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Influence of mineral-organic fertilizers on soil microbial respiration and nitrifying bacteria activity

INTRODUCTION

Undoubtedly, the amount of waste produced is increasing year by year. Therefore, it is very important to search for new possibilities of transforming and reusing waste materials. One such type of waste is fly ash, which is generated as a by-product in conventional power generation in coal-fired power plants. As it turns out, fly ash contains significant amounts of valuable components that can be reused. The synthesis process can produce zeolites – which are aluminosilicates with specific properties (Belviso 2018; Czarna-Juszkiewicz et al. 2020). Zeolites contain a complex system of channels and chambers in their structure, due to which they possess molecular-sieve properties. The properties of zeolites such as porosity, high ion exchange capacity and selectivity are very important from agricultural point of view (Ramesh and Reddy 2011). The combination of zeolites with minerals and the source of external organic matter in the form of mineral-organic fertilizer may lead to an optimized use of nutrients (Cairo et al. 2017; Rosalina et al. 2019).

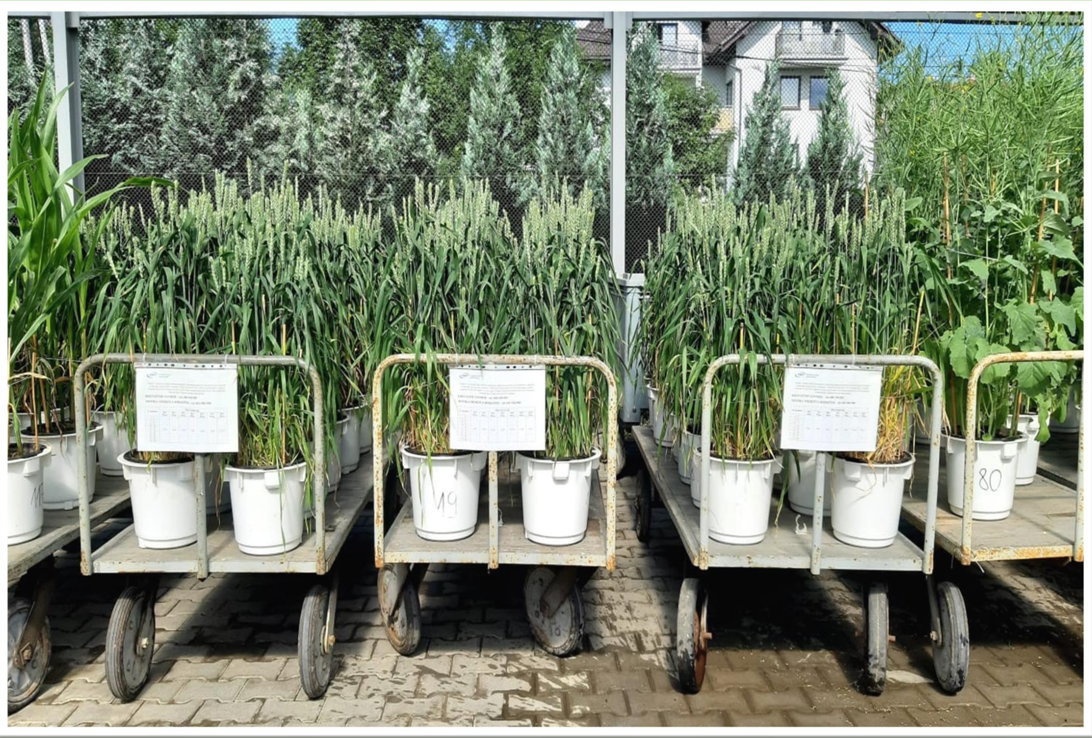
One of the methods of assessing the impact of the use of mineral-organic fertilizers with the addition of this materials is the microbiological activity of the soil. In order to determine the effect of applying innovative mineral-organic fertilizers with the addition of zeolites on soil microbial activity, we conducted a pot experiment in a vegetation hall using spring wheat as a test plant (Pic. 1.).

THE AIM OF REASERCH

The planned research tasks include the testing of at least two fertilizer formulations with the addition of functionalized sorption materials and lignite for biofortification of crop plant with selected micro- and macronutrients. The fertilizers have specific, new properties, e.g. they will allow extended release of nutrients. The aim of the study was to assess the effect of the fertilizer formulations on soil microbial respiration and nitrifying bacteria activity in a pot experiment conditions.

MATERIALS AND METHODS

The scheme of the experiment including: C (control soil without any fertilizers); MF (soil with only mineral fertilizers - NPK); CW3% (soil with addition of 3% of lignite and 3% of zeolite-vermiculite composite - NaX-Ver); CW6% (soil with addition of 6% of lignite and 3% zeolitevermiculite composite - NaX-Ver); CL3% (soil with addition of 3% of leonardite and 3% of zeolite-vermiculite composite - NaX-Ver); CL6% (soil with addition of 6% of leonardite and 3% of zeolite-vermiculite composite - NaX-Ver). Each treatment was performed in 4 replications. Soil for biochemical analyses was collected 5 months after of the mineral-organic mixtures application and stored at 4°C for biological analysis and at 25°C for chemical analysis. Soil microbial respiration (BR – basal respiration; SIR – substrate induced respiration; QR – respiratory activation quotient of control and amended soil) and nitrifying bacteria activity analysis was performer to determine the biological activity of the soil.



Picture 1: The first year of the pot experiment

RESULTS & DISCUSSION

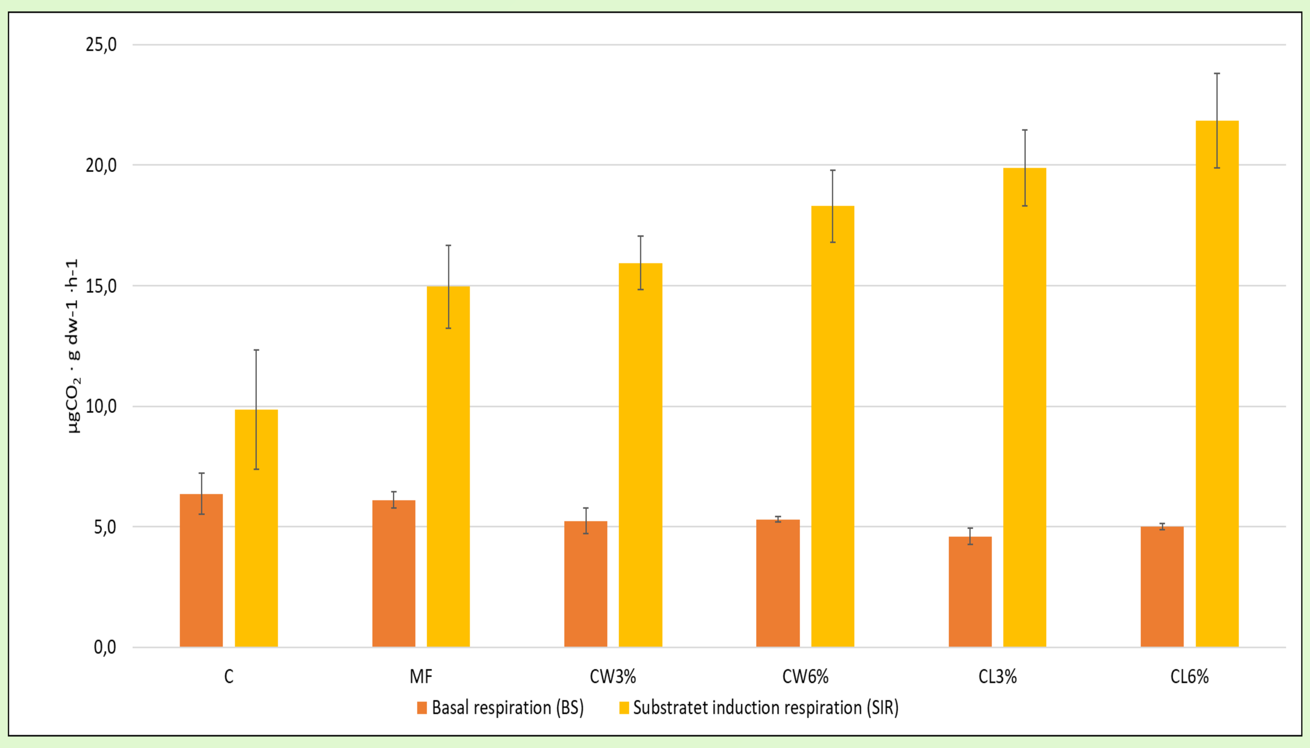


Figure 1: Basal respiration (BS) and substrate induced respiration (SIR)

Soil for biochemical analyses was collected 5 months after of the mineral-organic mixtures application and stored at 4°C for biological analysis and at 25°C for chemical analysis. Soil microbial respiration (BR – basal respiration; SIR – substrate induced respiration; QR – respiratory activation quotient of control and amended soil) and nitrifying bacteria activity analysis was performer to determine the biological activity of the soil. The significantly highest BR value was determined in control soil without fertilization (Fig. 1.). While the values obtained in the objects: CW3%, CW6%, CL3% and CL6% were on average 21% lower than in the control treatment. The addition of a substrate (glucose) to the analyzed soil samples caused a considerable increase in the respiration rate (Fig. 1.). The highest SIR values were obtained in the CL6% treatment.

The respiratory activation quotient (QR) (Fig. 2.) that was calculated in our study represents the number of dormant or active microorganisms. The highest values of QR were determined in the soil without fertilizers (C), while in the other treatments the values of this parameter were significantly lower. The lowest QR value (0.23) were obtained in CL3% and CL6% treatments.

Our study shows that the addition of 6% lignite and 3% zeolite-vermiculite composite had significant effect on nitrifying bacteria activity (Fig. 3.). Compared to the C treatment, nitrifying bacteria activity was higher 40% on average and compared to the MF treatment 15% on average.

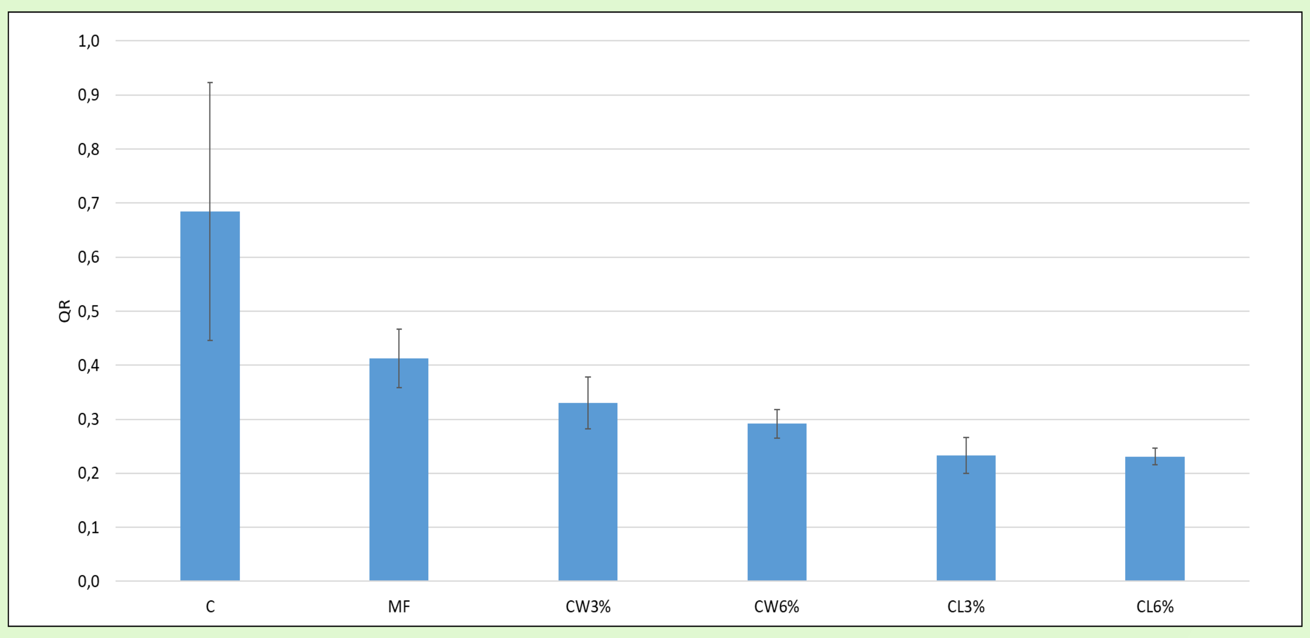


Figure 2: The respiratory-activation quotient (QR)

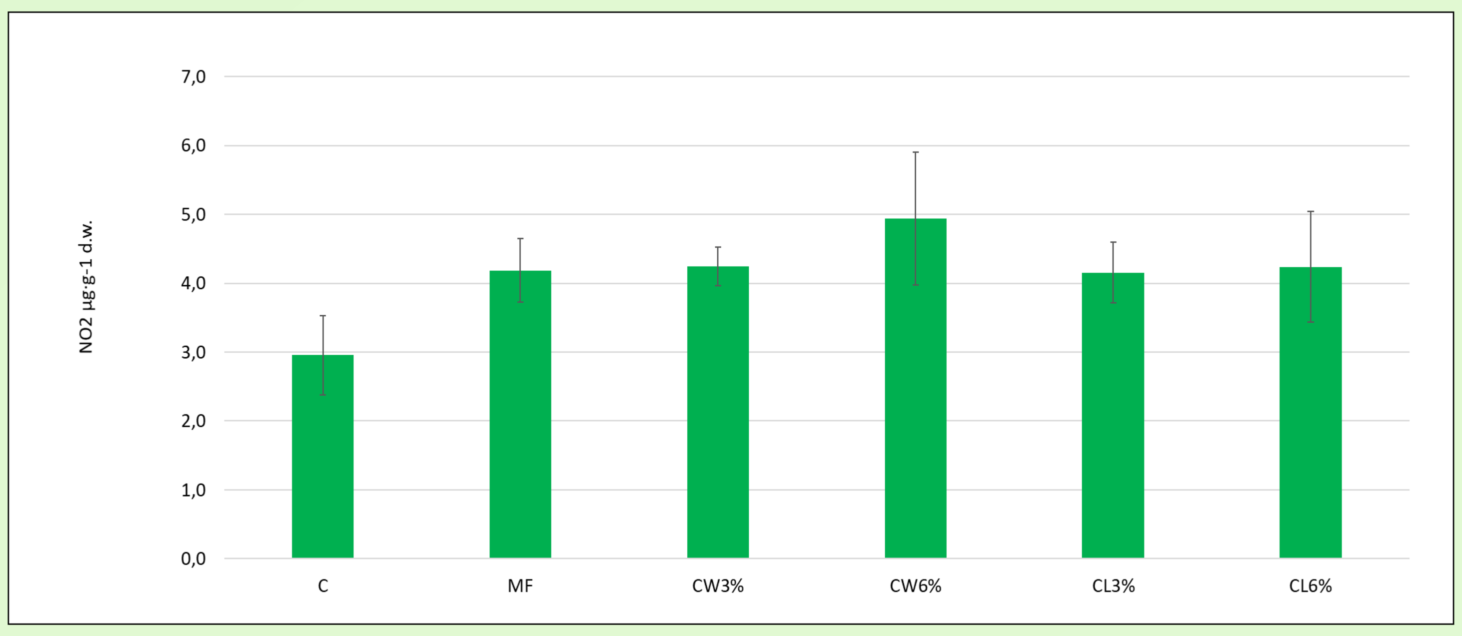


Figure 3: Determination of potential nitrification

CONCLUSIONS

1. The nitrifying bacteria activity determined in the studied soils indicated that the most favorable conditions for the course of nitrification occurred in the object CW6%.
2. The use of mineral-organic fertilizers increased the SIR value.
3. Substrate induced respiration (SIR), respiratory activation quotient (QR) and nitrifying bacteria activity are sensitive tools for rapid verification of the effects of changes in the analyzed soils.

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