New Micronutrient Fertilisers for Alkaline Soils

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Chapter 6. Conclusions and Future Directions

Abstract

Trace element deficiencies represent an ongoing limitation to agricultural productivity in Southern Australia and in many regions of the world. Trace element deficiencies are commonly encountered on alkaline and calcareous soils due to their high metal adsorption and fixation capacities. Chelating agents, such as EDTA, have been used to reduce fertiliser fixation in these soils and increase trace element transport to the rhizosphere. However, EDTA, which is the most commonly used chelating agent, can be relatively ineffective on alkaline soils and may have negative environmental implications due to its long-term persistence.

This study has identified two novel sequestering agents for use on alkaline and calcareous soils. The novel products differ significantly from EDTA in terms of their structure and functionality. For example, rhamnolipid is synthesised by *Pseudomonas* bacteria, is non-toxic, biodegradable and forms a lipophilic complex with cationic metal ions. The other chelating agent, polyethylenimine (PEI) can complex up to 4 times more metal (g Cu(II)/g ligand) than EDTA, which has important implications for chelate application rates and the cost effectiveness of chelate use.

In solution culture experiments, rhamnolipid and PEI facilitated Zn absorption into the root symplast; the kinetic rate of Zn absorption was greater than that of $ZnCl_2$ alone. On alkaline and calcareous soils the novel products were significantly ($P \leq 0.05$) more effective Zn sources than EDTA or the SO_4^{2-} salt. EDTA increased the concentration of Zn in soil solution. However, this did not translate to increased Zn uptake by canola plants. This was not surprising as EDTA inhibited Zn absorption by roots in the solution culture experiments.

Radioisotope experiments showed that rhamnolipid and PEI increased Zn adsorption to the soils solid phase. However, PEI increased the size of the total Zn labile pool ($P \leq 0.05$) and mobilised Zn from the pool of fixed native soil Zn ($P \leq 0.05$). Rhamnolipid did not significantly ($P \geq 0.05$) increase the total size of the Zn labile pool in either soil, but significantly ($P \leq 0.05$) increased Zn uptake by canola, probably by facilitating root absorption by the formation of lipophilic complexes with Zn.

These results showed that, on alkaline soils, chelates that increased the rate of trace element absorption into the root symplast were significantly more effective than EDTA, which was not readily absorbed by canola roots.

Experiments were also undertaken to explore the effect of chelation on the absorption of foliar applied trace element fertilisers. Perhaps not-unexpectedly, chelation reduced the absorption of foliar applied Zn. The lipophilic chelate, rhamnolipid, quadrupled Zn absorption by enzymatically excised *Citrus sinensis* cuticles but did not significantly ($P>0.05$) increase Zn absorption by live leaf tissue. Therefore, there was no discernable relationship between the $K_{c/w}$ of fertiliser solutions and Zn permeability.

This body of work has important implications for future fertiliser development, the cost effectiveness of chelate use and the treatment of micronutrient deficiencies on alkaline soils in the world today.