LIMING EFFECTS ON HEAVY METAL BIOAVAILABILITY IN ACID SOILS

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Introduction

Liming has been demonstrated to be effective in managing the bioavailability of potentially toxic heavy metals in acid soils. The geochemical changes brought about by the increasing pH are thought to be a key driver in achieving this (Kirkham, 2006). However, an undesirable side-effect of liming can be an associated reduction in the plant-available fraction of metals that are essential micronutrients (*e.g.* Fe, Mn and Zn). The extent to which plants can effect capture of these nutrients in different pH soils and associated mobilization/uptake of non-essential elements is not well understood. We undertook a dual approach to investigating the effects of liming on heavy metal bioavailability: (i) at a whole-plant scale and (ii) at the root-soil interface.

Methods

We amended two different well-characterized, acidic (pH_{H2O} 5.45 and 6.5) and nutrient-rich horticultural soils with different amounts of lime ($CaCO_3$, 0.31 - 10 wt%). The amended soils were then used in a greenhouse trial, where we grew replicate White Lupin (*Lupinus albus* L.) plants in the different treatments for six weeks. After the growth period, we harvested the plants and measured the shoot metal (Fe, Mn, Ni, Cu, Zn and Cd) concentrations.

We used the results of the pot trial to select two treatments of one soil, along with the unamended soil, for use in a rhizobox experiment. We filled duplicate rhizoboxes (adapted from the original design by Wenzel *et al.* (2001)) with the three soils and grew White Lupin plants in a controlled environment until they developed cluster roots. The mobilization of heavy metals in the soil near key root structures was then determined using high resolution diffusive gradients in thin-films (HR-DGT) and laser ablation-ICP-MS (LA-ICP-MS)(Lehto *et al.*, 2012; Williams *et al.*, 2014). The results were then used to analyze differences between the mobilization of different metals in the soil near the roots.

Results

The increasing lime rates effected significant changes to the pH of the two soils. White Lupin uptake of all of the metals decreased by over 50% in both soils between the control and the highest rate of lime application, with Mn showing the greatest decrease; however, there were distinct differences in the metals' responses to the lime application in the two soils. The HR-DGT measurements showed distinct hotspots of metal mobilization near the location of an observed cluster root in the control treatment (Figure 1).

Conclusions

The lime-induced increase in the pH of the two soils was strongly linked to the reduced bioavailability of the metals. Analysis of the relative mobilization rates of different metals at the root-soil interface suggests that there may be different mechanisms operating at the root scale that preferentially mobilize essential micronutrients, while rendering others passive.

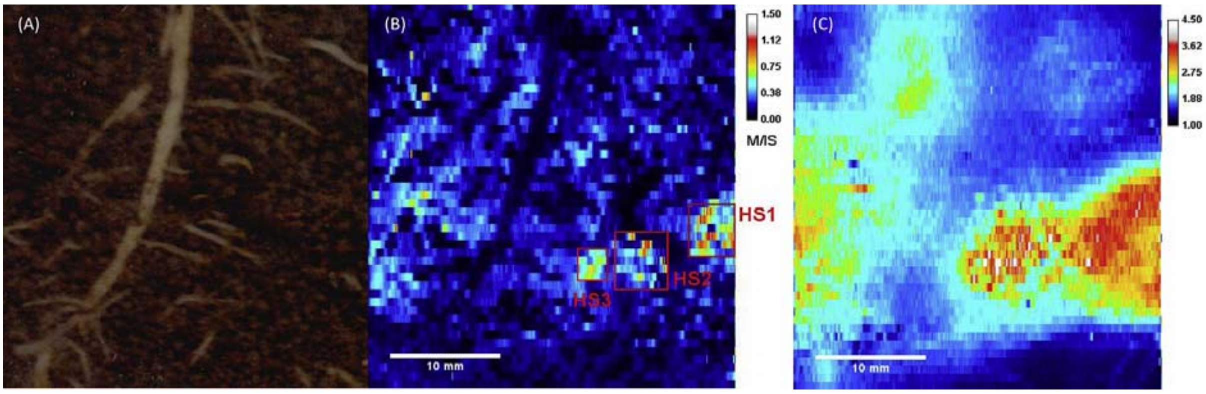

Figure 1. Visual image of a lupin root structure (A) and HR-DGT measured mobilization Fe (B) and Mn (C) in the surrounding soil. Relative Fe flux to the DGT is represented by M/IS data; Mn flux is shown as pg cm^{-2} s^{-1}. Statistical analysis of the Fe data identified three clear hotspots of Fe mobilization: HS1, HS2 and HS3 (Valentinuzzi *et al.*, 2015).

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