ZINC MICRONUTRIENT FACT SHEET

NATIONAL
AUGUST 2024

Zinc coatings on phosphorus fertilisers can limit zinc solubility and diffusion

Photo: University of South Australia

University of South Australia researchers Dr Claudia Moens (left) and Dr Gianluca Brunetti collecting soil core sampled from a fertiliser-amended wheat trial in Eyre Peninsula, SA.

KEY POINTS

- Some Australian cropping soils are zinc (Zn) deficient and require zinc fertiliser application to maintain productivity
- The amount of plant-available zinc in soils is dependent on the fertiliser formulation
- Zinc has low mobility when applied to soil in the form of co-granulated zinc-phosphorus fertiliser or zinc-coated phosphate fertilisers
- Placement of starter fertiliser granules in soils during seeding is important for plant growth

Importance of zinc fertilisers

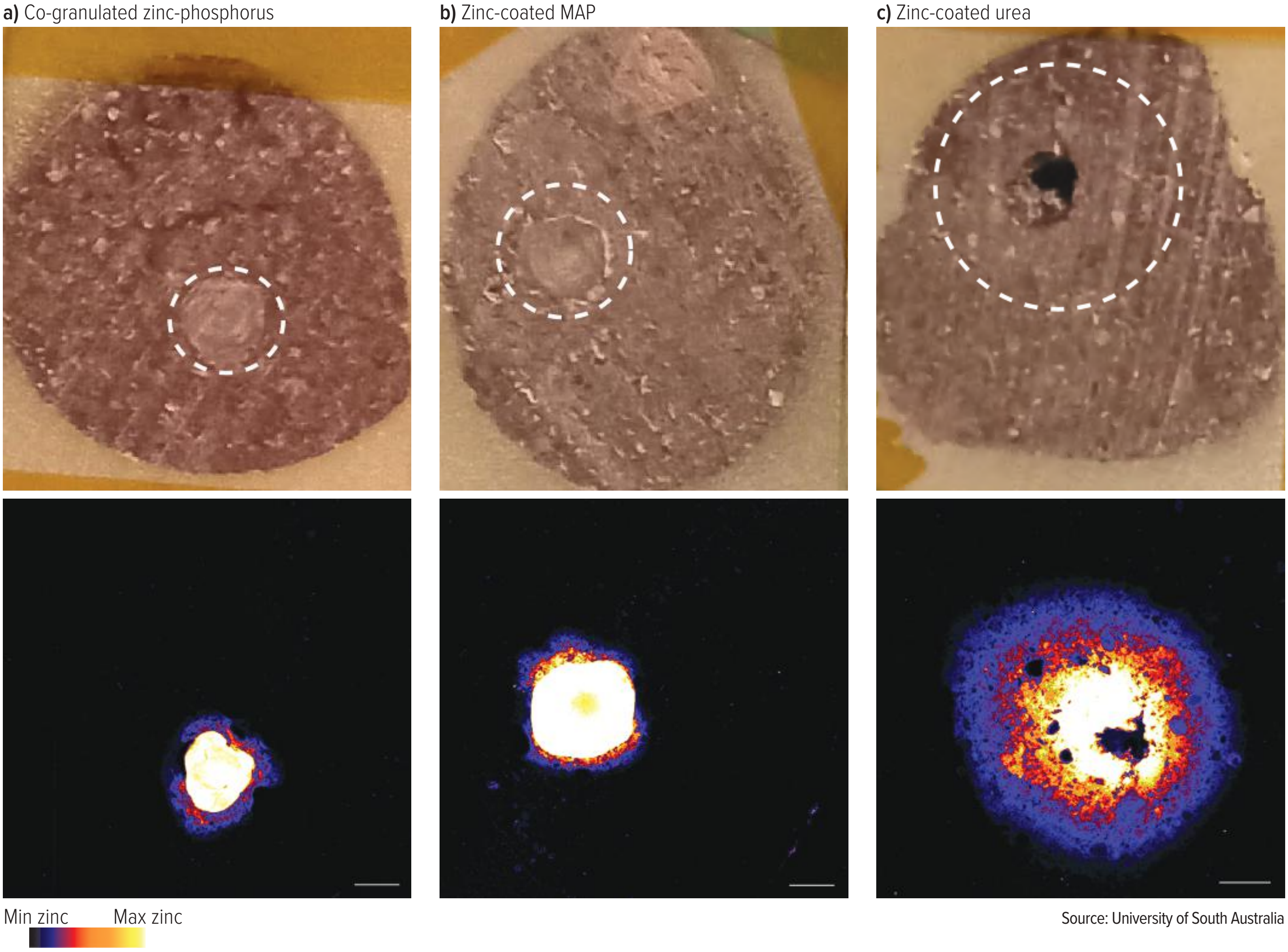
Australia's soils are known to be, in some cases, deficient in plant-available zinc (Zn) and other micronutrients. Plants grown on zinc-deficient soils have reduced productivity and contain low concentrations of zinc in edible plant parts (that is, cereal grains). Without the application of fertilisers or other soil management practices, these deficiencies can markedly decrease agricultural productivity and economic profitability. Zinc fertilisers can be applied to soil as a:

- single nutrient;
- blend with macronutrients, such as phosphorus (P), nitrogen (N) or potassium (K);
- coating on macronutrient granules; or
- co-granulated fertiliser.

Generally, zinc fertiliser is applied as a blend, but in minimum-tillage seeding operations of grain crops, the spatial distribution of blended fertilisers may impact zinc plant availability. The application of co-granulated or zinc-coated fertilisers is typically used during seeding operations.

P Level 4, 4 National Circuit, Barton ACT 2600 | PO Box 5367, Kingston ACT 2604
T +61 2 6166 4500 **F** +61 2 6166 4599 **E** grdc@grdc.com.au

Figure 1: Comparison of different zinc fertilisers applied to a Calcarosol soil and zinc dissolution from the fertilisers measured by X-ray fluorescence microscopy. Photos of soil with a single fertiliser granule (top row) and X-ray fluorescence microscopy images (bottom row). Scale shown in bottom images represents two millimetres and circled areas in top row represent approximate area of diffusion.



Source: University of South Australia

Zinc-coated fertilisers

Zinc can be applied to phosphorus-based products, including monoammonium phosphate (MAP) and diammonium phosphate (DAP), or incorporated into phosphorus-based fertiliser (that is, co-granulated). Zinc concentrations in fertiliser granules are typically between one per cent and five per cent zinc (w/w). These zinc concentrations are exceedingly high compared with the surrounding soil, and the dissolution of zinc fertiliser is controlled by the reaction in the area immediately adjacent to the fertiliser granule (fertosphere).

Furthermore, it is well known that zinc can react with phosphate to form poorly soluble precipitates (Degryse et al., 2024). To understand the influence of soil properties and fertiliser composition on potential zinc plant availability, researchers at the University of South Australia and the University of Queensland studied the behaviour of zinc-coated MAP and co-granulated zinc-phosphorus fertilisers in different cropping soils and compared it to that of zinc-coated urea.

Spatial distribution of zinc in soil

Three zinc-coated fertilisers and a co-granulated zinc-phosphorus fertiliser were incubated in Calcarosol and Kandosol cropping soils. Nutrient uptake by plant roots is achieved by the dissolution of nutrients from the fertiliser into the soil in a form amenable for uptake. The research found that zinc dissolution is dependent on the fertiliser type and soil properties.

Using synchrotron X-ray analysis at the Australian Synchrotron facility in Melbourne, the researchers showed that dissolution of zinc from phosphorus-based fertilisers was much less than that from zinc-coated urea (Figure 1). Figure 1 shows that limited zinc dissolved and then diffused away from the co-granulated zinc-phosphorus or zinc-coated MAP fertilisers compared with the zinc-coated urea fertiliser.

For simplicity, Figure 1 only shows the results in the Calcarosol soil, but a similar result was observed in the Kandosol. In addition, the result for the zinc-coated DAP fertiliser was comparable to zinc-coated MAP. The limited zinc mobility for zinc-phosphorus fertilisers indicates that fertiliser granule placement (that is, a few centimetres below the seeds) is important when seeding to ensure the plant roots can access any of the plant-available zinc.

Bioavailability of zinc in soils

Plants obtain the zinc they require for growth from the soil solution. Total soil zinc concentrations tell us little about the amount of zinc that is bioavailable to the plant. Using diffusive gradients in thin-films (DGT) devices, University of South Australia researchers assessed the diffusion of bioavailable zinc from the same fertiliser granules investigated above (Moens et al., 2024).

Using DGT devices and synchrotron X-ray analysis, researchers found that zinc was potentially more available in soils treated with zinc-coated urea compared with any of the zinc-phosphorus fertilisers. The spatial distribution of available zinc from the zinc-coated urea fertiliser (32 millimetres) was greater than that of the phosphorus-based fertilisers (eight to 12mm) as well, indicating the diffusion of zinc was greater in the absence of phosphorus fertilisers (Figure 2). This increased movement of zinc from the granule is important as it increases the volume of soil from which plants can take up zinc.

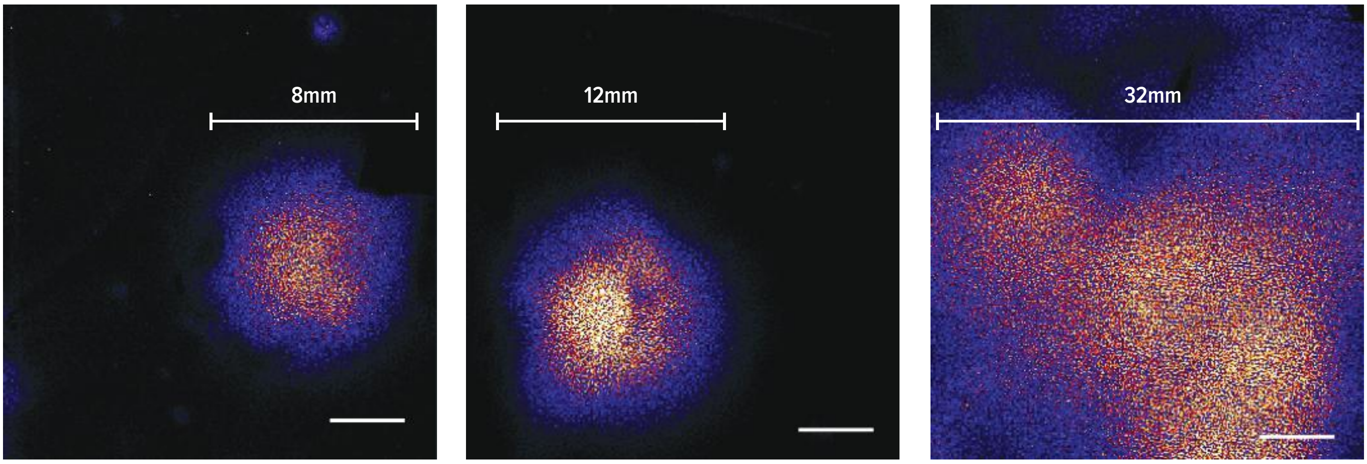
These results were also confirmed by isotopic dilution studies, which indicated a larger pool of potentially available zinc when applied to soil as zinc-coated urea than zinc-coated or co-granulated on/with phosphorus fertilisers.

Implications for fertiliser management

The research showed that zinc has limited mobility and availability in soils when applied as a coating on or co-granulated in phosphorus fertilisers. The diffusion of available zinc away from the fertiliser granule is strongly influenced by fertiliser type/composition. We found that zinc was potentially more available in soils treated with zinc-coated urea compared with any of the zinc-phosphorus fertilisers. The research also implies that given the limited diffusion of zinc in the fertosphere, placement of zinc-phosphorus fertilisers in soils a few centimeters below the seeds is important to ensure the maximum zinc availability for crops.

Figure 2: The diffusion of bioavailable zinc captured by DGT devices in the Calcarosol soil.

a) Co-granulated zinc-phosphorus fertiliser **b)** Zinc-coated MAP fertiliser **c)** Zinc-coated urea fertiliser



Source: University of South Australia

MORE INFORMATION

Professor Enzo Lombi
University of South Australia
enzo.lombi@unisa.edu.au

Professor Peter Kopittke
The University of Queensland
p.kopittke@uq.edu.au

ACKNOWLEDGEMENTS

Part of this research was performed on the XFM and XAS beamlines at the **Australian Synchrotron**, part of ANSTO.

USEFUL RESOURCES

Degryse F, Harris H, Baird R, Andelkovic I, da Silva RC, Kabiri S, Yazici A, Cakmak I, McLaughlin MJ (2024) Acid coating to increase availability of zinc in phosphate fertilizers. *Plant and Soil*, 495, 27–41.

Guide for the field deployment of diffusive gradients in thin-films devices (DGT). Available online from https://doi.org/10.25954/b97m-xa49

Moens C, Lombi E, Howard DL, Wagner S, Payne JL, Kopittke PM, Doolette CL (2024) Mapping phosphorus availability in soil at large scale and high resolution using novel diffusive gradients in thin-films designed for X-ray fluorescence microscopy. *Environ Sci Technol*. 58, 440–448.

GRDC CODES

USA1910-001RTX
UOQ1910-002RMX

GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION