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EFFECT OF ORGANIC FARMING ON SOIL MICROBIOLOGICAL PARAMETERS

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Abstract. All over the world, including Poland, interest in the organic farming is growing. It is based on an attempt to minimize human impact on the environment while maintaining the natural functionality and productivity of the agricultural system. At the same time, every human activity in the natural environment results in greater or lesser changes in the soil ecosystem. Organic farming also has an impact on physical and chemical parameters and soil biological activity. These changes should be monitored and considered in the context of long-term land management. This review focuses on the impact of the organic farming system on soil biological activity and diversity of soil microorganisms.

Keywords: organic farming, soil microorganisms, soil quality

INTRODUCTION

According to the European Commission, the term "organic farming" is used to define agriculture which aims to minimize human impact on the environment while maintaining the natural functionality of the agricultural system (Fig. 1). The system was established to improve food safety, increase soil fertility and biodiversity, protect the environment and the sustainable development of ecosystems (Gomiero *et al.* 2011). Organic farming methods are regulat-

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ed and enforced by many countries. The International Federation of Organic Agriculture Movements (IFOAM; https://www.ifoam.bio/) has also been active since 1972. This is the patronage organization of organic farming (Paull 2010). Organic farming is based on some principles (https://ec.europa.eu):

– broad crop rotation,
– minimizing use of chemical fertilizers and feed additives,
– leaving harvest residues,
– the prohibition of the use of genetically modified organisms,
– use of natural resources, i.e. animal fertilizers (manures and residues from the slaughter of animals), compost and farm produced feedstuff.

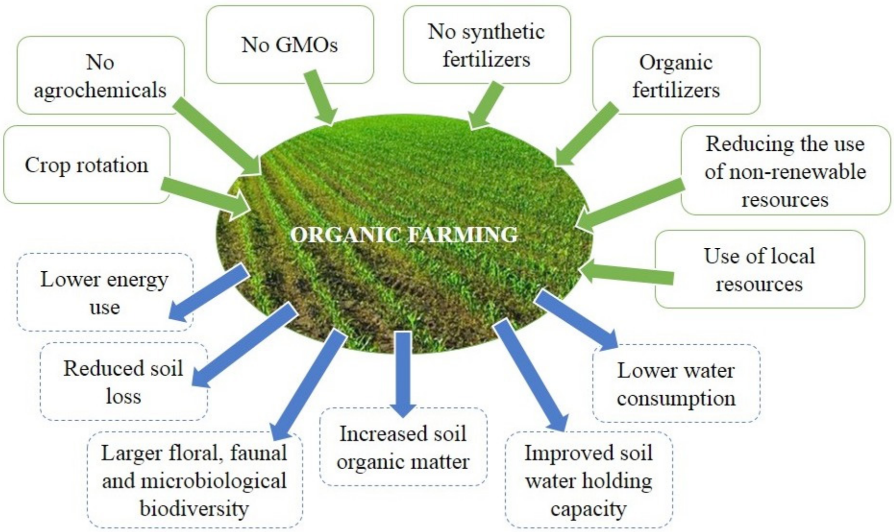

Fig. 1. The main principles and effects of organic farming

Organic farming is widely recognized as a sustainable system. There is also a growing interest from consumers in organic food. Every year the area of organic agriculture in the world is growing. In 2010, the total area of the organic agriculture in the world was around 37 million ha, whereas in 2017, it was 69.8 million ha (https://www.organic-world.net). In Poland, the area of organic farming in 2016 covered an area of around 494 thousand ha, which placed Poland 20^{th} in global scale (Table 1).

Table 1. Organic agricultural land in the world in 2017 by continent and their top countries, including Poland

	Organic agricultural land [ha]	Percentage of the global organic agricultural land
World	69,845,243	100%
Europe	14,558,246	20.84%
Spain	2,082,173	2.98%
Poland	**494,979**	**0.71%**
Australia and Oceania	35,894,365	51.4%
Australia	35,645,038	51.03%
Africa	2,056,571	2.94%
Tunisia	306,500	0.44%
Asia	6,116,834	8.76%
China	3,023,000	4.33%
North America	3,223,057	4.61%
United States of America	2,031,318	2.91%
Latin America	8,000,888	11.45%
Argentina	3,385,827	4.85%

The supporters of organic farming claim that it allows to conserve the biodiversity of the environment, sustainable soil management and to maintain the closed circle of elements, which can reduce climate change. It is claimed that the soil from organic farming is of higher quality through higher production of organic matter in comparison with conventional crops. On the other hand, among the negative opinions on organic farming, the majority is that it requires more land for cultivation, which can potentially lead to the degradation of forests (intended for arable land) and disturbances of ecosystems. The organic system is both commended and criticized.

The important aspect that must be taken into account when considering agriculture is soil. Its quality and productivity are key factors in yielding plants. Microorganisms and soil micro- and mesofauna are the main elements in the biochemical processes taking place in the soil (Gałązka *et al.* 2016). They are involved in the decomposition of organic residues, the formation of humus, the circulation of various biogenic components and their transformation into forms available to plants, as well as in the degradation of pollutants. Microorganisms are an important component of the soil environment, they are a very diverse group of organisms in phenotypic and genomic aspects, and in addition, despite many years of research, they are still not well known. Numerous studies have shown that the cultivation system and agronomic practices have an impact on the diversity and composition of soil microorganisms. The biological activity of the soil and its quality are therefore affected (Bonanomi *et al.* 2016). Research conducted by Tscharntke *et al.* (2012) has shown that there are about 1,000 species of microorganisms in natural soil not cultivated for agricultural use, and about 140–150 species in 1 g of agricultural soil.

ORGANIC FARMING AND SOIL QUALITY

Soil quality is the object of numerous scientific research (e.g. Reeve *et al.* 2016). Soil quality or health is most often defined as the: "capacity of a soil to function within ecosystem boundaries to sustain biological productivity, maintain environmental quality, and promote plant and animal health" (Doran and Parkin 1994). It is measured using a number of biological, biochemical, chemical and physical parameters. The application of agrotechnical techniques and fertilization may affect individual soil quality parameters. It has been shown that areas managed for agriculture are biologically degraded in comparison with uncultivated areas. Agricultural soils have a lower pH, a lower content of total carbon (TC) and permanganate oxidizable carbon (POXC) (Wolińska *et al.* 2016). Numerous research on long-term crops show that organic farms improve soil quality compared to conventional using of areas (Reeve *et al.* 2016). Soil quality is important for the sustainable management of natural resources and for agricultural development (Doran and Parkin 1994). The use of intensive crops, fertilizers and chemical plant protection products causes changes in the soil environment in agro-ecosystems (Gajda and Przewłoka 2012). The introduction of simplifications in tillage is important in the process of transformation of agricultural production from intensive to sustainable and improvement of soil environment conditions (European Environment Agency 1998). In organic farming,

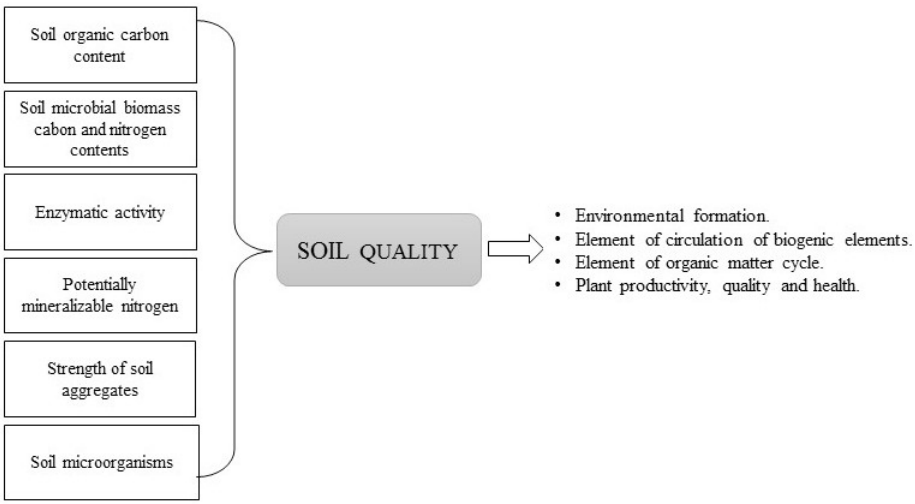

Fig. 2. Selected soil quality parameters and the elements that soil quality affect

agricultural production shall aim to close food cycles in which crop residues or livestock manure return to the fields, including multi-annual crops and legumes. This undoubtedly improves soil quality by accumulating organic matter in the soil and by natural processes without chemical intervention. Several studies have reported a positive effect of organic farming on soil quality including microbial community traits (Lori *et al.* 2017).

Enzymatic activity is one of the parameters measured in the assessment of soil quality. Dehydrogenases, phosphatases, urease, proteases, arylsulfatase, invertase and amidase are the most commonly studied soil enzymes (Furtak and Gajda 2017, 2018). Research conducted by Wang *et al.* (2016) has shown that the activity of invertase and acid phosphatase is significantly higher in soils from organic farming than in soils from conventional farming. There is also a higher activity of dehydrogenases in soils from ecological systems compared to conventional systems (Furtak *et al.* 2017, Furtak and Gajda 2017, Wolińska *et al.* 2015, Sikora *et al.* 2011, Mikanová *et al.* 2009). Similar results were obtained for (3,6-diazetylfluorescein) hydrolysis (Gajda *et al.* 2016) and urease activity (Kabiri *et al.* 2016, Mohammadi *et al.* 2013).

The determination of microbial biomass content is used as one of the soil quality indicators. It is the main component of soil organic matter and maintains the basic functions of the soil. Microbial biomass is affected by agrotechnology and soil management. Numerous research indicate that organic farming has a positive effect on the soil's microbial biomass carbon (MBC) and nitrogen (MBN) contents, compared to other farming systems (Kabiri *et al.* 2016, Wolińska *et al.* 2015, Lagomarsino *et al.* 2009, Melero *et al.* 2006, Gajda and Martyniuk 2005). Researchers indicate, in general, significant differences in soil biomass between conventional and organic crops. This is due to inputs of organic residues, with high C content.

The organic carbon content (SOM) is also used as an indicator of soil quality. Similarly to the parameters described above, its values are higher in the soils from organic farming than in the soils from conventional farming (Düring *et al.* 2002, Gajda *et al.* 2000).

ORGANIC FARMING AND MICROORGANISMS

The diversity and activity of soil microorganisms is important for the quality and productivity of soils. Research shows that in agricultural soils the number of operating taxonomic units (OTUs) may be even 30% lower than in uncultivated soils (Wolińska *et al.* 2017, 2016). Organic farming includes among its practices the use of natural fertilizers, including biopreparations containing microorganisms. These can be bacteria that stimulate plant growth by nutrient supply (e.g. atmospheric nitrogen fixation) and phytohormone synthesis, or they can have a protective effect by inhibiting phytopathogens (Pociejowska *et al.* 2014). The introduction of microorganisms into the soil environment can have an impact on the local microbial community. Research has shown that simplifications in cultivation result in an increase in the number of microorganisms, including *Cladosporium* and *Mucor* fungi, which can inhibit the growth of pathogens in the soil (Tautages *et al.* 2016). The positive effect of organic systems on the reduction of phytopathogenic microorganisms has been described (Bulluck *et al.* 2002). In the case of cultivation in tunnels, more bacteria from the groups were found: *Arthrobacter*, *Flavobacterium*, *Variovorax*, *Lysobacter* and *Massilia* in organic crops in comparison with conventional crops (Bonanomi *et al.* 2016). The use of organic fertilizers, including manure, increases the number of bacteria that decompose organic matter. On the other hand, the use of mineral fertilizers and pesticides may have a negative impact on some microorganisms (Hartmann *et al.* 2015).

In addition to the amount of microorganisms in the soil, their diversity is also important. Species diversity is significant in the context of the functions performed by individual species. The numerous processes occurring in the soil environment are not the result of a single microbial species, but of their communities as a whole. It is important that such a community contains microorganisms with different functions. Research by Lupatini *et al.* (2017) has shown that the organic system has resulted in an increase in the taxonomic, phylogenetic and heterogeneous richness of the soil microbial compared to the conventional system. Researchers show that overall organic farming enhances total microbial abundance and activity in agricultural soils on a global scale (Lori *et al.* 2017). A study carried out by Caporali *et al.* (2003) has also shown that organic farming contributes to the conservation of soil biodiversity. Comparing the taxonomic composition of soil microbial from organic and conventional crops, researchers have shown that greater diversity of bacteria occurs in soils cultivated with organic farming (Hartmann *et al.* 2015, Hiddink *et al.* 2005), or that diversity persists at a similar level in both cultivation systems (Sugiyama *et al.* 2010). Research on cultivation in plastic tunnels has shown that a greater variety of microorganisms is present when using an organic washing system. It even seems that organic farming can improve the microbiological balance of the soil, previously damaged by conventional crops (Bonanomi *et al.* 2016). In ecological systems, there are also observed well organized fungi communities (Wittwer *et al*. 2018). The research on the glomalin content of the soil, which is glycoproteins produced by arbuscular mycorrhizal (AM) fungi, has shown a higher content of these proteins in soils from organic farming compared to soils from conventional and integrated systems, and also from winter wheat monocultures (Gałązka *et al.* 2018). This indicates a higher activity of AM fungi in these soils.

CONCLUSIONS

Every human activity in the environment has a greater or lesser impact on the quality of the soil. Organic farming is also not indifferent to the soil environment. The research mentioned above indicates a positive influence of the organic farming system on the biological activity of soils and their biodiversity. Unfortunately, these effects are not accompanied by high plant yields. But productivity is one of the characteristics of soil that is more important from an agricultural and economic point of view. It is certain that organic soil management is more beneficial for the environment in the long term. Nevertheless, it is important to observe changes in soil as a result of these practices, because the introduction of large amounts of organic matter and biopreparations into the environment may unbalance natural ecosystems. To conclude:

1. The organic farming system affects the biological activity of the soil.
2. Organic farming changes the structure of the soil microorganisms community.
3. Organic farming has a positive effect on soil quality compared with conventional farming systems.
4. The impact of different farming methods, including organic, should be monitored with a perspective of long-term cultivation.

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