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Federal Department of Economic Affairs,
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Agroscope
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Media Release

Date 21/10/2014

Arable farming benefits from soil organisms: More biomass, less nutrient loss

Soil organisms play an important role in arable farming: A functioning underground food web composed of bacteria, fungi and soil fauna can improve plant nutrition, increase agricultural yields and reduce nutrient leaching. An Agroscope study published in the Journal of Applied Ecology shows that soil conservation has numerous benefits. Taking better care of soil organisms allows us to use less fertiliser and enhance water quality.

Soil organisms perform key functions for the sustainable management of arable land, according to new research findings of Franz Bender and Marcel van der Heijden of the Plant-Soil Interactions Research Group at the Agroscope Institute for Sustainability Sciences ISS, Zurich, Switzerland. For nearly two years, the two researchers studied the impact of soil biota on plant yields, plant nutrition and nutrient leaching as part of a Swiss National Science Foundation project. They observed that soil with a more-varied addition of soil organisms produced higher yields, better plant nutrition and significantly less nitrogen leaching than sterile soils with a much lower addition of soil biota. For the study, the researchers removed a total of around six cubic metres of earth from a pasture, sterilised this earth, and filled it into containers of a lysimeter facility. There, the soil was then inoculated with either an increased or reduced variety of soil organisms. The researchers grew a rotation of maize, wheat

The seepage water (leachate) is collected in canisters in the maize-planted lysimeter and then analysed.
(Photo: Franz Bender, Agroscope)

and grass-clover mixture in the soil. The soil water percolating through the lysimeter containers was collected in canisters and its nutrient content analysed.

Significant nitrogen savings

The yield and nitrogen content of the maize plants in the lysimeter containers with enriched soil life were around 20% higher than in those with reduced soil life and the phosphorus content was more than double. The results were of the same order of magnitude for wheat.

In the first year, nitrogen losses through leaching were lower by more than half in containers with enriched soil life compared to containers with a lower abundance of soil organisms. Over the entire duration of the experiment, nitrogen losses in soils with an enriched soil life remained just under one-quarter (i.e. 24%) lower. This corresponds to a savings of 59 kilograms of nitrogen per hectare, or around half of the annual fertiliser application for maize and wheat. In addition, the researchers found a connection between the colonisation of the plant roots with mycorrhizal fungi (cf. box) and the phosphorus content of the plants.

Choice of suitable cultivation methods

The results of this study on plant nutrient uptake and yields, as well as on fertiliser leaching in arable farming are relevant for practitioners. Globally, only around half of the nitrogen fertiliser applied is taken up by the plants, with the rest remaining in the soil. From there, the fertilisers may end up in bodies of water, resulting in environmental issues. Moreover, global fertiliser stocks are limited: According to estimates, both the quality and availability of global phosphate stocks will decrease in the future. Additionally, the industrial production of nitrogen fertilisers is very energy-intensive. Therefore, the efficient use of nutrients is essential for sustainable agriculture.

We know from the literature that cultivation methods which protect the soil through no- or low-till practices and the sparing use of fertilisers and plant-protection products can support sensitive soil organisms such as mycorrhizal fungi. The present findings show that such practices can also make an important contribution to the efficient use of nutrients. As part of the Swiss National Science Foundation’s ‘Soil as a Resource’ National Research Programme, the role of soil life in important soil functions will continue to be investigated by several research groups (cf. www.nrp68.ch).

Mycorrhizal fungi – efficient networks in the soil

Mycorrhizal fungi are a group of soil fungi occurring worldwide which form symbiotic relationships with the majority of terrestrial plants, penetrating into the plant roots and forming a network of fungal hyphae in the soil. The hyphae extend the surface area of the plants' roots, and are able to absorb important plant nutrients such as phosphorus and nitrogen from the soil. They have access to soil resources which the plant roots are unable to reach. In this way, the fungi improve plant nutrition. In return, they receive nutrients from the plant in the form of sugars which the plant produces through photosynthesis. Agroscope maintains the largest collection of arbuscular mycorrhizal fungi in Switzerland. Belonging to the most common type of mycorrhiza, arbuscular mycorrhizal fungi owe their name to the branched treelike hyphae – the so-called arbuscules – within the cells of the root.

Further information:

Bender, S. F. and van der Heijden, M. G. A. (2014): *Soil biota enhance agricultural sustainability by improving crop yield, nutrient uptake and reducing nitrogen leaching losses*, Journal of Applied Ecology.

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