LETTER

Reply to Lombi et al.: Clear effects of manufactured nanomaterials to soybean

Lombi et al. (1) have two concerns with our study (2): (*i*) nano-ZnO may not reach soils in "neat" form as it does in other Zn forms, which are already regulated; and (*ii*) the nano-CeO_2 concentrations we used are much larger than predicted from exposure modeling. They assert that we should have studied different materials, at different concentrations, as determined by "proper assessment of the pathways." This point does not change the importance of what we researched and reported: If these manufactured nanomaterials (MNMs) occur in soil at the concentrations studied, then the reported outcomes are possible. Indeed, our findings, which elucidate the key *processes* involved, will be essential for interpretation of future exposure assessments.

Further, there are many possible processes, not cited by Lombi et al. (1) and challenging to include in exposure models, that could affect impacts of MNMs. Relevant variables include not only the relative abundance of the MNMs in soil (1) but also other factors, such as soil biophysicochemical conditions, plant species, and cropping systems. Our results (2) are thus suggestive of many research avenues.

The arguments of Lombi et al. (1) are not made more compelling by the cited anaerobic digestion study (3), because the latter work was conducted by introducing MNMs to bench-scale anaerobic digesters directly [i.e., an MNM administration approach that Lombi et al. (1) apparently reject].

Lombi et al. (1) also express difficulty in envisioning the origins of impacts of low nano-CeO_2 treatment. Results concerning plant stress indicators, and plant macro- and micronutrients, for the plants described by Priester et al. (2) are part of a current study underway by Priester et al. Meanwhile, considering the complexity of the plant–microbe symbiosis, and that various stresses to the bacterial partner can elicit plant responses, one might envision that, for the low nano-CeO_2 treatment, the plant might have supplied its microbial partners with additional resources to overcome moderate symbiotic stress. This could be at a cost to plant growth. Lombi et al. (1) further state that Priester et al. (2) "made no attempt to measure the bioavailable Zn or its speciation." The bioavailability of Zn is obviated by the uptake into the plants, as discussed (2), but the water-extractable Zn is yet to be analyzed. Analyses of speciation data for plants in Priester et al. (2) are in progress, with a related manuscript, which is forthcoming.

To Lombi et al. (1), regarding the absence of "proper dose–effect curves": our study was toward delivering fundamental process-based understanding of potential effects on soybean by MNMs administered to organic farm soil. Our choice of wording (2) was sufficiently tentative [i.e., emphasizing "could" (2) instead of "may" (1) to describe potential outcomes]. Given the limited understanding of MNM release, deposition, transport, and transformation juxtaposed against the increasing production and use of MNMs, we assert that it is far from "premature" (1) to consider the importance of our results, and further that our results define future directions, including research that links to exposure modeling.

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The authors declare no conflict of interest.

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