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EFFECT OF PRP SOL ON MICROBIAL AND BIOCHEMICAL SOIL PROPERTIES

Summary

The aim of this work was to assess some microbial and enzymatic parameters in soil under winter wheat, maize and spring barley treated with PRP Sol in comparison to soil fertilized with NPK. Estimates of: total numbers of bacteria and fungi, numbers of Azotobacter spp., MPN of rhizobia, numbers of spores of AM fungi, glomalin content, as well as phosphatases activities in soil under winter wheat, corn and spring barley treated with PRP Sol generally did not differ significantly from those found in soil fertilized with NPK.
***Key words**: soil microorganisms, Azotobacter, rhizobia, enzymes, PRP Sol, soil improvers*

ODDZIAŁYWANIE PRP SOL NA MIKROBIOLOGICZNE I BIOCHEMICZNE WŁAŚCIWOŚCI GLEBY

Streszczenie

Celem badań było porównanie wpływu PRP Sol i nawożenia NPK na wybrane grupy mikroorganizmów i aktywność enzymów w glebie pod uprawą zbóż (pszenica ozima, kukurydza, jęczmień jary). Wartości następujących parametrów: ogólna liczebność bakterii i grzybów, liczebność Azotobacter spp., MPN rizobiów, liczebność spor grzybów mikoryzowych (AM), zawartość glomalin oraz aktywność fosfatazy kwaśniej i zasadowej w glebie pod ww. roślinami nawożonymi PRP Sol nie różniły się na ogół istotnie od wartości tych parametrów w glebie nawożonej NPK.
***Słowa kluczowe**: mikroorganizmy glebowe, Azotobacter, rizobia, enzymy, PRP Sol, polepszacze glebowe*

1. Introduction

PRP Sol is a granulated product manufactured by PRP Technologies, which has indicated in the declared composition of this product that it contains at least 35% of CaO, 8% of MgO, un-declared amounts of microelements and lignin sulphonate, a water soluble substance gluing mineral components of the product [11]. PRP Sol is included in the list of fertilizes and soil improving materials and it is approved for use in ecological (organic) farming as "liming preparation". Doses of PRP Sol recommended by the producer for growing cereals, legumes or rape-seed range from 150kg/ha to 250 kg/ha. The manufacturer of this product climes that beneficial effects of PRP Sol on various soil properties, and thus on crop yields, result from stimulation of soil macro- and microorganisms, both with respect to their densities and activities [10]. However, results of studies so far published with respect to effects of PRP Sol on soil properties and crop yields are controversial. For instance, Bielińska et al. [1] have shown (without statistical analyses) that this preparation stimulated the activity of soil enzymes such as: urease, protease and dehydrogenases, but decreased that of phosphatases. With respect to crop yields, Sulewska et al. [7, 8] have demonstrated that addition of PRP Sol to soil had a beneficial effect on grain yields of winter wheat and maize, but negative on yields of spring barley yields. Moreover, these authors did not find any significant effects of PRP Sol on soil physical properties (density) [7].

In this work we compared some microbial and enzymatic parameters in soil under winter wheat, corn and spring barley fertilized with NPK and with PRP Sol.

2. Materials and methods

These studies were based on a 3-year field experiment established in 2009 in Grabów Experimental Research Station and managed by Department of Systems and Economics of Crop Production, IUNG-PIB Puławy. This experiment included the following treatments: A0 - fertilization with N, no P and K fertilizers added; A1 - full NPK fertilization; A2 - fertilization with N + PRP-Sol. The treatment consisted of 4 plots (replicates), 50 m^2 each. During 2009-2011 the following crops were grown on the plots: winter wheat, corn and spring barley, which received NPK doses according to general recommendation used in Poland. PRP Sol was applied each year at the rate of 220 kg/ha.

Microbial analyses included the following determinations: - total numbers of soil bacteria and fungi by plate dilution method [4], - numbers of *Azotobacter* spp. on nitrogen-free agar medium [5], Most Probable Number of rhizobia nodulatingred clover (*Rhizobium. leguminosarum* bv. *trifolii*) and alfalfa (*Sinorhizobium meliloti*) [3], and numbers of spores of mycorrhizal fungi (VAM) by flotation method [2]. Biochemical analyses included: - estimation of acid and alkaline phosphatase activity using p-nitro-phenyl-phosphate as a substrate for these enzymes [9] and glomalin (glyco-proteins produced by endo-mycorrhizal fungi) content [10]. For the purpose of these studies soil samples were collected from 0-20 cm layer between rows of the following plants: winter wheat in 2009, corn in 2010 and spring barley in 2011. In the laboratory field moist soils samples were passed through 2mm sieves and refrigerated. Glomalin content was determined in air-dried samples of the soil.

3. Results and discussion

As it has already been mentioned, the producer of PRP Sol claims that this product containing mainly calcium and magnesium carbonates stimulates the development and activity of soil microorganisms and thus affects transformation and availability of phosphorus and potassium in soils. Therefore, beside counting total numbers of soil bacteria and fungi we have examined also some specific groups

of microorganisms, e.g *Azotobacter* spp. or alfalfa rhizobia which are sensitive to soil reaction and could positively react to components (Ca, Mg) present in PRP Sol. To assess effects of PRP Sol on microbial aspects of phosphorus transformation in soil two parameter were studied: - activities of acid and alkaline phosphatases, and - arbuscular mycorrhizal (AM) fungi, common colonizers of plant roots [2], which facilitate soil P acquisition by plants and are known to produce glomalin – stable glycoproteins involved in soil aggregation [10].

In 2009 soil samples were collected in April and July from winter wheat plots within the following treatments: A0 (fertilization with N, no P and K fertilizers added), A1 (full NPK fertilization) and A2 (fertilization with N + PRP-Sol), and effects of these treatments on microbial and enzymatic properties of the soil are given in table 1 as mean values for the two sampling dates. As the results presented in this table show, total numbers of bacteria and phosphatases activities did not differ significantly between the treatments. Generally, the soil on which this experiment was set up contained low population of bacteria belonging to the genus *Azotobacter*. In 2009 numbers of these bacteria ranged from 1 to 14 cells per gram of soil, and the highest number of *Azotobacter* spp. was found in the soil treated with NPK (A1) (tab. 1). The total number of fungi was significantly higher in soil fertilized with N+PRP Sol (A2) as compared to other treatments (A0 and A1).

In 2010 corn was grown on the experimental plots and soil samples from these plots were collected in June and September (tab. 2). Similarly to the previous year, total numbers of bacteria and phosphatases activities did not differ significantly between the treatments. In 2010 populations of *Azotobacter* spp were highest in soil from A2 plots (N+PRP Sol) and total numbers of fungi were significantly higher in soil receiving full NPK fertilization (A1) than in soil from A0 and A2 treatments (tab. 2).

In 2011 soil under spring barley was sampled in June and July (tab. 3). In this year significant differences between the treatments were found only in the case of bacteria belonging to the genus *Azotobacter*. Soil under spring barley treated with NPK (A1) or with N+PRP Sol (A2) contained significantly higher numbers of these bacteria than soil from A0 treated with N fertilizers only (tab. 3).

Symbiotic bacteria of leguminous crops, particularly rhizobia nodulating alfalfa are sensitive to soil acidity and this is probably one of the most important factor responsible for the absence of alfalfa rhizobia in most of Polish soils [3]. Therefore, it was expecting that PRP Sol containing Ca^{++} will increase populations of alfalfa rhizobia (*S. meliloti*) in A2 soil. Results shown in table 4 indicate, however, that this was not the case, since symbiotic bacteria of alfalfa were not detected at the beginning of the experiment (2009) as well as at the end (2011) in any of the treatments used, including A2 with PRP Sol (tab. 4). Contrary to alfalfa rhizobia, bacteria nodulating red clover (*R. leguminosarum* bv. *trifolii*) were numerous in the examined soil but the fertilization treatments had generally no significant influence on soil populations of these bacteria (tab. 4).

Table 1. Number of various groups of microorganisms and phosphatases activity in soil (1 g d.m.) under winter wheat as influenced by PRP Sol in comparison with NPK

Treatments*	Total number of bacteria x 10^8	Total number of fungi x 10^5	Number of *Azotobacter* spp.	Acid phosphatase	Alkaline phosphatase
				µg p-nitrophenol/g	
A0	2.1 a	2.7 a	1 a	50.3 a	39.4 a
A1	2.8 a	2.1 a	14 b	50.1 a	41.4 a
A2	2.4 a	3.9 b	1 a	53.0 a	41.0 a

*A0 - fertilization with N, no P and K fertilizers added; A1 - full NPK fertilization; A2 - fertilization with N + PRP-Sol

Source: Own work

Table 2. Number of various groups of microorganisms and phosphatases activity in soil (1 g d.m.) under corn as influenced by PRP Sol in comparison with NPK

Treatments*	Total number of bacteria x 10^8	Total number of fungi x 10^5	Number of *Azotobacter* spp.	Acid phosphatase	Alkaline phosphatase
				µg p-nitrophenol/g	
A0	2.1 a	2.4 a	13 a	56.0 a	45.0 a
A1	2.6 a	4.3 b	17 a	58.0 a	49.4 a
A2	2.0 a	3.0 a	27 b	54.4 a	49.2 a

*A0 - fertilization with N, no P and K fertilizers added; A1 - full NPK fertilization; A2 - fertilization with N + PRP-Sol

Source: Own work

Table 3. Number of various groups of microorganisms and phosphatases activity in soil (1 g d.m.) under spring barley as influenced by PRP Sol in comparison with NPK

Treatments*	Total number of bacteria x 10^8	Total number of fungi x 10^5	Number of *Azotobacter* spp.	Acid phosphatase	Alkaline phosphatase
				µg p-nitrophenol/g	
A0	3.0 a	3.6 a	3 a	58. 2 a	47.7 a
A1	2.3 a	2.9 a	14 b	57.1 a	47.7 a
A2	2.5 a	3.2 a	13 b	60.5 a	46.1 a

*A0 - fertilization with N, no P and K fertilizers added; A1 - full NPK fertilization; A2 - fertilization with N + PRP-Sol

Source: Own work

Table 4. Number of rhizobia nodulating red clover and alfalfa in soil (1 g soil d.m.), numbers of spores of AM fungi and amounts of glomalin in soil as influenced by PRP Sol in comparison with NPK

Treatments	Number of AM spores (in 100 g soil d.m.)	Glomalin content (µg /1 g soil d.m.)	MPN of *Sinorhizobium meliloti* (alfalfa)		MPN of *R. leguminosarum* bv. *trifolii* (red clover) x 10^5	
	2011	2011	2009	2011	2009	2011
A0	31 a	17.0 a	n.d**	n.d.	3.48 a	2.03 a
A1	37 a	16.6 a	"	"	4.50 a	1.90 a
A2	37 a	15.4 a	"	"	3.45 a	2.02 a

*A0 - fertilization with N, no P and K fertilizers added; A1 - full NPK fertilization; A2 - fertilization with N + PRP-Sol;
**n.d. – not detected *Source: Own work*

Numbers of spores of arbuscular mycorrhizal (AM) fungi and the content of glomalin produced by these fungi in soil were examined in the last year of the experimental period and the fertilization treatments had generally no significant effects on these parameters (tab. 4).

Results presented in tables 1-3 with respect to acid and alkaline phosphatases indicate that activities of these enzymes in soil were not significantly influenced by PRP Sol treatment in any of the experimental year. These results are generally in accordance with those presented by other authors studying effects of PRP preparation on various soil enzymes activities. For instance, Niewiadomska et al. [6] reported statistically insignificant influence of PRP Sol on dehydrogenases activities in soil under rape and spring barley, while Bielińska et al. [1] have shown beneficial effect of this product on dehydrogenases, urease and protease and negative on phosphatases activities, although no statistical assessments of these results were performed.

Our results indicate also, that addition of PRP Sol to soil on which different crops were grown had generally no significant influence on numbers of the studied groups of soil microorganisms. Occasionally detected significant differences in numbers of fungi or *Azotobacter* spp. (tab. 1-3) resulted from generally a great variability of biological soil properties rather than from any influence of the compared fertilization treatments. This suggestion could be confirmed by results published by Niewiadomska et al. [6], who detected a great variability of various groups of microorganisms in soil treated with NPK or PRP Sol and in consequence the differences between the treatments were statistically insignificant.

4. Conclusion

Estimates of: total numbers of bacteria and fungi, numbers of *Azotobacter* spp., MPN of rhizobia, numbers of spores of AM fungi, glomalin content, as well as phosphatases activities in soil under winter wheat, corn and spring barley treated with PRP Sol generally did not differ significantly from those found in soil fertilized with NPK. Occasionally detected significant differences in numbers of fungi or *Azotobacter* spp. resulted from a great variability of biological soil properties rather than from any influence of the compared fertilization treatments.

5. References

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