REVIEW ARTICLE **(Open Access)**

Soil Fertility in Organic and Conventional Farming Systems

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Review Article

Abstract

A healthy soil is initially determined by its fertility, which depends on the interactions of the physical, chemical, and biological soil properties.

Organic farming systems probably emphasize more biological characteristics, which act to create long-term reserves of nutrients for plants, where the use of organic fertilizers is a major factor. A fundamental principle of organic agriculture is to maximize the recycling of nutrients, i.e., returning them to the natural cycle and significantly affecting ecosystem protection. Conventional production systems ensure the direct supply of plants with nutrients taken from the soil through mineral fertilization. This principle does not take much into account the fact that the soil is a living and productive ecosystem. The vision in convectional agriculture is simplified to the sometimes-uncontrolled supply of nutrients from mineral fertilizers with the sole objective of increasing production. Such a practice of conventional agriculture can sometimes be dangerous and with negative consequences on soil quality, water, and biodiversity.

Combining the application of two: organic and conventional production systems together would be a good recommendation for obtaining efficiently high and qualitive crop production in agriculture.

Keywords: *soil fertility, soil biological properties, organic fertilization, organic agriculture, conventional agriculture, fertilization systems.*

1. Introduction

I. The impact of soil properties on its fertility

The fertility of the soil is its complex and dynamic ability to supply the plant throughout its life cycle with nutrients water, and air. The interaction of biological, physical, and chemical properties of the soil has a wide impact on the preservation and improvement of the soil fertility.

The fertilization systems of organic agriculture perhaps emphasize more biological characteristics, which act to create long-term reserves of plant nutrients. Attention is also devoted to physical and chemical properties, which are also very important for the development of agriculture. (Maci. A. and L. Miho, 2019); (Perez-Guzman, L. et al., 2021).

The physical soil characteristics directly affect the volume of the root system and the growth of the root hairs of the plants. The plant roots develop optimally in the soil that have a good stability of structural aggregates. It is worth mentioning here the minimum tillage, which positively affects the preservation of the soil structure. Porosity, good filtration, drainage system, water capacity, high density, resistance to strong surfaces and compression also affect the development of the root system of the plants in soil (Khan A., 2019); (Crystal-Ornelas, R. et al., 2021).

While the chemical soil characteristics control the availability of plant nutrients. One of the most important chemical parameters is the soil pH, which determines solubility (available state) of the nutrients and microbial activity in the soil. The normal plant growth for the most of plants requires a soil pH from

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6–7 (different authors 6,5–7.5). If the soil pH decreases and is lower than 5.5, then the availability of macro elements N, P, K, Ca, Mg, and microelement Mo decreases as well. The reduction of pH also affects the reduction of the microbiological processes of mineralization of the organic nitrogen, such as nitrification or fixation of atmospheric nitrogen by rhizobium bacteria, which live in symbiosis with leguminous plants. On the other hand, the increase of the soil pH above 8 decreases the availability of macro elements P and K, but also of the main microelements Fe, Cu, Mn, Zn and B (Neina D., 2019); (Marshall, C. B. and Lynch, D. H., 2020).

Another important indicator of the chemical soil properties that must be taken into consideration on the evaluation of soil fertility is also the cationic exchange capacity (CEC), which has to do with soil ability to hold cations (NH_4^+, K^+, Ca^{2+}, Mg^{2+} etc.) from negatively charged colloids (Mäder P. et al., 2002).

II. Long term Doctrine in organic farming

The maintenance and increase of soil fertility has been closely linked to the various systems of fertilization in crop production. We can mention four systems of fertilization most often used in crop production:

- Biodyn: bio-Dynamic
- Bioorg: bio-Organic
- CONFYM: K/Conventional FarmYardManure
- CONMIN: K/Conventional mineral fertilizer

The graph below shows the impact of the fertilization system in the microbial mass accumulation in soil over the long-term period (7 years).

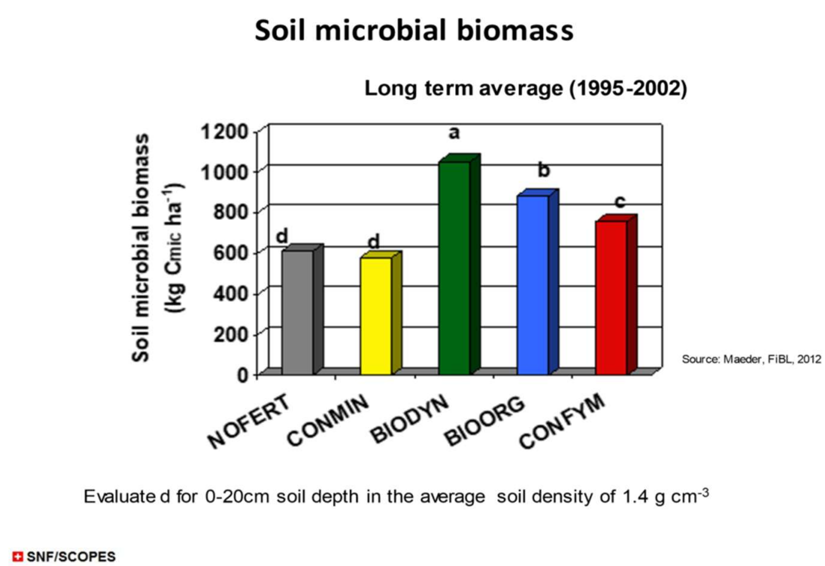

Figure 1. Soil microbial biomass

The observed considerable differences in the amount of soil microbial biomass among fertilizing systems is a result of long-term effect of the agricultural system (beginning of the experiment 1977). The positive effect of organic systems on soil microbial mass is obvious Mäder P. et al. (2012), Fliessbach A. et al., 2000; 2012).

The figure below shows the change in pH values depending on the agricultural systems. Comparing the agricultural systems, the results from long-term trial show that the soil pH increases sensibly in organic farming systems (BIODYN and BIORG) approaching optimal values for normal plant growth and development (Fliessbach A. et al. 2007).

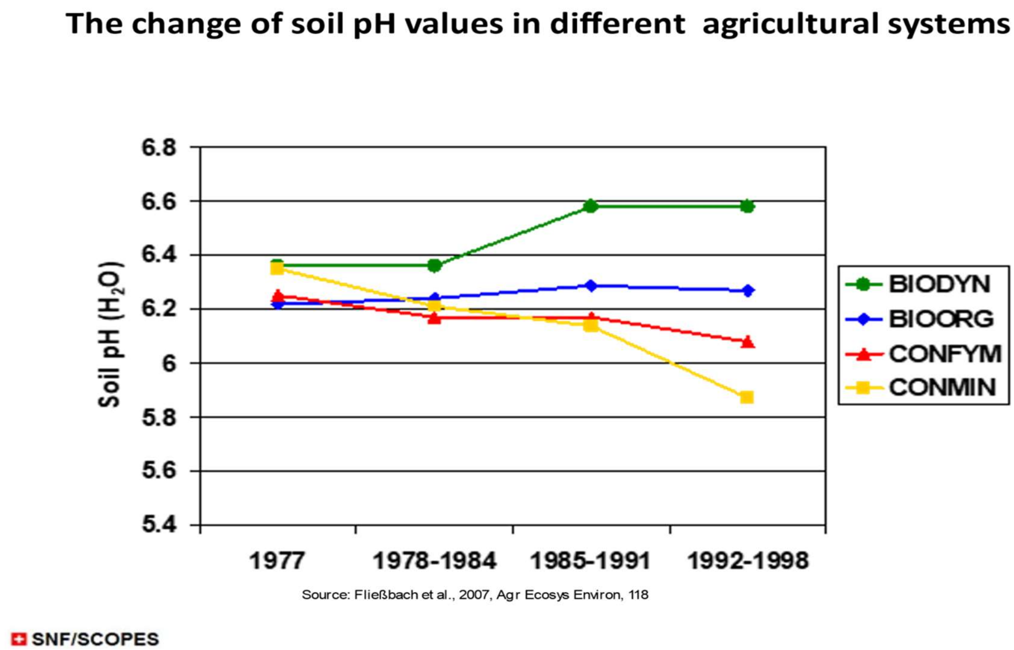

Figure 2. The change of soil pH values in different agricultural systems

In organic farming a special importance is devoted to maintaining and improving soil fertility, which is inconceivable without organic fertilization, i.e., food for flora and fauna in soil (Arncken C.M. et al., 2012). Conventional agricultural systems provide direct supply of plants with nutrients that are taken from the soil through mineral fertilization. This principle does not take much into account the fact that the soil is a living and productive ecosystem. The vision in conventional agriculture is simplified in the sometimes-uncontrolled supply of nutrients with a sole objective of increasing crop production. Such a practice of conventional agriculture can sometimes be dangerous and with negative consequences in soil, water, biodiversity, and quality of crop production (Mäder P. et al., 2007); (Maci. A. and L. Miho, 2019). The picture below shows the physical, chemical, and biological soil properties effected by the different long term fertilization systems applied on the soil.

The long-term field trial compares organic and non-organic farming systems. The differentiated management of the farming systems has led to system-specific changes of soil physical, chemical and biological properties. The positive effects of biodynamic and bioorganic farming on soil quality and soil biodiversity are evident (Pfiffner L. et al,1996); (Mäder P. et al., 2002); (Fließbach A. et al., 2007).

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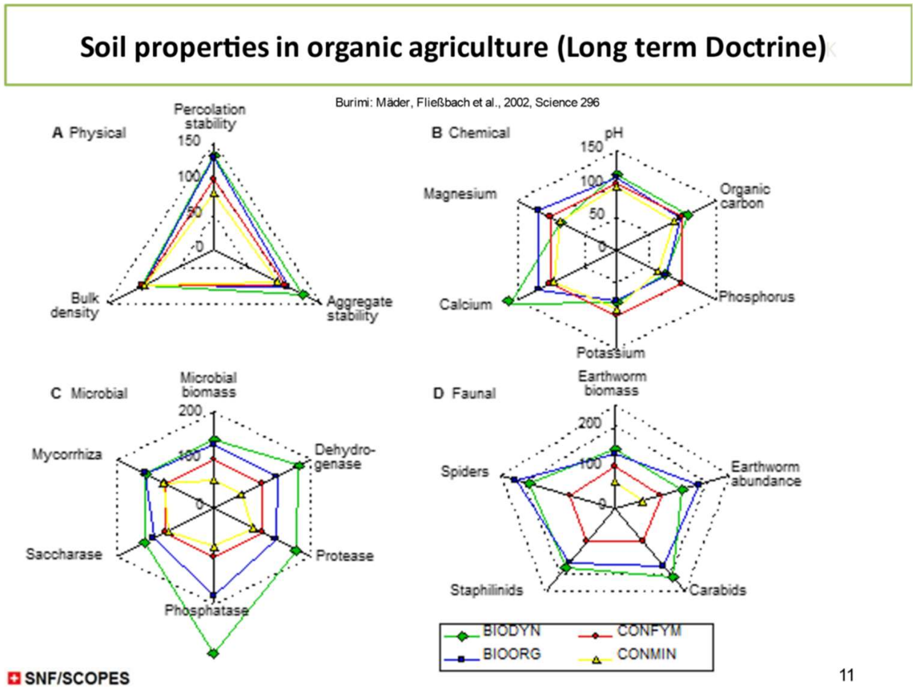


Figure 3. Soil properties in organic agriculture (Long term Doctrine)

III. The role of microflora and microfauna on soil fertility

A fundamental principle of organic agriculture is the effort to maximize the recycling of nutrients, i.e., their return to the natural cycle by affecting the protection of the ecosystem. Plants cultivated in these conditions are supplied with nutrient elements indirectly, through the soil-plant system, in which a main role play the soil microorganisms, responsible for the processes of decomposition of organic matter, mineralization and transformation of nutrients.

Soil organisms control the closing of nutrient cycling by process of mineralization of organic matter in soil. Soil microorganisms can mobilize nutrients from the mineral components of the soil, air (nitrogen) and organic matter and make them assimilable to plants (Maci A. and K. Mengel, 2001).

The main soil organisms with positive effects on plant nutrition are symbiotic interactions of nitrogen fixing *Rhizobia* bacteria and root *mycorrhizae*, free living soil microorganisms and earthworms. Nitrogen fixing *Rhizobia* bacteria live in nodules on the roots of plant legumes and fix nitrogen from the atmosphere. They absorb carbohydrates from plant roots as the energy source (Mäder P. et al, 2002; 2006).

The root *mycorrhizae*, part of fungi invade the root cells (ecto *mycorrhizae*) or the spaces between cells (endo *mycorrhizae*). Other part live in surrounding soil. The root *mycorrhizae* live with symbiosis with approximately 80 % of crops. Fungal threads penetrated the plant roots allow nutrients to be transferred directly from the soil into the plant's root system (Pfiffner L., Balmer O., 2009).

The fine structure of mycorrhizal mycelia means that they are more effective than plant root heirs at absorbing plant nutrients including phosphorus, nitrogen, potassium, and calcium as well as water. They are transported into the plant in exchange for carbohydrates. Mycorrhizae fungi are believed to use between 4 and 20% of host plant photosynthetic products. The total length of hyphae is typically 200 times the total length of the plant's roots and root hairs. In addition, the hyphae are much thinner than root hairs. They can thus enter tiny micro-pores in the soil, which the relatively thick root hairs cannot penetrate. The mycorrhizae help plant's resistant against diseases by synthesis of antibiotics. The hyphen secrete slime, which is food for bacteria. The slime of mycorrhizae fungi is helping to stick clay particles in water stable aggregates. The mycorrhizae quickly die in contact with soluble mineral fertilizers and pesticides (Oehl F. et al 2003; 2004).

The figure below shows the effect of P-fertilizer on the growth of flax and leeks in soils with and without mycorrhizae. The Mycorrhizae effect in flax and leeks is equivalent to the application of 150 kg P/ha and 100 kg P/ha, respectively.

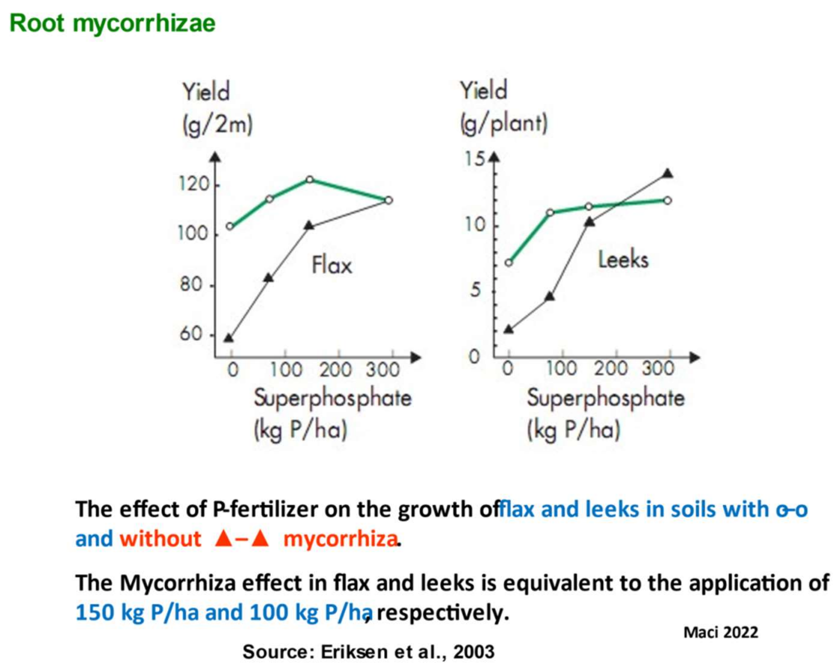


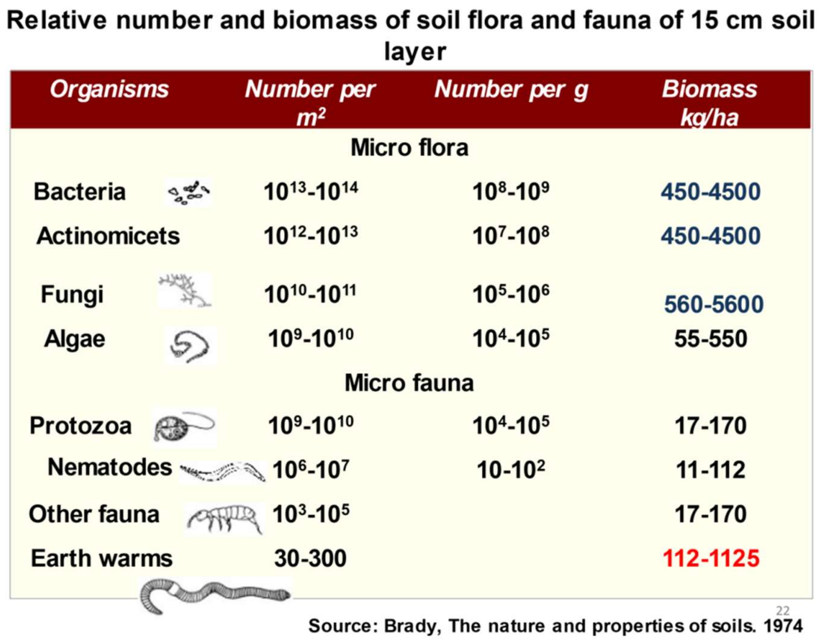
Figure 4. Root mycorrhizae

All free-living soil microorganisms by means of their vital activity influence on release of available nutritional elements in soil by mineralization of soil organic matter and weathering of soil minerals (Maci A. et al., 2007).

The Rhizosphere is the place where the plant roots contact the soil and form an integral part of soil ecosystem. The space around roots is reach on organic matter released from the roots and soil micro-organisms, which feed with this organic matter. The plant roots exude a mixture of different organic compounds known as mucigel. This mixture contains sources of nutritional compounds and energy for the micro-organisms living into the soil (Hildermann I. et al., 2010).

Earthworms are an important factor for soil fertility as well. They process soil and organic residues through its gut. Clay and organic matter are intimately mixed and coated with organic stabilising gums and lime secreted from special gland within the digestive tract. Earthworms play unique role for forming of water stable soil aggregates, make a significant contribution to organic matter incorporation in soil, and enrichment of topsoil with nutrients and humus. They build channels facilitating drainage. They allow exploration of deeper soil layers by plant roots, along with concentrated and readily available supply of nutrients. Earthworms cannot tolerate acidic soils with a pH < 5. An active worm population can process as much as 40 t of dry soil per hectare, or the equivalent of at least 0.5 cm soil annually. Compared to the soil casts are higher in bacteria and organic matter, total and NO_3^- - N, exchangeable Ca and Mg, available P and K and CEC. The weight of casts in cultivated field may reach up to 18 t/ha/annually (Pfiffner L. et al., 1997); (Willer, H., and Lernoud, J., (Eds.), 2018).

The table below shows the relative number and biomass of soil flora and fauna of 15 cm soil layer, which effect on the improvement of the physical soil characteristics.



Relative number and biomass of soil flora and fauna of 15 cm soil layer

Organisms	Number per m2	Number per g	Biomass kg/ha
Micro flora			
Bacteria	10^{13}-10^{14}	10^{8}-10^{9}	450-4500
Actinomicets	10^{12}-10^{13}	10^{7}-10^{8}	450-4500
Fungi	10^{10}-10^{11}	10^{5}-10^{6}	560-5600
Algae	10^{9}-10^{10}	10^{4}-10^{5}	55-550
Micro fauna			
Protozoa	10^{9}-10^{10}	10^{4}-10^{5}	17-170
Nematodes	10^{6}-10^{7}	10-10^{2}	11-112
Other fauna	10^{3}-10^{5}		17-170
Earth warms	30-300		112-1125

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Source: Brady, The nature and properties of soils. 1974

Figure 5. Relative number and biomass of soil flora and fauna of 15 cm soil layer

The cultivation of plants and their rotation in organic farming has its own distinct specificities for each culture, characteristics which are taken into consideration in the plant nutrition balance (Esperschütz J. et al.,2007); (Garland, G. et al., 2021). In the conditions of organic farming the fundamental task of fertilization (organic, green, and various composts) is to maintain and improve the soil fertility, provide nutrients for the soil microorganisms, restore the nutrients to the natural cycle (organic fertilizers produced by the farm itself) and ensure the renewal of nutrient elements removed from the soil through plant uptake. Organic fertilization increases the biological activity of the soil, which is the basis for maintaining and increasing the soil fertility. In a biologically active soil, plants are generally more tolerant, more capable of resisting different diseases and insects by significantly affecting the quality of plant production.

2. Conclusion

Generally, the fertilization systems in crop production can be collected in two alternatives: Conventional and Organic.

The combination of the two would positively affect not only the maintenance and increase of soil fertility, but also the quantitative and qualitative increase of the crop production in agriculture.

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