

Modelling plant soil interaction: From the soil particle to plant scale

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In this talk I will present models that deal with plant nutrient uptake. In particular I will discuss the role plant exuded organic acids and mycorrhizae can have on this process.

I will begin by describing our recent work on modelling exudation of 2'-deoxymugineic acid (DMA) and the effect this has on plant acquired zinc. We assume that DMA and zinc are both present in two forms in the soil, in the soil solution phase and bound to the soil particles. We will develop a model that describes this competitive binding reaction and then link it up to a model for plant exudation and zinc uptake. In particular we will investigate the effect of the diurnal DMA exudation pattern on the zinc uptake.

The second model I will describe deals with the uptake of nutrients, such as phosphate, that in addition to binding to the soil particle surfaces can also diffuse into the soil particle micropores and bind to their internal surfaces. This leads to a so called dual porosity models for the soil and we will show how the results for nutrient uptake by plants differ when one considers simple particle surface binding in comparison to dual porosity nutrient binding. We find that the results are qualitatively and quantitatively very different. This highlights the need for the simultaneous measurement of soil properties and root nutrient uptake properties.

A third model I will discuss deals with modelling the effect mycorrhizae have on phosphate uptake by plants. We consider the phosphate movement within the soil, uptake by roots and fungus, and transport of phosphate within the fungus to the root surface. We find that the model predictions for phosphate depletion profiles in the soil differ significantly for two plausible and experimentally reported fungal phosphate uptake rates. Whilst both depletion profiles have support within the literature clearly, only one of them has to be correct. I will suggest a controlled experiment which has not yet been performed that can decide between the two scenarios.

In the concluding section I will discuss different approaches on modelling whole plant nutrient uptake.

Keywords: plant-soil interaction, plant modelling, soil modelling, organic acid exudation