates of the plant. The fact is explained in numerous publications concerning the role of compounds exudated by the roots of different cultivated plants (Funck-Jensen and Hockenhull 1984; Huber and Watson 1970; Pięta 1999; Rovira 1965; 1969; Schoruvitz and Zeigler 1989; Schroth and Hildebrand 1964). The total number of bacteria and fungi in 1 g of dry weight of the examined soil as compared to the non-rhizosphere soil indicated that the biologicall activity in the rhizosphere potato soil was considerably larger. Besides,

potato created favourable conditions for the development of both antagonistic bacteria *Bacillus* spp. and *Pseudomonas* spp. and antagonistic fungi of *Gliocladium* spp., *Penicillium* spp. and *Trichoderma* spp. This is shown by more numerous occurrence of antagonists in the rhizosphere of the analysed plant than in non-rhizosphere soil. According to Keel (1992) and Weller (1988) antagonistic bacteria from *Pseudomonas* spp. are capable of active colonization of plant roots, owing to which they effectively compete with pathogens for the nutritional elements occurring in root exudates and that is why they become a barrier protecting the roots from infection. An especially important role is also played by metabolites produced by antagonistic *Bacillus* spp. and *Pseudomonas* spp., which have a fungistatic or fungitoxic effect on pathogens (Ahl et al. 1986; Dowling and O'Gara 1994; Howell and Stipanovic 1980; 1983; Kloepper et al. 1999; Weller 1988). The effect of antagonistic fungi, especially *Gliocladium* spp. and *Trichoderma* spp. towards pathogenic fungi is similar to the effect of antagonistic bacteria (Hwang and Chakravarty 1993; Lin et al. 1994; Mukherjee et al. 1995; Papavizas 1985). In the case of *Penicillium* spp. some authors pay attention to the fact that those fungi produce toxic metabolites, also harmful for plants (Bojarczuk 1974; Smyk 1980).

Microorganisms characterized by antagonistic effect towards pathogenic agents not only limit their growth in the soil but they also reduce soilborne spores (Łacicowa and Pięta 1985a; 1985b; 1989; Papavizas 1985). Hence, one should expect the potato, through the positive effect on the increase of the number of antagonists in the soil, to contribute to the improved phytosanitary condition of the soil.

V. CONCLUSIONS

1. The mean number of microorganism population in the rhizosphere soil of potato was larger than in non-rhizosphere soil.
2. Potato cultivation had a positive effect on the increase of numbers of antagonistic bacteria (*Bacillus* spp. and *Pseudomonas* spp.) and fungi (*Gliocladium* spp., *Penicillium* spp., *Trichoderma* spp.).
3. A larger number of the communities of bacteria and fungi, including antagonistic ones, in the root area of potato indicates considerable biological activity, which contributes to a better phytosanitary condition of the soil.

VI. REFERENCES

1. Ahl P., Voisard C., Defago G. 1986. Iron-bound siderophores, cyande, and antibiotics involved in suppression of *Thielaviopsis basicola* by *Pseudomonas fluorescens* strain. J. Phytopath., 116: 121-134.
2. Batalin M. 1962. Studium nad resztkami pożniwnymi roślin uprawianych w łanie. Rocz. Nauk Roln., 98, s. D: 8-16.
3. Bojarczuk M. 1974. Studia nad relacją pszenicy na grzyby zasiedlające glebę. cz. II. Ocena patogeniczności wyosobnionych gatunków grzybów. Hod. Rośl. Aklim., 18, 2: 177-198.
4. Defago G., Haas D. 1990. *Pseudomonas* as antagonists of soil - borne pathogens: modes of action and genetic analysis. Soil Biochem., 6: 249-291.

5. Dowling D. N., O'Gara F. 1994. Metabolites of *Pseudomonas* involved in the biocontrol of plant disease. Trends in Biotechnology 12, 4:133-141.
6. Funck-Jensen D., Hockenhull J. 1984. Root exudation, rhizosphere microorganisms and disease control. Växtshyddsnotiser 48, 3-4: 49-54.
7. Howell C. R., Stipanovic R. D. 1980. Suppression of *Pythium ultimum* induced damping off cotton seedlings by *Pseudomonas fluorescens* and its antibiotic, pyoluteorin. Phytopath., 70: 712-715.
8. Howell C. R., Stipanovic R. D. 1983. Gliovirin, a new antibiotic from *Gliocladium virens*, and its the biological control of *Pythium ultimum*. Can J. Microbiol., 29: 321-324.
9. Huber D.M., Watson R.D. 1970. Effects of organic amendments on soil-borne pathogens. Phytopath., 60: 22-26.
10. Hwang S.F., Chakravarty P. 1993. Integrated biological and chemical control of *Rhizoctonia* root rot of field pea by *Gliocladium virens* and fungicide. Z. Pfl. Krankheit. Pfl. Schutz 100, 3: 308-316.
11. Keel C.J. 1992. Bacterial antagonists of plant pathogens in the rhizosphere: mechanisms and prospects. Bull. OILB/SROP, XV, 1: 93-99.
12. Kloepper J.W., Rodriguez – Kŕbana R., Zehnder G.W., Murphy J.F., Sikora E., Fernŕndez C. 1999. Plant root-bacterial interactions in biological control of soilborne diseases and extension to systemic and foliar diseases. Austr. Pl. Pathology 28: 21-26.
13. Lorito M., Di Pietro A., Hayes C.K., Woo S.L., Harman G.E. 1993. Antifungal synergistic interaction between chitinolytic enzymes from *Trichoderma harzianum* and *Enterobacter cloacae*. Phytopath., 83, 7: 721-728.
14. Lin A., Lee T. M., Rern J. C. 1994. Tricholin, a new antifungal agent from *Trichoderma viride* and its action in biological control of *Rhizoctonia solani*. Journal of Antibiotics 47, 7: 799-805.
15. Łacicowa B., Pięta D. 1985a. Szkodliwość niektórych mikopasożytów dla *Sclerotinia sclerotiorum* (Lib.) de Bary. Acta Micologica XXI (1): 125-134.
16. Łacicowa B., Pięta D. 1985b. Szkodliwość niektórych mikopasożytów dla fitopatogenicznych *Fusarium* spp. Rocz. Nauk Roln. - Seria E – Ochrona Roślin 15 (1/2): 87-97.
17. Łacicowa B., Pięta D. 1989. Szkodliwość grzybów z rodzajów *Trichoderma* i *Gliocladium* dla niektórych patogenów fasoli. Zesz. Probl. Post. Nauk Roln., nr 374: 235-242.
18. Mańka K. 1974. Zbiorowiska grzybów jako kryterium oceny wpływu środowiska na choroby roślin. Zesz. Probl. Post. Nauk Roln., nr 160: 9-23.
19. Mańka K., Kowalski S. 1968. Wpływ zespołów grzybów glebowych z dwu szkółek leśnych (sosnowej i jesionowej) na rozwój grzyba zgorzelowego *Fusarium oxysporum* Schl. Pozn. Tow. Przyj. Nauk 25: 197-205.
20. Mańka K., Mańka M. 1992. A new method for evaluating interaction between soil inhibiting fungi and plant pathogen. Bull. OILB/SROP XV: 73-77.
21. Marois J.J., Mitchell D.J., Sonoda R.M. 1981. Biological control of *Fusarium* crown rot of potato under field conditions. Phytopath., 71, 12: 1257-1260.
22. Martin J. P. 1950. Use of acid, rose bengal and streptopmycin in the plate method for estimating soil fungi. Soil Sci., 38: 215-220.
23. Martyniuk S., Masiak D., Stachyra A., Myśków W. 1991. Populacje drobnoustrojów strefy korzeniowej różnych traw i ich antagonizm w stosunku do *Gaeumannomyces graminis* var. *tritici*. Pam. Puł. Pr. IUNG, 98: 139-144.
24. Milczak M., Piotrowski J. 1980. Związki fenolowe roślin i ich rola w odporności na choroby powodowane przez grzyby. Post. Nauk Roln., nr 2: 59-78.
25. Mukherjee P. K., Mukhopadhyay A. N., Sarmah D. K., Shrestha S. M. 1995. Comparative antagonistic properties of *Gliocladium virens* and *Trichoderma harzianum* on *Sclerotinia rolfsii* and *Rhizoctonia solani* – its relevance to understanding the mechanisms of biocontrol. J. Phytopath., 143: 275-279.
26. Oktaba W. 1987. Metody statystyki matematycznej w doświadczalnictwie. PWN, Warszawa.
27. Papavizas G.C. 1985. *Trichoderma* and *Gliocladium*: Biology, ecology and potential for biocontrol. Ann. Rev. Phytopath., 23: 23-54.
28. Pietr S. J., Sobiczewski P. 1993. Możliwości i ograniczenia zastosowania bakterii do ochrony roślin przed chorobami. Materiały z Sympozjum nt. "Biotyczne środowisko uprawne a zagrożenie chorobowe roślin". Olsztyn: 47-58.

29. Pięta D. 1988. Mikozy występujące w uprawach fasoli (*Phaseolus vulgaris* L.) i podatności różnych odmian na porażenie przez niektóre grzyby. Ser. Wyd-Rozpr. Nauk. AR, Lublin.
30. Pięta D. 1999. Initial studies of populations of fungi and bacteria in the soil under influence of the cultivation of spring wheat and winter wheat in a growth chamber. Acta Agrobot., 52, 1-2:161-166
31. Piotrowski J., Milczak M. 1982. Biochemiczne wskaźniki stopnia odporności chmielu na *Verticillium albo-atrum* i *Fusarium sambucinum*. Acta Agrobot., 34: 277-284.
32. Rovira A.D. 1965. Plant root exudates and their influence upon soil microorganisms. In: Baker K.F., Snyder W.C. Ecology of soil-borne pathogens. Univ.Calif. Press Berkeley, Los Angeles.
33. Rovira A.D. 1969. Plant root exudates. Bot. Rev., 35: 35-57.
34. Schoruvitz R., Zeigler H. 1989. Interaction of maize roots and rhizosphere microorganisms. Z. Pflanzenkranch. Bodenh., 152: 217-222.
35. Schroth M.N., Hildebrand D.C. 1964. Influence of plant exudates on root infecting fungi. Ann. Rev. Phytopath., 2: 101-132.
36. Smyk B. 1980. Wpływ zmianowań specjalistycznych na kształtowanie się mikrobiocenoz i ich oddziaływanie na środowiska. Zesz. Nauk. ART., Olsztyn, Rolnictwo 29: 41-55.
37. Sytnik K.M., Kniga N.M., Musatienko L.J. 1977. Fizjologia korzeni. PWRiL, Warszawa.
38. Weller D.M. 1988. Biological control of soilborne plant pathogens in the rhizosphere with bacteria. Ann. Rev. Phytopath., 26: 379-407.

Danuta Pięta, Elżbieta Patkowska, Alina Pastucha

ZBIOROWISKA GRZYBÓW I BAKTERII W RYZOSFERZE ZIEMNIAKA I ICH WPŁYW NA FITOPATOGENY

STRESZCZENIE

W latach 1996-1998 przedmiotem badań była gleba ryzosferowa ziemniaka oraz pozaryzosferowa. Na podstawie analizy mikrobiologicznej uzyskane wyniki wykazały, że w 1 g s. m. gleby ryzosferowej ziemniaka średnia liczebność bakterii oraz średnia liczebność grzybów była większa, aniżeli w glebie pozaryzosferowej. Podobna zależność wystąpiła w przypadku bakterii z rodzaju *Pseudomonas*. W przypadku bakterii z rodzaju *Bacillus* o 6% więcej kolonii uzyskano z gleby pozaryzosferowej w porównaniu z glebą ryzosferową ziemniaka.

Na podstawie badań laboratoryjnych stwierdzono, że w obrębie zbiorowisk populacji bakterii i grzybów w glebie ryzosferowej opisanej rośliny było znacznie więcej antagonistycznych *Bacillus* spp., *Pseudomonas* spp., *Gliocladium* spp., *Penicillium* spp. i *Trichoderma* spp., aniżeli w glebie pozaryzosferowej.

Liczebność populacji bakterii i grzybów w strefie przykorzeniowej ziemniaka była większa w porównaniu z glebą pozaryzosferową, co może świadczyć o zwiększonej aktywności biologicznej gleby ryzosferowej.