Composites of biopolymers and metal oxide nanoparticles for controlled release of micronutrients in agricultural soils

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Zinc micronutrient deficiency is a common problem in soils worldwide. Zinc is crucial for plant growth and development as it takes part in a range of plant biochemical processes. Zn is vital for the regulation of plant growth hormones, the maintenance of healthy root systems and the preservation of tolerance to plant stressors [1,2]. To correct Zn deficiency and prevent crops losses, fertilizers containing Zn are added to the soils. Due to lack of synchronization between the release of Zn from conventional ionic fertilizers (Zn as salt or chelated forms) and the uptake by plants, along with the high mobility of ionic species in soils, only a small part (30-50%) of the fertilizers applied to the soils are actually used by plants [2]. The remaining Zn applied forms nonbioavailable complexes in soils, or it is removed by leaching or runoff, causing negative environmental impacts [2]. Zn-based engineered nanomaterials (ENMs) can be used to control the release of Zn in soil/plant systems according to specific soil biochemical conditions, plant species, and plant life cycle stages, allowing a reduction of nutrient loss and of fertilizer application rates [3]. In the present work [4], composites of biopolymers (microcrystalline cellulose, chitosan, and alginate) and ZnO nanoparticles (NPs) were prepared and characterized. The potential of these materials for the controlled release of Zn, in acidic agricultural soils, was tested and their impact on the growth of maize plant was assessed. Comparative studies using $ZnCl_2$ and ZnO NPs not immobilized in the biopolymer were also performed. While $ZnCl_2$ salt leached from the soil resulting in very low extractable Zn concentration, Zn in ZnO NPs was less labile, and ZnO NPs/alginate beads maintained a better constant supply of extractable Zn than all other treatments, at least over the 30 days of experiments. Results further indicated that ZnO NPs/ alginate beads could meet the maize Zn needs while avoiding the early stage Zn toxicity induced by conventional ionic Zn supplies. Perspectives of applications and required environmental impact assessment will be discussed, namely by considering that these ENMs might be a sustainable way to supply Zn in a controlled manner in acidic soils.

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