Abstract

The incessant growth of the world's population and the consequent strong intensification and chemization of agriculture contribute to disturbing shifts in agroecosystems, resulting in a decline in the productivity and quality of arable soils. It is beyond doubt that synthetic fertilizers are an important source of nutrients indispensable for the proper development of plants, however, excessive and inappropriate application of such preparations leads to environmental pollution and a loss of biodiversity within soil microbiome and mycobiome. Microorganisms are an integral component of the terrestrial ecosystems, directing the soil processes and thus shaping the availability of mineral compounds and ensuring of the ecological balance. Owing to the invaluable contribution of bacterial, archaeal and fungal communities to the functioning of agroecosystems, a growing interest is emerging in the evaluation of the impact of different agricultural practices on the biodiversity and activity of microorganisms inhabiting arable soils. The contemporary vision of ecological and sustainable agriculture links the status of the soil microbiome and mycobiome with the general soil quality, and the rich biodiversity allows for the maintenance of soil's productive potential at a sufficiently high level. This is of particular importance in case of degraded soils with disrupted homeostasis and reduced mineral content.

One of the approaches to overcome the issues arising from the intensive human agricultural activity is the exploitation of strains of beneficial microorganisms in the biofertilizers form. Biofertilizers represent an environmentally friendly alternative or supplement to traditional mineral fertilizers, and an increasing number of reports confirm the favourable impact of such formulations on the microbiological parameters of arable soils, which is inextricably linked to improved soil health. The employment of biofertilizers containing microorganisms also remains in line with the principles of sustainable agriculture, as well as with the policy requiring a reduction in the quantity of agrochemicals applied to the soil.

With an eye to the growing interest towards biofertilizers and the development of sustainable soil management practices, the research which was undertaken in this thesis concerned the effect of an innovative phosphorus mineral fertilizer enriched with strains of beneficial bacteria on microbiological parameters of degraded soils (including enzymatic activity and functional and genetic diversity of bacterial, archaeal and fungal communities). Two-year field experiments were conducted in 2018-2019 on two different soil types, under maize cultivation. The field experiments included the following fertilization treatments: an optimal dose of fertilizer without microbial enrichment (FC), an optimal dose containing microorganisms (FA100) and a 40% reduced dose of fertilizer containing microorganisms (FA60). Soil samples were taken three times in both years of the experiments: before (bio)fertilizers application (April), one week after (bio)fertilizers application (June) and after maize harvest (October).

Soil enzymatic activity was assessed based on the variations in the protease, urease, acid phosphatase and β-glucosidase activities. Investigation of functional diversity involved 8 the determination of the catabolic potential of soil microbial communities to utilize carbon substrates distributed on BIOLOGTM ECO and FF plates. Genetic diversity was analyzed using terminal restriction fragment length polymorphism (t-RFLP) and Next Generation Sequencing (NGS). The performed research referred to both the immediate microbial response and seasonal changes in the status of the soil microbiome and mycobiome after phosphorus biofertilizer application.

The research showed a positive effect of the phosphorus biofertilizer on microbiological parameters of degraded soils. Application of the phosphorus biofertilizer increased soil enzymatic activity and maintained this effect over time. Changes in the utilization rates of carbon sources belonging to different groups and expansion of the catabolic capacity of soil microbial communities were also observed. The phosphorus biofertilizer stimulated the occurrence of microorganisms promoting plant growth and development and increased the genetic diversity and the number of

operational taxonomic units associated with metabolic and cellular processes. There was also an increment in maize yield and in the content of phytoavailable phosphorus in the soil. The obtained results demonstrate the comprehensive impact of phosphorus biofertilizer on the soil environment and confirm its potential for effective implementation on sustainable and regenerative agriculture.

Keywords: biofertilizers, sustainable agriculture, soil microorganisms, degraded soil, soil enzymatic activity, soil microbial diversity, regenerative agriculture