Using organic fertilisers to manipulate soil microbiology for improved nutrient bioavailability

Lead Supervisor: Dr Mark Pawlett: Cranfield University, School of Water Energy and Environment
Email: m.pawlett@cranfield.ac.uk

Co-Supervisors:

- Dr Tom Sizmur: University of Reading
- Professor Elizabeth Shaw: University of Reading
- Professor Jim Harris: Cranfield University

Project Description: Soils are essential to food production through the delivery of bioavailable nutrients required for crop growth. Depleted nutrients are routinely replenished as mineral fertilizers at specific times of the crop growing season to promote productivity. However, this approach means that fertiliser application rarely matches crop demand, resulting in costly and often environmentally damaging over-application of mineral fertilizers. In addition, soil organic matter (the natural reserve of nutrients) becomes depleted with a resultant reduction in biodiversity. This reduced organic matter and biodiversity has essentially reduced the soils natural ability to deliver crop available forms of nutrients, increasing the reliance of food production on agrochemicals.

Organic materials often considered as a waste (e.g. residual digestate from the anaerobic digestion process of organic materials for biogas production, straw, woodchip, paper-mill sludge) may provide a valuable source of soil organic matter, with the potential to provide valuable nutrients to crops. However sufficient and functional soil microbial biomass is required to transform the organically bound nutrients into crop available forms. The quality (in terms of carbon/nitrogen ratios) and quantity of the organic matter has important implications for nutrient cycling, and influences the quantity of nutrients that become incorporated into new microbial biomass.

We will investigate novel ways to bioengineer soil organic matter through manipulating the microbiology using anaerobically derived digestates co-amended with other forms of organic materials. The intention is that this manipulation will increase the provision of nutrients to the crop throughout the year. Strategies will be investigated as to how to “feed” the soil microbiology directly, to improve nutrient delivery through the crop season. This is particularly novel as current fertilizer strategies focus on feeding the crop rather than soil microorganisms. Thus the intention is to increase soil organic matter reserves through increasing microbial biomass and biodiversity, and so re-connect the soils natural processes within the rhizosphere to improve nutrient availability.

Anaerobic digestion (AD) is a microbial process which converts organic wastes into biofuels, providing a supply of low carbon energy from renewable resources. The residual slurry (digestate) contains large quantities of bioavailable nutrients and so is of commercial interest as it can produce yields of similar quantity to mineral fertilisers. However currently much of the digestate currently goes to waste as there remains a lack of confidence from users regarding its efficacy. We intend to investigate strategies to co-amend digestate with other organic resources to direct bioavailable nutrients to the microbial biomass for nutrient release that is timed to match crop demand.

It is currently known that digestate liquor initiates a short-term increase in soil microbial biomass and activity due to a large flush of readily available nutrients within the digestate. It is likely that this response will accelerate the decomposition of organic residues with high C/N ratios and increase the quantity of nutrients immobilized into the microbial biomass, which is an integral component of soil organic matter. This process will provide a store of labile nutrients within the microorganisms in soil surrounding plant roots ('the rhizosphere') that can be accessed by plants through root exudation-driven rhizosphere processes.

Hence the aim of this PhD is to understand the mechanisms associated with utilizing anaerobic digestate as a rich source of labile nutrients, combined with recalcitrant organic residues with high C/N ratio, towards improving crop nutrients. Digestate is particularly interesting as it has been subjected to anaerobic decomposition and so its fiber component may represent stable organic matter. An understanding of how these materials interact with rhizosphere microorganisms, and thereby instigate the release of organically bound nutrients for crop development throughout the year, will enable nutrient strategies to be developed that will reduce reliance on mineral fertilizers.