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Initial studies of the populations of fungi and bacteria in the soil under the influence of the cultivation of spring wheat and winter wheat in a growth chamber

DANUTA PIĘTA

Department of Plant Pathology, Faculty of Horiculture, Agriculture University, Leszczyńskiego 7, 20-069 Lublin, Poland

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Summary

The purpose of the studies was to determine the populations of fungi and bacteria after the cultivation of spring wheat and winter wheat. As a result of the studies it was found out that winter wheat had a stimulating effect on the total number of bacteria, especially *Pseudomonas spp.* On the other hand, spring wheat had a smaller influence on the growth of bacteria, while stimulating the growth of the number of fungi. Among the bacteria and saprophytic fungi isolated from the soil after the cultivation of particular plants there were microorganisms having antagonistic effect towards phytopathogens. Three times as many antagonists were found in the soil after the cultivation of winter wheat as after the cultivation of spring wheat.

Key words: spring and winter wheat, soil, fungi, bacteria

INTRODUCTION

The quantitative and qualitative composition of soil borne communities of microorganisms undergoes continuous changes under the influence of various biotic and abiotic factors (Parke, 1990). One of the major factors causing those changes are the plants. Both the plants in their vegetation period through their root exudates and the crop residue remaining after the harvest can change the numbers of the population and the species composition of microorganisms (Funck - Jensen, Hockenhull, 1984, Rovira, 1965, Schruvitz, Zeigler, 1989). Root exudates, which contain aminoacids , sugars, phenol acids and their derivatives, organic acids, vitamins and metal ions constitute a rich nutritional source for the microorganisms living in the soil (Darcy, 1982, Funck - Jensen, Hockenhull, 1984, Rovira, 1969). Besides, the crop residue, including the roots of plants are the basic source of the organic substance which is the subsoil for the growth of both fungi and bacteria (Huber, Watson, 1970). In the case of winter wheat the amount of the root weight

ranged from 1.5 dt to 2 dt.h^{-1}, depending on the rainfalls and the soil type (Grzebisz, 1991, Malicki, 1969, Pawłowski, Wesołowski, 1980/81). On the other hand, the root weight of spring wheat was about 1 dt .h^{-1} (Pałys, 1980/81). The quantity of the organic substance and its chemical composition modify the number of the communities of microorganisms in the soil.

The main purpose of the studies was to determine the populations of bacteria and fungi in the soil after spring and winter wheat cultivation.

MATERIAL AND METHODS

Experiments were conducted in a growth chamber with controlled conditions (relative air humidity from 65 to 80 %, temperature from 16 to 24^{0}C, light exposure with the intensity of 1500 to 3500 Lux for 18 hours). The conditions in a growth chamber were similar to field conditions used in the experiment relating to cereales (Łacicowa, et al. 1997). Plastic pots were filled with the soil taken from the experimental plots after the cultivation of winter wheat and spring wheat. The experiment was conducted on loess soil containing about 1,4% of organic substance and 34% of soil powder. During the experiment soil humidity was about 60% of full water capacity. Four containers (4 repetitions) with the diameter of 25 cm and height of 15 cm were prepared for each plant species. 250 healthy grain, with no visible disease symptoms, was sown into the pots. The experiment considered the grain of winter wheat of Kobra cv. and spring wheat of Sigma cv. The experiment included 4 cycles of cultivation of each plant species. In each of the cycles the plants grew for 8 weeks, after which the overground parts were cut and mixed with the soil. During the experiment neither fertilizer nor chemical preparation were used. Before the experiment was closed the proportion of the plants with necrotic symptoms on the roots and the leaf sheath was settled. At that time the soil was also taken to the laboratory to determine the quantitative and qualitative composition of the soil borne microorganisms. The microbiological analysis was conducted according to the method described by Martyniuk et al. (1991).

Both the bacteria (200 isolates *Bacillus* spp. and 200 isolates *Pseudomonas* spp.) and saprophytic fungi (20 isolates *Gliocladium* spp. and 140 isolates *Trichoderma* spp.) obtained in this way were used to determine the antagonistic effect towards the pathogenic fungi for the studied plants (*Fusarium avenaceum*, *F. culmorum*, *Rhizoctonia solani*).

A five-degree scale by Martyniuk et al. (1991) was used in order to determine the antagonistic effect of the examined bacteria towards the pathogenic fungi. The scale considered the following degrees: 0^0 - no antagonism, 1^0 - inhibition zone of 1 - 2 mm, 2^0 - inhibition zone of 3 - 5 mm, 3^0 - inhibition zone of 6 - 10 mm, 4^0 - inhibition zone more than 10 mm. Besides, for the full determination of the antagonistic effect of bacteria the degrees of inhibition of the phytopathogen growth were also fixed: 0^0 - no inhibition of the growth of the phytopathogen colony, 1^0 - the growth of the phytopathogen colony inhibited to 20%, 2^0 - the growth of the phytopathogen colony inhibited to 50%, 3^0 - the growth of the phytopathogen colony inhibited to 80%, 4^0 - the growth of the phytopathogen colony inhibited to 100%. The effect of saprophytic fungi on the examined pathogenic fungi was determined by the method of biotic series (Mańka, 1974, Mańka, Mańka, 1992), and the individual result of the antagonistic effect was determined on the basis of the scale provided by Mańka and Kowalski (1968).

RESULTS

The microbiological analysis of the soil conducted after the cultivation of spring wheat and winter wheat showed out considerable differences in the numbers of particular populations of microorganisms (tab. 1). In the case of the soil on which spring wheat was cultivated the total of 8.72 x 10^6 bacteria colonies were obtained in 1 g of the dry mass of the soil, while after the cultivation of winter wheat the number was 11.14 x 10^6 bacteria colonies. The examined plants also had a modifying effect on the number of bacteria from the genera of *Bacillus* and *Pseudomonas*. Much more colonies of those bacteria were found in 1 g of the dry mass of the soil taken from the pots after the repeated cultivation of winter wheat than after spring wheat. Approximately 12% more colonies of *Bacillus* spp. were obtained from the soil after winter wheat as compared to the soil after the cultivation of spring wheat. A much greater difference was found in the numbers of *Pseudomonas* spp. since twice more colonies of these bacteria were isolated from the soil after the cultivation of winter wheat (tab. 1). As for the total number of the fungi there was a reverse relation as in 1 g of the dry mass of the soil after the cultivation of spring wheat there were almost twice as many fungi colonies as after winter wheat (tab. 2).

Table 1
The number bacteria and fungi in the soil after plants cultivation

Specification	Soil	
	after spring wheat cultivation	after winter wheat cultivation
Total number of bacteria (mln/1 g of soil dry weight)	8.72 a	11.14 b
Number of bacteria *Bacillus* spp. (mln/1g of soil dry weight)	1.91 a	2.14 a
Number of bacteria *Pseudomonas* spp. (mln/1g of soil dry weight)	3.18 a	7.47 b
Total number of fungi (thousands/1 g of soil dry weight)	66.07 b	34.86 a

* Significant differences within studied feature between winter and spring wheat at $P \leq 0.05$.

Table 2
Microorganisms antagonistic isolated from soil after spring and winter wheat cultivation

Bacteria and fungi	Number of isolates	
	Soil	
	after spring wheat cultivation	after winter wheat cultivation
Bacillus spp.	10	17
Pseudomonas spp.	13	44
Total bacteria	23	61
Gliocladium catenulatum Gilman et Abbott		9
Gliocladium fimbriatum Gilman et Abbott	4	3
Gliocladium roseum Bainier		2
Trichoderma hamatum (Bon.) Bain	6	12
Trichoderma harzianum Rifai	7	36
Trichoderma koningii Oud.	12	32
Trichoderma pseudokoningii Rifai	4	9
Trichoderma viride Pers.	8	41
Total fungi	41	144

In the bacteria colonies of *Bacillus* spp. and *Pseudomonas* spp. from the soil after the cultivation of both spring wheat and winter wheat there were found the isolates which were distinguished by their antagonistic effect towards *F. avenaceum*, *F. culmorum* and *R. solani*. The frequency of the occurrence of the antagonists varied. Much more isolates distinguished by their antagonistic effect were obtained after the cultivation of winter wheat than after spring wheat. Particularly many isolates of *Pseudomonas* spp. were found in the soil after the cultivation of winter wheat (tab. 2).

In the group of saprophytic fungi obtained from the soil after the cultivation of winter wheat there were 3.5 times as many isolates distinguished by their antagonistic effect towards phytopathogens as compared to the fungi isolated from the soil after the cultivation of spring wheat.

After the repeated cultivation of particular plant species the proportion of the diseased seedlings of spring wheat and winter wheat was different. For spring wheat the proportion of the plants with necrotic symptoms on the roots and the leaf sheath was 36.4%, while for winter wheat it was only 17.1%.

DISCUSSION

In the presented studies, the repeated cultivation of spring wheat and winter wheat and the ground green mass of those plants introduced into the soil contributed to the formation of a definite quantitative and qualitative composition of the populations of bacteria and fungi in the soil, which was confirmed by the microbiological analysis. It seems that the root exudates and the green mass of winter wheat had a favourable effect on the development of bacteria, while having a poorer effect on the growth of fungi. A reverse phenomenon occurred in the composition of the population of microorganisms living in the soil after the cultivation of spring wheat. According to Myśków (1989), there are definite proportions between the degrees of bacteria growth and fungi growth. The author found out that intensive reproduction of bacteria refers to poor reproduction of fungi, and vice versa. Besides, it should be expected that the root exudates of winter wheat and the green mass of that species also have a stimulating effect on the growth of antagonistic microorganisms. The fact was confirmed by the results of laboratory tests and the information from literature (Funck - Jensen, Hockenhull, 1984, Rovira, 1969). Numerous occurrence of antagonistic microorganisms in the soil has a positive effect on the inhibition of the occurrence of phytopathogens (Martyniuk et al., 1991, Solarska, 1996, Pięta, Patkowska, 1997). One should suppose that this phenomenon of reducing the propagules of pathogenic fungi occurred in the soil after the cultivation of winter wheat, because the health state of the seedlings was satisfying. Poorer healthiness of the plants of spring wheat could have been caused by the small numbers of antagonists in the soil. With the small proportion of antagonists in the soil the probability of direct contact with the pathogen is little, and it is only such a contact which conditions the inhibiting effect on the pathogenic fungi (Metzler, 1991).

CONCLUSIONS

1. The effect of winter wheat on the growth of antagonistic bacteria was more positive in comparison to spring wheat.
2. Spring wheat stimulated the growth of fungi in the soil better than winter wheat.
3. Winter wheat contributes to the increase in biological activity in the soil and it improves the phytosanitary condition of the soil.

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Wstępne badania nad populacjami bakterii i grzybów w glebie pod wpływem uprawy pszenicy jarej i pszenicy ozimej w warunkach fitotronu

Streszczenie

Celem badań było określenie populacji grzybów i bakterii ukształtowanych w glebie po uprawie pszenicy jarej i pszenicy ozimej. W wyniku przeprowadzonych badań stwierdzono, że pszenica ozima miała stymulujący wpływ na ogólną liczbę bakterii, a w tym szczególnie na bakterie *Pseudomonas* spp. Natomiast pszenica jara miała mniejszy wpływ na rozwój bakterii, a stymulowała wzrost liczebności grzybów. Wśród bakterii i grzybów saprofitycznych wyizolowanych z gleby po uprawie poszczególnych roślin były mikroorganizmy o antagonistycznym oddziaływaniu względem fitopatogenów. Trzykrotnie więcej antagonistów było w glebie po uprawie pszenicy ozimej, aniżeli po uprawie pszenicy jarej.