

The impact of organic fertilizer composition on soil processes controlling Zn and Cd uptake in wheat crops

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Wheat grown in Zn-limiting conditions can lead to decreased nutritional value of resulting food products. Organic fertilizer application can increase plant-available Zn in soils either directly, via addition of Zn from the fertilizer, or indirectly, via solubilization of Zn from the soil solid phases. However, this may also increase the plant-availability of Cd, a toxic element with similar biological uptake pathways as Zn.

We performed a wheat-growth pot experiment to understand how the composition of organic fertilizers impacts plant-available Zn and Cd. Four organic fertilizers (sunflower, poultry manure, cattle manure, and compost) with highly different organic matter (OM) compositions and Zn/Cd contents were applied to a low-Zn soil from Jura, Switzerland. Soil extractions with water and DGT samplers were performed after eight weeks of wheat growth to measure potentially plant-available Zn/Cd pools. Binding of Zn/Cd to OM in water extracts was measured using SEC-UV-ICP-MS/MS¹. Isotopic dilution was used to determine the fraction of Zn/Cd derived from fertilizers vs. soil in wheat roots, shoots, and grains.

Organic fertilizer application did not increase soil DGT-Zn/Cd but did increase Zn/Cd bound to water-soluble OM. Furthermore, no increase in Zn/Cd uptake was observed in roots and shoots harvested at eight weeks. Nevertheless, organic fertilizer application impacted Zn/Cd concentrations in wheat sampled at full maturity. Poultry and cattle manure increased grain Zn concentrations from 29.5 mg (kg DW)⁻¹ in the control to 32 and 33.5 mg (kg DW)⁻¹, respectively. Isotopic dilution revealed that this increase was due to direct addition of plant-available Zn from the fertilizers. Sunflower increased Zn concentrations to 32 mg (kg DW)⁻¹ due to Zn solubilization from soil solid phases. Meanwhile, sunflower and poultry manure application increased grain Cd concentrations from 0.11 mg (kg DW)⁻¹ to 0.14 and 0.15 mg (kg DW)⁻¹ respectively, while cattle manure did not increase Cd compared to the control. Compost application decreased concentrations of Zn/Cd in the grains, likely due to formation of stable metal complexes with degraded OM. Overall, our results demonstrated that soil processes controlling plant-available Zn and Cd are intimately linked to the composition of organic fertilizers applied.

[1] Tolu et al. (2022). <https://doi.org/10.1038/s41467-022->

Organic fertilizers vary in OM degradability and Zn & Cd speciation

