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EFFECT OF PRP SOL ON C AND N CONTENTS IN LABILE FRACTIONS OF SOIL ORGANIC MATTER

Summary

Labile fractions of soil organic matter (SOM), e.g. hot (or cold)-water extractable C and living (active) microbial biomass (MB) are much more dynamic and sensitive to changes in soil management practices than total SOM and can be useful indicators of soil quality and SOM transformation processes as influenced by different factors, e.g. agro-technical practices (mineral and organic fertilizers). The aim of this work, based on a plot experiment, was to compare effects of PRP SOL and NPK on C and N contents in labile fractions of organic matter extracted from soil under winter wheat, corn and spring barley grown in the years 2012-2014. Hot water fraction (HWF) was obtained by heating of soil solution in 80^{o}C for 16 h and microbial biomass (MB) was determined by the fumigation-extraction method. An Automated N/C Analyzer (Multi N/C 2100, Analytik-Jena, Germany) was used to measure C and N contents in soil extracts. Results of this study indicate that soil treated with mineral fertilizers (N or NPK) or with PRP SOL had, in general, similar C and N contents in MB and in HWF obtained from these soils, irrespective of the experimental year and the plant.
Key words: *soil organic matter, carbon, nitrogen, labile fraction, microbial biomass, PRP SOL*

ODDZIAŁYWANIE PRP SOL NA ZAWARTOŚCI C I N W RUCHOMYCH FRAKCJACH GLEBOWEJ MATERII ORGANICZNEJ

Streszczenie

Labilne (ruchome, aktywne) frakcje glebowej materii organicznej(GMO) m.in. takie jak MO ekstrahowana z gleby za pomocą wody (zimnej lub gorącej) oraz ożywiona (aktywna) frakcja MO, czyli biomasa mikroorganizmów glebowych, są bardziej dynamiczne niż GMO i mogą być one dobrymi wskaźnikami aktualnych zmian zachodzących w GMO oraz jakości i żyzności środowiska glebowego pod wpływem różnych czynników, np. zabiegów agrotechnicznych (nawożenie mineralne i organiczne). Celem badań, przeprowadzonych w latach 2012-2014 w oparciu o trzyletnie doświadczenie poletkowe, było porównanie wpływu PRP SOL i nawożenia mineralnego (N i NPK) na ww. frakcje glebowej MO. Frakcję rozpuszczalną w wodzie gorącej (HWF) wydzielano po 16 godzinnym ogrzewaniu próbek gleby w temp. 80^{o}C. Biomasę mikroorganizmów (MB) glebowych określano metodą fumigacji-ekstrakcji. Zawartość C i N w HWF i MB oznaczano przy użyciu automatycznego analizatora C/N (Multi N/C 2100, Analytik-Jena). Badania te wykazały, że żaden z badanych czynników, tj. nawożenie N, NPK i PRP SOL nie różnicował istotnie badanych parametrów, czyli zawartości C i N w frakcjach HWF i MB gleby pod uprawianymi roślinami.
Słowa kluczowe: *glebowa materia organiczna, frakcje rozpuszczalne, węgiel, azot, biomasa mikroorganizmów, PRP SOL*

1. Introduction

Soil organic matter (SOM), a key determinant of soil quality, can be defined as a series of fractions ranging from very active (labile) to recalcitrant organic matter according to turnover rate [2, 11]. Particulate organic matter and dissolved organic matter, e.g. hot water-extractable fraction (HWF) and microbial biomass (MB) are considered as the most important labile fractions of SOM (2, 4, 9]. These fractions have been shown to be much more sensitive to changes in soil management practices than total SOM and can be useful indicators of soil quality and SOM transformation processes as influenced by different factors, e.g. mineral and organic fertilizers [3, 5, 9, 11].

PRP SOL is a granulated product manufactured by PRP Technologies, which contains, according to the producer, 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 [14]. In Poland 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 150 kg·ha^{-1} to 250 kg·ha^{-1}. 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 [14]. However, results of studies so far published with respect to effects of PRP SOL on soil properties and crop yields are controversial [1, 8, 12, 13]. For instance, Sulewska et al. [12, 13] 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 (compaction) [12]. In our previous studies PRP SOL had generally no significant effect on several microbial and biochemical parameters such as: total numbers of bacteria and fungi, numbers of *Azotobacter* spp., MPN of rhizobia, numbers of spores of AM fungi, glomalin content and phosphatases activities in soil under winter wheat, corn and spring barley as compared to NPK fertilization.

Table. Contents of C and N ($\mu g \cdot g^{-1}$ soil d.m.) in microbial biomass and hot water fraction as influenced by soil treatment with mineral fertilizers or PRP SOL

Tabela. Zawartość C i N ($\mu g \cdot g^{-1}$s.m. gleby) w biomasie mikroorganizmów i we frakcji ekstrahowanej gorącą wodą w zależności od nawożenia NPK lub PRP SOL

Treatment	Microbial biomass		Hot water fraction	
	Carbon (C)	Nitrogen (N)	Carbon (C)	Nitrogen (N)
	2012 (winter wheat)			
A0 (+ N, - PK)	184 a	63 a	421 a	53a
A1 (+NPK)	182 a	65 a	420 a	52 a
A2 (+ N, +PRP Sol	186 a	61 a	424 a	56 a
	2013 (corn)			
A0 (+ N, - PK)	136 a	50 a	427 a	76 a
A1 (+NPK)	141 a	68 b	435 a	88 a
A2 (+N, +PRP Sol)	147 a	55 a	427 a	82 a
	2014 (spring barley)			
A0 (+ N, - PK)	122 a	29,9 a	457 a	75,5 a
A1 (+NPK)	116 a	28,8 a	440 a	78,9 a
A2 (+N, +PRP Sol)	116 a	29,2 a	424 a	68,5 b

Source: own study / *Źródło*: opracowanie własne

The aim of this work was to compare effects of PRP SOL and NPK on C and N contents in labile fractions of organic matter (HWF and MB) extracted from soil under winter wheat, corn and spring barley grown in a plot experiment.

2. Materials and methods

These studies were based on a 3-year field experiment established in 2012 at 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 the years 2012-2014 the following crops were grown on the plots: winter wheat, corn and spring barley, which received 250 $kg \cdot ha^{-1}$ of NPK according to general recommendation used in Poland. PRP SOL was applied each year at the rate of 220 $kg \cdot ha^{-1}$. For the purpose of these studies soil samples were collected from 0-20 cm layer between rows of the following plants: winter wheat in 2012, corn in 2013 and spring barley in 2014. In the laboratory field wet soil samples were passed through 2mm sieves and refrigerated.

To prepare hot water (80°C) extracts from field wet soil duplicate samples, equivalent to 5 g soil dry matter (d.m.), were weighed into 50 ml centrifuge tubes, mixed with 25 ml of distilled water and further treated as described by Ghani et al. [5]. Microbial biomass C and N were determined by the chloroform-fumigation-extraction method and calculated according to the following formula: $C_{mic.} = E_C/k_{EC}$, where E_C = soluble C in fumigated samples – soluble C in control (un-fumigated) samples and $k_{EC} = 0.45$ [6] and $N_{mic.} = E_N/k_{EN}$, where E_N = soluble N in fumigated samples – soluble N in control (un-fumigated) samples and $k_{EN} = 0.54$ [7]. An Automated N/C Analyzer (Multi N/C 2100, Analytik Jena, Germany) was used to measure C and N contents in soil extracts.

The data were subjected to the analysis of variance (ANOVA) at with significance of differences assessed at $p < 0.05$.

3. Results and discussion

According to the producer PRP SOL has beneficial effects on soil quality by improving physical and chemical soil properties, as well as by stimulation of the activity of soil dwelling micro-organism and macro-organisms, and in consequence application of mineral fertilizer can be substantially reduced or even eliminated, particularly with respect to phosphorus and potassium [14]. For this reason in our experiment all plots were treated with N and those not treated with PRP SOL received either full P and K fertilization (A1) or no amendments with these nutrients(A0) [Table].

In contrast to the total SOM, labile fractions of SOM have been shown to be more sensitive and responsive to changes in agricultural practices, e.g. crop rotation, soil tillage, organic or mineral amendments [2-5, 9, 11]. Results presented in Table 1 show that the soils under all crops treated with mineral fertilizers (NPK) or with PRP SOL had similar C and N contents in microbial biomass and hot water fraction obtained from these soils, irrespective of the experimental year and the plant. Microbial biomass C and N estimated by the fumigation-extraction method is a measure of total microbial populations in soil and hot water extractable pools of C and N have been proven in previous studies to be important for soil metabolism, particularly for the turnover of organic matter and the cycling of nutrients in soils, in which these fractions serve also as a short-term reservoir of plant nutrients [2-7, 9, 11]. Results of this study (Table 1) indicate that PRP SOL does not affect the above mentioned processes, as compared to mineral fertilizes. In our earlier studies [8] it was found that*:* 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 soils under winter wheat, corn and spring barley treated with PRP SOL generally did not differ significantly from those found in soils fertilized with NPK. Also, Niewiadomska et al. [10] reported statistically insignificant influence of PRP SOL on dehydrogenase activities in soils under rape and spring barley and a great variability of various groups of microorganisms in soils treated with NPK or PRP SOL, thus in consequence differences between the treatments were statistically insignificant.

In conclusion, the results of the present work and those of our earlier studies indicate that PRP SOL, in comparison to N or NPK treatment, does not exert significant influence on the contents of C and N in labile fractions of SOM and on microbial and enzymatic activities of soil.

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