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Developing (field-relevant) synchrotron techniques to support agricultural innovation

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Synchrotron techniques have been used to investigate a range of processes in soils and plants. While these applications were initially addressing environmental issues related to pollution, recent years have seen increasing interest in using synchrotron approaches for agricultural research. This presentation will focus on new methodologies developed to address some major challenges related to (i) food production, with a particular focus on fertiliser efficiency (ii) soil constraints and (iii) the nutritional value of crops.
Fertiliser efficiency: the fertiliser use efficiency of conventional fertilisers is limited with most applied nutrients either remaining in the soil or being dispersed in the environment. However, understanding the reactions of nutrients in the fertosphere is challenging given the extreme gradients present around the point of fertiliser applications and the lack of analytical techniques to explore such gradients at large scale and high spatial resolution. In recent years, we have developed techniques enabling us to assess nutrient availability in the fertosphere using a combination of novel large scale and robust diffusive gradients in thin-films devices (DGT) and tandem X-ray Fluorescence Microscopy (XFM). Using these techniques, we have been able to visualise gradients in phosphorus availability in both laboratory and field trials.
Soil constraints: Approximately 75% of Australian soils have one or more constraints such as high pH, high concentrations of boron, deficiencies in macro and micronutrients, soil acidity, salinity and sodicity as well as compacted soils that limit root growth and function and crop utilisation of subsoil water. The ability of roots to grow through soil unhindered by physical or chemical constraints is key to making full use of the available water and nutrient resources. However, understanding how roots develop and respond to soil amendments is challenging. Here, we will report on the development of tomographic techniques that have enabled visualisation of roots in large soil cores from glasshouse and field trials.
Nutritional value of crops: food staples like cereals have been bred to increase yield but their nutritional value, for instance in terms of micronutrients, remains limited. One major challenge is the lack of efficient methods to screen libraries of mutated plants to identify individuals which have desirable elemental characteristics. In the last 4 years we have developed XFM techniques and analysis pipelines to quickly determine the concentration of micronutrients in a large number of seed libraries in a non-destructive manner. Examples for both rice and wheat studies will be shown.

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