EGU22-4712
https://doi.org/10.5194/egusphere-egu22-4712
EGU General Assembly 2022

Trade-offs between soil carbon sequestration and greenhouse gas emissions, and nitrogen leaching losses: addressing knowledge gaps

Peter Maenhout[1], Claudia Di Bene[2], Maria Luz Cayuela[3], Anton Govednik[4], Frida Keuper[5], Sara Mavsar[4], Rok Mihelic[4], Adam O'Toole[6], Ana Schwarzmann[4], Marjetka Suhadolc[4], Alina Syp[7], and Elena Valkama[8]

[1]Plant Sciences Unit, Flanders Research Institute for Agriculture, Fisheries and Food (ILVO), Merelbeke, Belgium
[2]Council for Agricultural Research and Economics, Research Center for Agriculture and Environment, Rome, Italy
[3]Department of Soil and Water Conservation and Waste Management, CEBAS-CSIC, Campus Universitario de Espinardo, Murcia, Spain
[4]Chair of Soil and Environmental Science, Department of Agronomy, University of Ljubljana, Ljubljana, Slovenia
[5]BioEcoAgro Joint Research Unit, INRAE, Barenton-Bugny, France
[6]Department of Biogeochemistry and Soil Quality, NIBIO – Norwegian Institute of Bioeconomy Research, Ås, Norway
[7]Department of Bioeconomy and Systems Analysis, Institute of Soil Science and Plant Cultivation - State Research Institute, Poland
[8]Natural Resources Institute Finland (Luke), Bioeconomy and environment, Sustainability Science and Indicators, Jokioinen, Finland

Carbon sequestration in agricultural soils is an important strategy to mitigate climate change which gained renewed attention in the EU soil strategy for 2030. Stimulation of soil organic carbon (SOC) sequestration can be achieved via soil management strategies. However, these strategies may stimulate greenhouse gas (GHG) emissions such as nitrous oxide (N_2O) and methane (CH_4) and cause nitrogen (N) losses via leaching. While these trade-offs can offset the intended climate change mitigation via SOC sequestration, synergistic (positive) effects of certain soil management strategies may positively affect the mitigation potential as well. Despite the major importance of these trade-offs and synergies for the selection of sustainable and climate-proof soil management strategies, knowledge on the understanding of these effects remains limited.

In the Framework of Horizon 2020 – European Joint Programme SOIL, the ∑OMMIT-project aims to investigate the trade-offs and synergies for the most relevant soil management strategies applied in European agricultural systems. A dedicated literature study was made by eight agricultural research institutes across Europe, summarizing the results of reviews, meta-analyses, reports and original articles. The most important soil management strategies were identified and grouped into four categories: tillage management, cropping systems, water management, and fertilization and organic matter (OM) inputs (crop residues, cover crop, livestock manure, slurry, compost, biochar, liming). Search criteria including literature and land use type, time-period, and geographic origin resulted in a unique selection of 110 references (31 reviews, 46 meta-analyses, and 33 original papers). Meta-data, extracted knowledge gaps, research recommendations and main conclusions were compiled in a knowledge gap review which allows for better insight in existing trade-offs and

synergies and provides guidance to future research.

This review highlights that the increase of both SOC stock change and the microbial biomass C and N, as well as the reduction in N leaching are positively affected by conservation tillage, crop rotation, permanent cropping, more efficient water management as well as using fertilization and OM inputs (e.g., cover crops, organic amendments, biochar, and liming). The effects on the N_2O and CH_4 emission mitigation are dependent on the specific soil management strategy (e.g., water management, fertilization and OM inputs) and require more research to allow to define (uniform) conclusions.

In conclusion, more dedicated research is needed for the soil management strategies that simultaneously examines SOC stocks, GHG emissions, and N leaching losses. Furthermore, we identified a lack of information on the impact of pedoclimatic conditions, specifically on the longer-term, on trade-offs and synergies. A more concerted use and installation of new long-term field experiments in different pedo-climatic European regions, seems essential for a comprehensive understanding of the impact of soil management strategies at the European level. Further, since soil management strategies are often combined and their interaction may affect the trade-offs and synergies, the impact of different soil management practices should be assessed simultaneously. Overall, the review provides a unique framework to aid the (re)design of dedicated field experiments and targeted measurements as well as simulations to improve our understanding of the identified knowledge gaps.