ICONICA (ID 120)

Impact of long-term phosphorus additions on Carbon sequestration and Nitrogen Cycling in Agricultural soils

Coordinator

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Project partners

Country	Organization
Danmark	Aarhus University
France	University Paris Saclay
France	Centre national de la recherche scientifique
Germany	Justus Liebig University
Ireland	University College Dublin
New Zealand	University of Otago
New Zealand	Lincoln University
Sweden	Swedish University for Agricultural Sciences

Summary

Background: The EU Green Deal through the Farm to Fork and Biodiversity 2030 strategies aims to make Europe a climate-neutral continent by 2050 while ensuring food security. Achieving this ambitious objective will require the adoption of sustainable agricultural soil management practices. Management of agro-ecosystems to enhance both soil and subsoil organic carbon (SOC) storage could potentially be a strategy to mitigate climate change by reducing increases in atmospheric carbon dioxide (CO2) concentration. However, long-term SOC storage is dependent on many factors, especially the interactions with other nutrients. The coupled Carbon-Nitrogen-Phosphorus cycles mediates soil organic matter formation and turnover. Soil phosphorus (P) is a key nutrient for crop growth and P limitation can reduce plant and soil microbial biomass affecting SOC sequestration. In vitro studies have shown that the current agronomic optimum soil P concentration significantly reduces nitrous oxide, a potent greenhouse gas (GHG) emissions, soil nitrogen (N) mineralisation, N immobilisation and improves prediction of C fluxes. In particular, the gross rates of elemental transformations in soil are only poorly understood. Varying P level impacts on microbial composition and activities which are predicted to control specific transformation pathways within the C and N cycles in soil influencing the stabilisation of GHG emissions, SOC and nutrients. While the stoichiometric constraint of P on plant growth is known, the effects of this constraint on other soil processes at different P levels is uncertain, particularly in relation to GHG emissions and N and C cycling. A number of long term P experiments in the EU and New Zealand will be utilised to investigate soil P availability on SOC sequestration and GHG emissions and CN cycling in soils.

Overarching aim: ICONICA seeks to quantify the effect of P availability on soil C sequestration, N cycling, GHG emissions and associated soil microbial processes within managed grassland and arable systems in order to identify mechanisms for SOC and N sequestration. Data generated by ICONICA will be used to identify optimal soil P levels for SOC sequestration, minimizing GHG emissions, while maintaining crop yields from various agricultural soils.

Specific objectives: ICONICA will employ a unique set of long term P fertilisation trials from five countries, including a range of P treatments, to establish the relationship between long term P availability and (i) soil C:N:P stoichiometry, (ii) SOC stocks (SOC fractions, OM decomposability), (iii) microbiologically mediated gross nutrient transformations in grassland and arable soils with respect

to SOC (iv) GHG emissions, (v) model management practices that minimize GHGs and increase SOC stocks.
We hypothesize that the effect of soil P availability on SOC and N turnover depends on soil nutrient conditions (C:N:P ratio). We hypothesize that 1) at high soil P availability GHG emissions, in particular N2O, are increased due to increasing microbial demand for N,and 2) SOC turnover and N cycling will increase, as a result of elevated P, thus reducing the potential for SOC sequestration. The project will combine soil CNP characterisation with soil biological characterisation of long term P experiments, stable isotope tracing and modelling, soil microbial functioning. The data will be used to parameterise a CNP model to identify the optimal soil P level from a soil carbon, GHGs and agronomic perspective.
Impact: An improved understanding of soil P availability on soil C and N storage, and cycling mechanisms, will provide knowledge for improving soil management practices aimed at increasing carbon sequestration and reducing GHG emissions. The project will identify the optimal soil P level to optimise SOC accumulation, GHGs and crop yields.

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