ON THE EFFECTS OF BACTERIAL FERTILIZATION ON THE MICROBIOLOGICAL PARAMETERS OF CHERNOZEM SOIL BASED ON A POT EXPERIMENT

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Abstract
In a pot experiment we studied the effects of NPK fertilization, bacterial fertilization and straw application in the University of Debrecen, in 2010. In the experiment we applied Bactofil A, EM-1 and Microbion UNC biofertilizers. We measured the total number of bacteria, the amount of microscopic fungi, and the CO_2 production and microbial biomass-C content of the soil. We found that the treatments influenced most parameters positively. Our results were the following:

By the fertilizer treatment (NPK fertilizer with no combination) all the measured parameters increased, except for the microbial biomass-C content. In straw treatments the total number of bacteria and microbial biomass-C content decreased. The number of microscopic fungi and the CO_2 production of the soil were increased by bacterial fertilization, while the number of microbes, CO_2 production and microbial biomass-C were increased by the artificial+bacterial fertilizer combinations. In some cases the combined straw+bacterial fertilizer treatments were effective.

Keywords: bacterial fertilization, the total number of bacteria, the number of microscopic fungi, CO_2 production of soil, microbial biomass-C content.

INTRODUCTION

The determination of the number of microorganisms in the soil does not indicate duly the amount of microbial biomass, actually. The microbial biomass of soil has a very important role in the transformation and accessibility of some nutrients – like carbon and nitrogen. The determination of microbial biomass includes that of the CO_2-production and the biomass-C content of soil. Several studies deal with the investigation of the soil's microbial biomass, e.g. Csitári & Hoffman (2005), Kátai et al. (2005), Kátai et al. (2006), Németh (1996), Szili-Kovács et al. (2008), Tállai (2011) and Török et al. (2000).

In our study we investigated the effects of different treatment combinations on different microbial parameters of a calcareous chernozem soil in a pot experiment.

MATERIALS AND METHODS

The pot experiment was set up in the greenhouse of the University of Debrecen, Centre for Agricultural and Applied Economic Sciences, Institute of Agricultural Chemistry and Soil Science in 2010. The soil type applied was calcareous chernozem from Debrecen (Látókép). The properties of soil studied were the following: K_A 37.5; silt and clay content 51%; pH_{H2O} 6.6; pH_{KCl} 5.5; humus% 2.8; AL-P_2O_5 140 mg kg^{-1} and AL-K_2O 316 mg kg^{-1}. The soil was mildly acidic loamy soil with medium nitrogen and good phosphorus and potassium content. The test plant applied was ryegrass (*Lolium perenne*, L.). At the beginning of the experiment we put 1-1 kg air dried soil into the pots and stirred in 0.6-0.6 g ryegrass' seed upper the 2 cm of soil layer. The pots were placed in a trolley that was pushed indoors at night and on rainy days. The pots were irrigated to 60% of the field water capacity every day. The applied treatments were the following: 1-Control, 2-NPK fertilizer, 3-Wheat Straw, 4-Bactofil A bacterial fertilizer, 5-NPK+Bactofil A, 6-Straw+Bactofil A, 7-EM-1 bacterial fertilizer, 8-NPK+EM-1, 9-Straw+EM-1, 10-Microbion UNC bacterial fertilizer, 11-NPK+Microbion UNC, 12-Straw+Microbion UNC.

The NPK fertilizer applied was variegated by nitrogen as 0,2857 g NH_4NO_3; phosphorus and potassium as 0,1915 g KH_2PO_4 and 0,0625 g K_2SO_4 fertilizer. 20cm^3 of the fertilizer solutions was applied to each pot. The wheat straw was applied 3 g pot^{-1}, corresponding to the amount of 7 t straw $hectar^{-1}$. The Bactofil A and EM-1 biofertilizers applied were mixed into the soil in solution after dilution, 20 cm^3 and 15 cm^3 to each pot. 0,01 g Microbion UNC bacterial fertilizer was mixed in each pot. A double-dose of biofertilizers was used in the experiment. The important parameters of biofertilizers were published by Jakab et al. (2011). The total number of bacteria (on Bouillon soup agar) and the number of microscopic fungi (on peptone-glucose agar) were determined from soil-water suspension by the plate dilution method based on Szegi (1979). The CO_2 production of soil was measured with Witkamp's method (1966, cit. Szegi, 1979). The microbial biomass-C content of soil was assessed after chloroform fumigation incubation (CFI), while the CO_2-C content was determined with the method of Jenkinson & Powlson (1979). The soil samples were collected after 8 weeks. The plant samples were collected twice, after 4 and 8 weeks. From the values we calculated average values, which are presented in this paper. The experiment was set up in random block design in three replications that gives 36 pots totally.

For the examination of the statistically justifiable differences between the average values of the results we applied Tolner's (2008) one-factor analysis of variance on statistical data which shows the average values and $LSD_{5\%}$ values. The correlation analysis was made with MS Office 2003 to determine the relations between values (Sváb, 1967).

RESULTS AND EVALUATION

In this paper we examine the following soil parameters: the total number of bacteria, the amount of microscopic fungi, the CO_2 production of soil and the microbial biomass-C content of soil.

The soil's microbiological parameters– the total number of bacteria and the number of microscopic fungi — are illustrated in *Table 1*.

Table 1

The microbiological parameters of soil and the LSD5% values of experiment

	Without bacterial fertilizer	Bactofil A	EM-1	Microbion UNC
The total number of bacteria ($*10^6$ soil^{-1})				
Control	17.88	14.52	13.67	11.91
NPK fertilizer	26.27	17.61	16.82	13.30
Straw	11.70	13.12	10.79	7.24
$LSD_{5\%}$	*0.37*			*Average 14.56*
The number of microscopic fungi ($*10^3$ soil^{-1})				
Control	22.33	31.33	32.33	20.33
NPK fertilizer	42.00	43.33	37.33	37.67
Straw	35.00	37.33	17.33	27.33
$LSD_{5\%}$	*1.51*			*Average 31.94*

The total number of bacteria was increased by the NPK fertilization, due to the improvement of nutrient content after fertilization. In straw treatment the number of bacteria decreased. All the three bacterial fertilizers resulted in a decrease in the number of bacteria. The combination of artificial+bacterial fertilizers decreased the number of bacteria significantly compared to the NPK fertilization. The straw+bacterial fertilizer combinations decreased the number of bacteria (except for the straw+Bactofil A treatment) relative to the straw treatments. The NPK fertilization was the most effective; the total number of bacteria was the largest in this case.

The number of microscopic fungi was increased by the NPK fertilization and also that of bacteria. The straw treatment had a positive effect. The straw application was a good medium for the fungi. The addition of bacterial fertilizers in some cases – Bactofil A and EM-1 – increased the number of fungi. The artificial+bacterial fertilizer combinations decreased significantly the number of fungi at the EM-1 and Microbion UNC biofertilizers. The straw+Bactofil A treatment increased, the straw+other biofertilizers decreased the number of fungi. The NPK+Bactofil A combination proved to be the most effective, resulting in the largest number of microscopic fungi.

The soil's microbial production is illustrated in *Table 2* – the CO_2 production and the microbial biomass-C of soil (CFI).

Table 2

The microbial production of soil and the LSD5% values of experiment

	Without bacterial fertilizer	Bactofil A	EM-1	Microbion UNC
The CO_2 production of soil (µg CO_2 g^{-1} 10 day^{-1})				
Control	127.90	137.56	161.67	171.12
NPK fertilizer	160.18	165.21	169.16	201.67
Straw	168.83	173.89	173.42	171.02
$LSD_{5\%}$	*6.02*			*Average 165.14*
The microbial biomass-C content of soil (µg CO_2 g^{-1} day^{-1}, CFI)				
Control	86.82	173.03	144.87	101.21
NPK fertilizer	86.13	82.81	85.43	84.56
Straw	72.43	159.20	129.90	87.03
$LSD_{5\%}$	*2.92*			*Average 107.79*

The CO_2 production of soil increased with the NPK fertilization, which was the consequence of the increasing number of microbes, probably. The straw treatment increased the CO_2 production. The self-applied bacterial fertilizers increased the production in all of the treatments. The artificial+bacterial fertilizers increased the CO_2 production, except for the NPK+Bactofil A treatment. The extent of CO_2 processing was increased by the application of artificial and bacterial fertilizers. The straw+EM-1 treatment had similar effects on the production. The straw+Microbion UNC combination decreased the amount of CO_2 produced. The highest value was measured at the NPK+Microbion UNC treatment.

We determined *the microbial biomass-C content of soil* from the CO_2 production of fumigated and non-fumigated soil samples. The straw treatments decreased the biomass-carbon content significantly. Bacterial fertilization increased the average values in all cases. The artifical+bacterial fertilization caused a decrease. The straw+bacterial fertilizer treatments increased the biomass-C content of soil. The highest value was experienced at the NPK+Bactofil A treatment.

We defined with *correlation analysis* the relations between our results (*Table 3*). We established a positive medium relation between the CO_2 production of the soil and the treatments. There was a negative medium relation between the total number of bacteria and CO_2 production. Finally, a positive medium relation was seen between the number of microscopic fungi and the total number of bacteria.

Table 3

The results of correlation analysis

Correlation (n=36)		**Relation**
CO_2 production of soil	Treatments	0,657*
The total number of bacteria	CO_2 production of soil	- 0,574*
The number of microscopic fungi	The total number of bacteria	0,541*
* Correlation is significant at the 0.05 level.		

CONCLUSION

The conclusions from our results are the following:

- The NPK fertilization increased the total number of bacteria.

- The amount of microscopic fungi was increased by the NPK fertilization and NPK+bacterial fertilizer combinations.

- All treatments influenced the CO_2 production of soil positively.

- In some cases the biomass-C content of soil was increased by the bacterial fertilization and straw+bacterial fertilizer combinations.

The treatments applied influenced the parameters measured, which is supported by the correlation-analysis, too. In 2010 we determined medium average relations between treatments, soil microbes, soil CO_2-production and microbial biomass carbon content.

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