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The effect of arbuscular mycorrhiza on zinc phytoavailability, uptake and translocation in rice: a pilot natural stable isotope investigation

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Zinc is critical for immune function, cognitive and physical development, and metabolic regulation. Zinc deficiency affects ~20-25% of the global human population and remains a major, under-recognised contributor to poor health outcomes. This 'hidden hunger' is often associated with cereal-based diets. To solve this problem, improvements to zinc phytoavailability and bioavailability are necessary. One proposed nature-based solution involves harnessing specific beneficial plant-fungi relationships. Arbuscular mycorrhizal fungi (AMF) form symbiotic root associations, known as arbuscular mycorrhiza (AM), with about 80% of land plants. The fungi help plants gather otherwise inaccessible nutrients via their network of fine, root-like tendrils (hyphae).

Mass dependent isotope compositions are altered by and hence reflect the processes that occur during elemental regulation by plants. As such, they can reveal whether plants use distinct mechanisms for maintaining homeostasis with changing environmental conditions. This is the first investigation to use natural stable isotope analysis to characterise AM.

Rice plants were grown under controlled environmental conditions, and half were inoculated with an AMF (*Rhizophagus irregularis*). The growth substrate comprised autoclaved sand and half-strength Hoagland solution. After harvesting, representative samples of inoculated roots were analysed via light microscopy to quantify the extent of AMF colonisation. Zinc concentrations and isotope compositions of shoots, roots and nutrient solution were analysed, via MC-ICP-MS, to determine whether the AM i) improved the phytoavailability of Zn, and/or (ii) altered the mechanisms by which the rice took up and translocated the Zn.

Inoculated rice plants took up on average 60% more Zn, and these plants also had ~40% more Zn in the shoots, compared to controls. Zinc in inoculated and control plants was isotopically heavier than that of the nutrient solution. In 7/8 plants, the shoots contained isotopically heavier Zn than the roots, and this difference was slightly more pronounced in the control plants. Isotope mass balance modelling, used to determine precise isotope fractionation factors, requires well-constrained and characterised systems. To this end, extraction experiments were conducted on the amended sand to quantify the effect of adsorption on phytoavailability. These novel pilot results set the foundation for extensive future investigation of AM via natural stable isotope analysis.