Soil microbial carbon metabolism for climate positive soils

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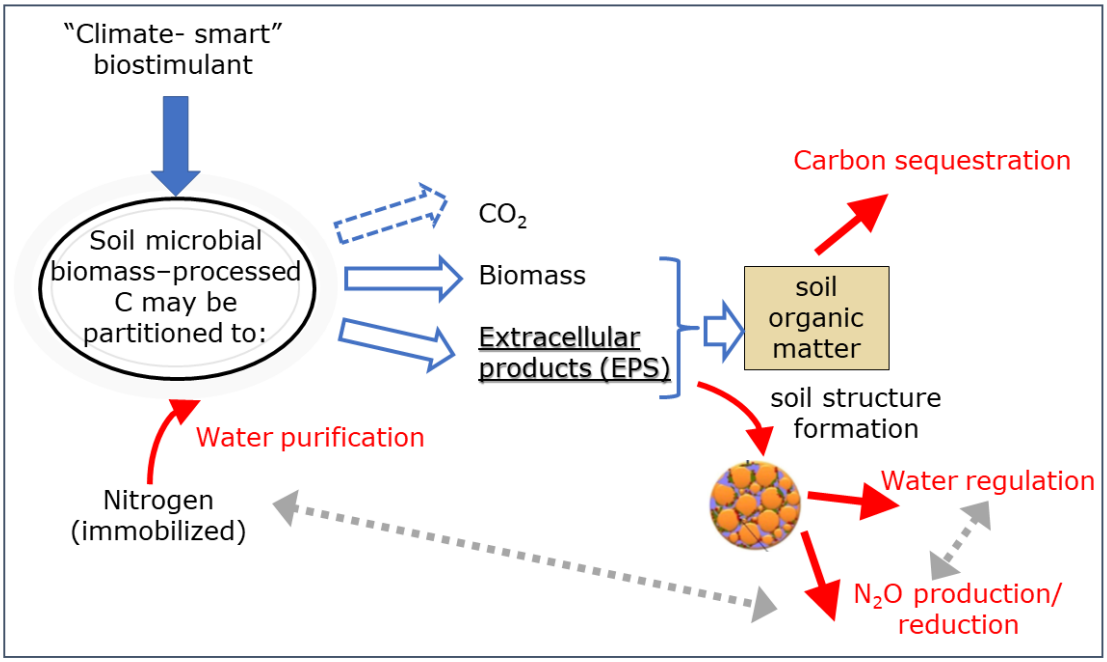
Soils are essential to human well-being because they perform multiple functions that underpin the provision of ecosystem services that sustain life and regulate climate. There is a pressing need for improved management of soils for amelioration of climate change and for improved environmental sustainability in general. Many of soil's functions are driven by the soil microbial biomass in decomposing organic matter inputs to soil; a process for which there might be considerable potential, through informed manipulation of soil inputs, to optimize for delivery of multiple objectives in environmental sustainability.

On entering soil, organic matter inputs are metabolized by the soil microbial biomass and the constituent carbon partitioned for use in production of new biomass, extracellular products and respiration. This key control point influences the quantity and quality of soil organic matter (SOM) with important implications for soil functions, including water retention and stabilization of soil physical structure, which further feeds-back on the stabilization of soil C with consequences for CO_2 and also other greenhouse gas emissions from soils.



We have shown [Redmile-Gordon et al., 2015a] that it is possible to engineer SOM quality through addition of a "climate-smart" (biodiesel-co-product) amendment to redirect microbial resources to production of sticky and

elastic exudates (EPS). The advantages of increasing EPS are suspected to include: i) reducing emissions of greenhouse gases via improvements in soil microarchitecture (greenhouse gases such as N_2O are often a result of poor soil-structure); ii) improving sequestration of C in SOM as physical stability of soil protects SOM from decomposing inside soil aggregates; iii) improving intra-aggregate water retention (EPS are highly absorbent and are anticipated to improve plant/crop drought tolerance); and, iv) improving resilience of microbial populations and the beneficial functions they perform. However, whilst suspected, the benefits of such amendments have yet to be tested in different contexts and scales. Furthermore, whilst we have proof-of-principle for EPS manipulation, we do not understand how the success of such engineering attempts depends on interactions between microbial, input quality and environmental (e.g. soil physical) factors. There might be considerable potential to optimize EPS production for delivery of multiple objectives in environmental sustainability.

Therefore, the **overall aim** of this PhD is **to understand the extent to which soil microbial carbon allocation (between CO_2, intracellular and extracellular products) can be manipulated to benefit soil-plant systems and climate.**

Training opportunities:

You will develop multidisciplinary skills in biogeochemistry and microbiology and in laboratory experimentation, fieldwork (at the RHS, and on calcareous hills of the South Downs), data-driven approaches and translation skills through communicating research to a non-academic audience.

Project specific training will be given on: microbial meta-barcoding and bioinformatics pipelines (Centre for Ecology and Hydrology); soil biogeochemistry, soil fractionation techniques for estimation of soil carbon quality; use of isotopes to trace carbon and nitrogen dynamics (University of Reading); quantification of soil EPS (Royal Horticultural Society).

This project involves a placement at RHS Wisely to conduct experiments and communicate findings and will also work with the Soil Association who are contributing funds to support experimentation on the South Downs.

Student profile:

This project would be suitable for students with a background in Environmental Science, Chemistry, (Micro)Biology and/or Ecology. Applicants should preferably hold an MSc in a relevant subject and at minimum an upper 2nd class degree or equivalent.

Funding particulars:
This PhD project has CASE sponsorship by the Royal Horticultural Society and additional support for field experiments from the Soil Association.

References:

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Redmile-Gordon et al. (2015a) Engineering soil organic matter quality: Biodiesel Co-Product (BCP) stimulates exudation of nitrogenous microbial biopolymers. Geoderma 259. 10.1016/j.geoderma.2015.06.006.
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