Sustainable agriculture for the future environment (SAFE) – Optimising the nitrogen use efficiency of intercropping to mitigate pollution and climate change

Supervisory team:
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Project description:
Inefficient N use in agriculture arises from over fertilisation and a disconnect between nutrient supply and crop demand, as soil/climate conditions are rarely considered in agricultural management plans. Legume use is a suitable strategy for minimising and optimising N application in agriculture, as symbiotic rhizobia can fix atmospheric N2 (Biological Nitrogen Fixation, BNF). Fixed N converted to NH4+ or nitrified to NO3– can be used by crops resulting in higher N use efficiency (NUE). However, at the same time, NO3– is prone to leaching and (ca. 30%, IPCC, 2006) is therefore a potential source of both indirect water pollution (i.e. eutrophication of watercourses) and direct nitrous oxide (N2O, a powerful greenhouse and ozone destroying gas) emissions from soils (i.e increased loadings of greenhouse gases). Although this only represents a small loss of N [0.8 to 1.5% for mineral fertiliser in the UK's direct N2O Emission Factors (EF's)] of urea and ammonium nitrate fertilisers, its environmental impact is large due to its role in climate change and stratospheric ozone depletion.

This study will determine the rates of N transformations, both in areas close to the roots and the rest (bulk) of the soil in mixed cropping systems where legume and grass/crop species are grown. Legumes are known to be able to fix N2 from the atmosphere, via BNF, converting it to ammonium (NH4+) that can be converted further to nitrate (NO3–) in soils. Mixed cropping (or intercropping) is common in agriculture globally and is gaining traction in UK systems due to improvements in N use, management of weeds/pests, improvement of soil physical properties and increased diversity of soil bacteria.

It is vital that we study root exudates, the rhizobiome, and their mutual interactions affecting root-root interactions to improve our understanding of these interactions and how they affect NUE. Using cutting-edge compound-specific stable-isotope tracing methodologies we will follow N from legume fixation to crop uptake in soil cores for a variety of legume and crop species. The results will enable us to determine NUE and thereby inform the selection of the most efficient vegetation combinations. This will promote a shift away from inorganic N fertilisers towards a more sustainable, environmentally friendly and globally applicable use of N in agriculture.

Our aim as the SWBio DTP is to support students from a range of backgrounds and circumstances. Where needed, we will work with you to take into consideration reasonable project adaptations (for example to support caring responsibilities, disabilities, other significant personal circumstances) as well as flexible working and part-time study requests, to enable greater access to a PhD. All our supervisors support us with this aim, so please feel comfortable in discussing further with the listed PhD project supervisor to see what is feasible.