PhD Project Advertisement

Project title: Unravelling the phosphate fertisphere and its interactions with soils and roots
Project No: FBS2023-21-Hammond-rc

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Project description:

Food production systems are reliant on fertilsiers for high crop yields and quality. Crops require an adequate supply of nutrients from the soil, including nitrogen, phosphate, and potassium. These are commonly supplied as manufactured fertilisers to meet the demands of these high yielding crops. However, these inputs are economically costly and if managed inappropriately, damaging to the environment. With increasing pressure to develop sustainable agricultural systems, there is an urgent need to manage these inputs efficiently, maximizing their benefits to deliver a sustainable food system for the future.

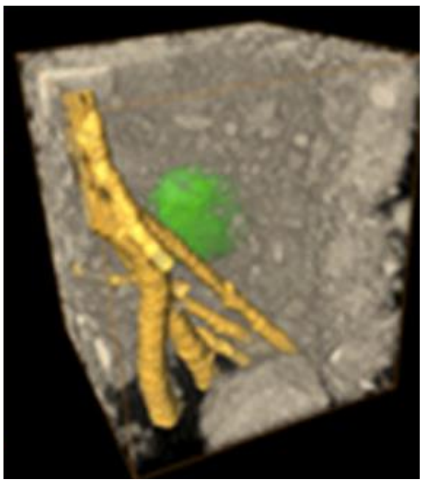

Fig. 1. 3D rendering of µCT imaging data of the root system interacting with fertiliser granules. Source: Sharif et al., 2016.

One of these nutrients, phosphate, often limits productivity due to its poor availability in many soils. In cropping systems, these limitations are addressed by adding phosphate fertilisers. However, the utilisation of these phosphate fertilisers is extremely low (often <30%), and we can only meet sustainable food production targets if this is radically improved. This is further compounded by a diminishing stock of finite rock phosphate resources needed to produce fertilisers and geopolitical issues relating to sourcing and the currenrt price volatility of fertilisers (Hammond and Gadanakis, 2022). The long-term solution to this problem is the optimisation of fertiliser-soil-root interactions to improve phosphate use efficiency.

Critical knowledge gaps in this optimisation are challenging to address as they occur in the soil and many approaches to studying these interactions are destructive. Utilising non-destructive measurement capabilities at the Diamond Light Source (DLS), the student will have a unique opportunity to quantify and visualise the fertiliser-soil-root interactions (the fertisphere; Fig. 1) in in-tact soil profiles and address these challenges (Sharif et al., 2016). This will include investigating the interaction of roots with phosphate fertiliser granules, and collecting data on the interactions and the breakdown of the fertiliser granules to model the availability of phosphate to the root and associated microbial community (Kuppe et al., 2022).

Phosphate fertiliser granules can lead to a locally high concentration of phosphate, which no longer limits the growth of the bacteria in the fertisphere. This may lead to shifts in the soil microbial community function and the ultimate fate of the fertiliser phosphate. Soil microcosms will be incubated with carbon sources to stimulate microbial activity with and without Pi fertilisers to investigate these shifts in microbial community structure using DNA and/or RNA sequencing, with data from the beamline and used to model moisture, pH and Pi concentrations.

Finally, plants with different root traits will be grown in soil with placed fertiliser granules. Root systems will be imaged to capture their interactions with fertiliser pellets using the facilities at DLS and quantify the interaction of the root as it grows through the soil. Changes in root phosphate uptake systems will be quantified at the transcriptional level and used to advance our understanding of how these uptake mechanisms are regulated as they enter the fertisphere.

Training opportunities:

You will receive training in plant physiology, plant transcriptomics and soil microbial analyses to support the development of experiments at Diamond Light Source (DLS) and address key questions around the spatial and temporal interaction of Pi fertilisers with plant root systems and their microbial communities. At Cranfield University, you will receive training in soil science, root-soil interactions and modelling of processes in the rhizosphere affecting nutrient availability and uptake into roots. Through extended stays at DLS, you will be trained to acquire, post-process and analyse 3D X-ray tomography data as well as X-ray powder diffraction data. They will also be given specific training on writing successful proposals for beamtime at synchrotron facilities.

Student profile:

The project requires a student with skills in biology and/or data, with an interest in cross-disciplinary research and working with big data. You will have the opportunity to work with state-of the-art facilities at the partner organisations and develop a range of skills. Therefore, we are looking for an individual that can see the potential in these approaches and maximise these opportunities throughout their PhD studies.

Stipend (Salary):

FoodBioSystems DTP students receive an annual tax free stipend (salary) that is paid in instalments throughout the year. For 2022/23 this will be £17,668 and this will increase slightly each year at rate set by UKRI.

Equality Diversity and Inclusion:

The FoodBioSystems DTP is committed to equality, diversity, and inclusion (EDI), to building a doctoral researcher (DR) and staff body that reflects the diversity of society, and to encourage applications from under-represented and disadvantaged groups. Our actions to promote diversity and inclusion are detailed on the FoodBioSystems DTP website.

In accordance with UKRI guidelines, our studentships are offered on a part time basis in addition to full time registration. The minimum registration is 50% FT and the studentship end date will be extended to reflect the part-time registration.

References:

Hammond and Gadanakis (2022) Ukraine: how the global fertiliser shortage is going to affect food. The Conversation, 11th March 2022, https://theconversation.com/ukraine-how-the-global-fertiliser-shortage-is-going-to-affect-food-179061.

Kuppe, et al. (2022) Rice increases phosphorus uptake in strongly sorbing soils by intra-root facilitation. Plant, Cell & Environment, 45, 884–899. https://doi.org/10.1111/pce.14285

Sharif, et al. (2016) Imaging the interaction of roots and phosphate fertiliser granules using 4D X-ray tomography. Plant and soil, 401, 125-134.

For up to date information on funding eligibility, studentship rates and part time registration, please visit the FoodBioSystems website.