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Editorial: Agricultural diversification: Benefits and barriers for sustainable soil management

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Editorial on the Research Topic
Agricultural diversification: Benefits and barriers for sustainable soil management

Opposite to agricultural intensification, agricultural diversification is a key management practice to improve crop productivity and deliver multiple ecosystem services by adopting crop rotation, multiple cropping or intercropping in arable crops, intercropping in orchards, and agroforestry, among other strategies. Agricultural diversification aims to reduce inputs of energy and agrochemicals in order to mitigate the negative impacts of intensive agriculture on soil quality, water pollution, and eutrophication, emissions of greenhouse gases, soil erosion, and biodiversity loss. If coupled with sustainable soil management strategies such as adopting cover crops, conservation agriculture, organic farming, and fertilization management, agricultural diversification could also contribute to stable yields, profitability, and make agroecosystems more resilient to climate change, environmental risks, and socio-economic shocks. Therefore, new research and policies must play a key role in supporting more sustainable practices for agri-food production while ensuring environmental and food security. Ultimately, the goal of agricultural diversification is to achieve a sustainable agroecosystem in terms of 1) enhancement of soil quality, fertility and structure, water availability and soil carbon sequestration, 2) reduction of soil erosion, greenhouse gas emissions and pollutants, and 3) economic profitability. The eleven papers in this Research Topic deal with the following topics related to agricultural diversification and sustainable soil management in different cropping systems.

Two contributions studied soil organic carbon (SOC) dynamics using simulation models. Oliveira et al. used the CQESTR model to study the effect of two Integrated Crop-Livestock Systems (ICLS) with pasture, and tillage management under tropical conditions in Brazil. ICLS included 1) corn + pasture and 2) soybean + rice + corn + pasture. ICLS increased soil C sequestration compared to simple grain cropping systems under both NT and CT. The ECOSSE model was modified, parameterized, and used to simulate diversified cropping systems by Begum et al. in four long-term experiments in Spain, Italy, and Finland. The addition of manure and cover crops and no-tillage management produced an increase in SOC and the loss of SOC was compensated when grass was introduced in the rotations.

Rahman et al. studied an Integrated Plant Nutrient System (IPNS) to restore soil fertility in degraded acidic and charland soils in Bangladesh to assess the effect of biochar and compost-based IPNS approaches. IPNS increased microbial biomass carbon (MBC) and basal respiration, with the largest increase in poultry manure biochar (PMB), and significantly improved SOC and particulate organic carbon.

Yang et al. addressed the problem of soil pollution by multiple metal(loid)s and their uptake in rice, studying the application of compounds containing iron (Fe) to remediate soil pollution. Using an Sb and Cd co-contaminated soil, soils were treated with a continued submergence condition plus $FeCl_3$, or with different water management. Results indicated that when $FeCl_3$ is used to remediate contaminated soils, dry farming for a short time is needed to avoid As accumulation, and intermittent irrigation is a potential choice to avoid the excessive accumulation of contaminants in the edible parts of rice plants.

Di Bene et al. made a survey of farmers and other stakeholders in Italy to find out their perceptions of barriers and opportunities for implementing crop diversification strategies. The profitability of agricultural production was considered the most important priority to be improved, followed by the need to improve biodiversity, soil structure and fertility, and to reduce energy consumption. Crop rotations were considered the most appropriate farming practices for progressing towards these priorities, though few farmers are experts in crop diversification. The findings also provide detailed and concrete suggestions for effective policy and competence building.

Torrus-Castillo et al. assessed the contribution of temporary spontaneous cover crops to atmospheric CO_2 fixation and nutrient retention in 46 commercial olive groves with different tree densities and cover crop layouts located in Southern Spain. They demonstrated the important role of temporary spontaneous cover crops in woody cropping systems for climate change mitigation through atmospheric CO_2 fixation as well as for nutrient retention, suggesting the adoption of these temporary spontaneous cover crops in the whole area between the tree rows in order to enhance these important agroecosystem services.

Franco-Luesma et al. assessed the potential of inter-cropping an irrigated conventionally managed maize system with legumes for mitigating soil N_2O emissions under Mediterranean conditions. Soil N_2O emissions were measured over 2 years in a maize monoculture and a pea-maize rotation under three different N fertilization levels. They observed that intermediate N fertilization levels showed lower yield-scaled N_2O emissions and N emissions factors than high N fertilization levels, demonstrating the potential of replacing the fallow period with a legume in combination with an adjusted N fertilization rate to mitigate soil N_2O emissions in high-yielding maize systems.

While diversification aims to improve numerous ecosystem services, there can be tradeoffs when it comes to soil greenhouse gas emissions. Hüppi et al. present field measurements of nitrous oxide and methane from two different diversification experiments in the Pannonian region. The results show that the addition of leguminous intercrops can increase nitrous oxide emissions whereas the addition of herbs to uncovered inter-rows significantly decreased nitrous oxide emissions.

Suproniene et al. addressed the important issue of improving soil health in three different cereal crops (spring wheat, triticale, and barley). The authors evaluated the effect of applying different types of animal waste-based digestates (pig, chicken, and cow manure) and synthetic mineral nitrogen on soil prokaryotic diversity and composition after 3 years through Illuminia MiSeq sequencing. They found that the richness and diversity of the soil prokaryotic community were not affected by digestate application, while other factors such as the yearly crop varieties, seasonal climate changes, and soil pH were the major contributors to shaping the prokaryotic community composition over time.

Chaudhary et al. considered the injudicious application of chemical fertilizers that affects soil quality and plant growth and studied the effect of an eco-friendly approach consisting of the application of different bioinoculants and agriusable nanocompounds to improve soil quality, using nanozeolite and nanochitosan along with two *Bacillus* spp., on rhizospheric microbial flora and indicator enzymes for maize. This novel research showed that nanocompounds with *Bacillus* spp. significantly enhanced total microbial count, NPK solubilizing bacteria, and the level of soil health indicator enzymes up to twofold over control plots.

Lu et al. highlighted the relevance of using plastic shed films to improve phthalate acid esters (PAEs) residues in ginseng cultivation and respective soils. These authors registered the status of a total of 19 PAEs in ginseng and soils, and plastic shed film samples from eight ginseng cultivation plots located in the Jilin Province (China). The main findings demonstrated that 6 PAEs are omnipresent contaminants in ginseng cultivation bases. They indicated that the use of plastic shed film could be possibly recognized as a source of PAEs in ginseng bases. The age of plantations also generated some differences in PAEs accumulation. Finally, noncancer and carcinogenic risks were detected for adult intake.

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The outcomes of this Research Topic identify needs and directions for further research, such as assessing the effect of organic and biofertilizers on soil microbial diversity and functionality, developing remediation and management strategies to decrease soil pollution, boosting long-term experiments since they represent a unique platform to test any process taking place at an extremely slow rate, including cost-benefits analysis to assess profitability and finding effective agricultural management strategies locally adapted to mitigate greenhouse gas emissions.

Author contributions

RF coordinated the editorial writing, all authors contributed to writing and revision and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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