Geophysical Research Abstracts
Vol. 20, EGU2018-17002-1, 2018
EGU General Assembly 2018

Impact of conventional, organic and conservation agriculture on soil functions and multifunctionality

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The green revolution and the intensification of arable production have made a substantial contribution to increased world food production over the last 50 years. However, intensive agricultural practices have also given rise to environmental concerns such as decreased biodiversity, impaired water quality, and degraded soil quality. Soil is the basis for food production and provides a range of ecosystem functions, mostly mediated through the soil biota. Various strategies and management practices have been suggested to preserve and improve soil functioning. These include organic farming, agricultural practices with reduced or no soil tillage (e.g. conservation agriculture), and the use of cover crops instead of longer bare fallow periods. However, how soil improving cropping systems influence a range of soil functions is still unclear.

Making use of a comprehensive dataset obtained from a replicated long-term cropping system experiment (Farming System and Tillage experiment (FAST)) as well as from data obtained on-farm from a farmer's network consisting of 60 fields in Switzerland (Hubs for soil improving cropping systems (Hubs46)), we investigated the impact and effect size of conventional, organic and soil conservation (no and reduced tillage) arable cropping systems on soil properties and related ecosystem functions.

Overall, a tradeoff between productivity and environmental services was observed. Organic and soil conservation systems resulted in lower yields (from -5% to -30%) but presented ecological benefits such as enhanced soil aggregation and soil life, reduced erosion risk, increased biodiversity and a lower environmental impact. Nitrogen management was identified as a key leverage point to improve the environmental performance of arable cropping systems. Moreover, we found that the implementation of cover cropping, as ecological management practice, reduces the yield gap for extensive systems and cover crops can reduce the amount of synthetic inputs needed in intensive systems to maintain high yields. Thus, such practices permit to minimize the tradeoff between productivity and ecology.

The role of microbial communities in ecosystem functioning is unequivocal. Microbes play key roles in a wide range of ecosystem services. In-depth analysis of soil and root microbiota revealed that about 10% of variation in microbial communities was explained by the tested cropping practices. Cropping sensitive microbes were taxonomically diverse and they responded in guilds to the specific practices. These microbes also included frequent community members or members co-occurring with many other microbes in the community, suggesting that cropping practices may allow the manipulation of influential community members. Moreover, analyzing the root fungal communities from a large farm network we found that those communities were much more interconnected under organic management than the conventional systems.

Taken together, our results indicate that while the benefits of soil improving cropping systems are noticeable, the implementation of site-specific management strategies is crucial rather than a generalization of single cropping system.