BONARESnewsletter

Summer 2020

In focus

# Microorganisms - significance for soil and plant health

Winter wheat in long-term field experiment in Bernburg-Strenzfeld of AUAS. Photo: Doreen Babin (JKI)

**Nearly 90 percent of our food and crop products are produced with the soil. Soils are therefore the foundation of our life. But soils are sensitive ecosystems and damage is difficult to reverse within short periods of time. It is therefore important to maintain soil fertility with site-specific agricultural management.**

Soil is one of the most important resources on earth. As a living and dynamic ecosystem, it provides habitat for a wide variety of life forms. This includes microorganisms such as bacteria and fungi, which are involved in almost all soil processes. One gram of soil can contain billions of microorganisms. These microorganisms are an elementary component of the soil and are of enormous importance for soil fertility and health. A healthy, fertile soil is a crucial prerequisite for plant productivity. It is therefore of fundamental importance for mankind to maintain soil fertility.

## Functions of microorganisms in soil

The various soil organisms fulfil important functions. Soil organisms convert dead organic matter into plant nutrients. They also ensure that poorly soluble mineral nutrients such as phosphate, zinc or manganese are released and absorbed by the plant. Without these nutrients, plant growth would not be possible. Currently, researchers are also discussing whether microorganisms can mobilise potassium. Soil organisms further help to maintain and improve soil structure by participating in the formation of humus and soil. Fungal hyphae and organic substances, released by microorganisms into the soil, bind soil particles into aggregates. Soils with a good soil structure are more fertile because they are able to better absorb and store water and nutrients.

## The close relationship between plants and microorganisms

Through their roots, plants establish relationships with soil-dwelling microorganisms by releasing organic compounds such as sugar molecules, amino acids and other organic substances into the soil around the roots. This area is also called the rhizosphere. The organic substances released by the plant roots serve as nutrients for microorganisms. Plants thus attract microorganisms which multiply in the rhizosphere and, for example, improve the availability of nutrients for the plant. The rhizosphere is thus of crucial importance for a functioning soil ecosystem.

GEFÖRDERT VOM

Bundesministerium für Bildung und Forschung

The interactions between plants and microorganisms in the soil can be mutually beneficial. A well-known example of a mutually beneficial partnership is the symbiosis with mycorrhizal fungi, which support the supply of water, nitrogen and minerals such as phosphate and zinc to the plant, thus improving plant growth. In exchange, the fungi receive sugar from plant photosynthesis.

## Microorganisms as plant pathogens

However, soil microorganisms also include pathogens that harm plants or negatively affect their health. It is undisputed that a healthy soil not only supports the supply of nutrients to plants, but also contributes to keeping plants healthy. Whether and what relationship a plant can establish with soil microorganisms depends, among other things, on the microbial community living in the soil.

## Soil microorganisms and agriculture

Although microorganisms are an integral part of the soil, we know little about how agricultural management affects the soil microbial community. What does farming mean for the relationship between plants and soil microorganisms and how do these changes affect plant growth and plant health?

To answer these questions, scientists in the BonaRes joint project DiControl are investigating on the one hand how agricultural measures affect the composition and functionality of the bacterial and fungal community in the soil in the long term. On the other hand, they are investigating how microorganisms in the immediate vicinity of roots influence plant growth and plant health. The knowledge gained will be incorporated into new cultivation strategies for sustainable soil management, in which the use of synthetic fertilizers and pesticides can be significantly reduced while maintaining or even increasing yields.

## Challenge for agricultural production

The protection of the environment, including soil fertility, is one of the greatest global challenges of our time. At the same time, agriculture should secure the increasing demand for food for a steadily growing world population as well as plant raw materials for industry such as vegetable oils for the production of detergents and cosmetics and for energy production. Sustainable crop production must therefore protect natural resources and maintain or even increase soil productivity. In intensive agriculture, as it is currently predominantly practised, large quantities of synthetic fertilizers and pesticides are used to ensure high yields. However, too intensive use of organic fertilizers such as liquid manure can also cause environmental problems through undesirable nutrient losses (nitrates) or pollutant inputs (antibiotics, heavy metals).

Already in 2011, the Food and Agriculture Organisation of the United Nations (FAO) stated that global yields in intensive agriculture, for example of cereals, have not increased since the 1990s. Why is this? Plant growth and plant health depend crucially on soil quality.

## Biodiversity important for soil fertility

If a species-rich microbial community is present in the soil, soils can do more for agriculture. This is shown not only by our own investigations, but also by those of the Agroscope Research Station and the University

GEFÖRDERT VOM

Bundesministerium
für Bildung
und Forschung

of Zurich. Plants can absorb more nutrients and grow better if a large number of fungal and bacterial species are present in the soil.

## Pesticides damage communities of microorganisms

We assume that synthetic fertilizers and pesticides have a negative impact on the microbial communities in the soil and thus also have a negative effect on plant growth and health. These are then more susceptible to pathogens that are usually controlled by synthetic pesticides - a vicious circle. After repeated and increased use of the respective pesticides, pathogens develop resistances after some time, so that their effect diminishes.

A vital soil life with high microbial diversity and activity can prevent the accumulation of pathogens in the soil and thus protect the plants from diseases. Numerous studies show that certain microorganisms help plants to defend themselves against pathogens and handle stress better. Ideally composed communities of microorganisms could help to reduce or eliminate the use of synthetic pesticides. Sustainable plant production systems should therefore treat and maintain the soil as a vital living and biological system.

## Soil as a complex biological system

Plant cultivation measures evidently influence microbial communities in the soil, as has been demonstrated by various studies (AGRARForschung 13, 2006; Landinfo 4, 2018; both in German). Long-term experiments show that the way in which the soil is managed, influences the physico-chemical and biological soil properties.

In organic farming, for example, preventive crop-related measures such as versatile crop rotation, optimum soil management, the use of organic fertiliser or the supply of the soil with sufficient organic matter provide for an active soil life. Versatile crop rotation is positive for soil biodiversity, as the plant roots themselves are colonised by a multitude of microorganisms and each plant species carries a specific microbial community. We assume that the cultivation of different crops promotes a species-rich microbial community both in the soil and in the rhizosphere. Each plant releases very specific organic substances and thus builds up an optimal microbial community in the rhizosphere. As already mentioned, an active and diverse soil life can counteract the occurrence of diseases and ensure that pathogens living in the soil (e.g. *Gaeumannomyces graminis*, *Pythium* spp. or *Phytophthora* spp.) reproduce less strongly.

In current agricultural practice, however, we are usually dealing with narrow crop rotations which are restricted to only a few crop species. In such crop rotations, pathogens can accumulate in the soil over time. This example shows that crop management measures become embedded in the "memory" of the soil, so to speak.

Unfortunately, at present we still know too little about how conventional crop management measures influence the "soil memory" or soil life - especially the microorganisms associated with the plant - and thus plant health. The aim of the research of scientists in DiControl is to better understand the interactions between plants and microorganisms in agroecosystems and thus to decipher the memory of the soil. The scientists are particularly interested in whether certain agronomical measures promote the accumulation of pathogens in the soil and whether the occurring microbial community can inhibit pathogens in their

GEFÖRDERT VOM
Bundesministerium
für Bildung
und Forschung

development. In a next step, we will then investigate whether a targeted inoculation of the plant with beneficial microorganisms supports these processes. On this basis, recommendations for sustainable plant production in conventional agriculture will be developed.

*Rita Grosch (IGZ) and Kornelia Smalla (JKI)*

**Rita Grosch** is head of the programme area **Plant-Microbe Systems** at the **Leibniz Institute of Vegetable and Ornamental Crops (IGZ)** in Großbeeren. She studied biology with a focus on plant physiology at the Humboldt-Universität zu Berlin. Her research focuses on interactions of plants with pathogens and beneficial microorganisms. A better understanding of these interactions at the molecular level and with the environment should help to control plant diseases in an environmentally friendly way. She has been coordinating the **Bonares** joint project **DiControl** since 2015.

**Kornelia Smalla** is deputy head of the **Institute of Epidemiology and Pathogen Diagnostics** at the **Julius Kühn Institute (JKI)** in Braunschweig. For more than two decades, she has been using molecular methods to investigate microbial communities in the rhizosphere of cultivated plants and is interested in how various abiotic and biotic factors influence the composition and dynamics of the rhizosphere microbiome. Since 2015 Kornelia Smalla is leading the DiControl project at JKI.

GEFÖRDERT VOM

Bundesministerium
für Bildung
und Forschung