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Nanotechnology in agriculture: focus on fertilizers

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Abstract

Nanotechnology is the exploitation of materials at the nano scale (1-100 nm in any dimension). The high bioreactivity of nanomaterials (or nanoparticles) has led to the potential for their application in a variety of systems, including agriculture and food. Although exposure of food crops to nano-scale nutrient elements at high doses has produced dramatic negative responses, evidence has since mounted that at the right, usually low, doses and environmental condition, nanoparticles of nutrient elements have beneficial effects, with the potential to be used as fertilizers to address multiple crop productivity parameters, including growth promotion, yield enhancement, crop health stimulation, nutrient agronomic fortification, and nutrient management. These benefits, therefore, warrant the development of nano-scale fertilizers to enhance the use efficiency of nutrients by crops, thereby mitigating the undesirable fertilizer effects in the environment. Whereas sufficient evidence exist to motivate industry investment in the technology, nanofertilizer as a concept is still at the early developmental stages, and several concerns remain, such as inadequate field-based studies, type of nanofertilizers (encapsulated or naked; nano-enabled bulk fertilizers) to produce, how to efficiently and effectively apply nanofertilizers at field scale (powder broadcasting, suspension application, seed coating, foliar or soil placement), and the lack of adequate understanding of the fate of intact nanoparticles taken up by plants - considering that plants, after all, need the ions, not the particles. Nevertheless, it is anticipated that the development of cost-effective nanotechnologies that are non-disruptive to existing bulk fertilizer production processes are likely to be favored by the fertilizer industry, allowing the incorporation of nanofertilizers into current fertilization regimes for sustainable and qualitative food crop production. This presentation highlights the rationale for developing nanofertilizers, types of nanofertilizers and relevant nutrients, and the fate and effects observed with nanomaterials in plant-soil systems. Perspectives for scaling and commercialization of nanofertilizers are also presented.

Short Bio

Dr. Christian Dimkpa conducts research in agricultural and environmental nanoscience and nanotechnology, including plant and microbial nanotoxicology, development of enhanced efficiency fertilizers based on formulation with nanoparticles, and beneficial plant responses to mineral nutrients based on particle size (nano vs bulk) and solubility state. He is currently the Chief Scientist and Head, Analytical Chemistry Department, Connecticut Agricultural Experiment Station. Prior professional experiences include being a senior scientist at the International Fertilizer Development Center, Alabama, USA; a Research Assistant Professor at Utah State University, USA; and a Research Supervisor at the International Institute of Tropical Agriculture, Nigeria. He obtained his PhD (2009) in Bio-Environmental Science from the University of Jena Germany, under the auspices of Max Planck Institute for Chemical Ecology. In 2005, he obtained an MSc in plant molecular biology from the Inter-university program of Vrije University Brussels and Katholieke University Leuven, Belgium. He also obtained a Higher National Diploma in crop production technology from Imo State Polytechnic, Owerri, Nigeria in 1998. Between 1999 and 2003, Dimkpa was a Research Supervisor at the biotechnology unit of the International Institute for Tropical Agriculture, Nigeria, where he was involved in plantain and banana improvement research. He has published over 70 research papers, many in the area of nanomaterials and their interaction in plant-soil systems in the contexts of bio-toxicology and plant fertilization.