Challenges for a more sustainable agriculture: predicting the fate of nano-enabled nutrients and fungicides in the plant-soil continuums

Sónia M. Rodrigues[1], Matheus Miranda[2], Sandra Rodrigues[1], Diana Dias[1], Bruno Morais[2,3], Mariana B. Oliveira[3], João Mano[3], Astrid Avellan[4]

1 – Department of Environment and Planning & CESAM, University of Aveiro
2 - Department of Chemistry & CESAM, University of Aveiro
3 - Department of Chemistry & CICECO, University of Aveiro
4 - Géosciences Environnement Toulouse (GET), CNRS, IRD, Université de Toulouse, France

Emerging trends in nano-enabled agriculture propose solutions for targeted and smart delivery of nutrients and pesticides, and for improving plant response to biotic and abiotic stresses, while reducing nutrient and pesticides losses to air, soil and water, and reducing deterioration on soil fertility and health. However, the fate, efficacy, and nano-specific effects of nanoparticles upon application to plants via soil or leaves are currently still largely unknown. Research developed by CESAM RG BPP members focus on nano-bio interactions towards a deeper understanding of observed bioactivities of inorganic nanoparticles and for the characterization of nanospecific bioavailability effects on plants (1–5). We have already reported that nanoparticles applied to the leaves can deliver macro and micro elements to plant roots and rhizosphere soil to enhance plant vigor and health and that the mobility of NPs in planta is mainly controlled by NPs size and surface charge(5, 6). We developed and validated tools to assess how biogeochemical conditions influence nanoparticles reaction in rhizosphere soils(3, 4). We discussed how localized biogeochemical conditions at the rhizosphere drive short-term kinetic reactions and increase the phytoavailability of metal ions dissolved from inorganic NPs. We also demonstrated that the immobilization of ZnO NPs onto natural polymers is a way to produce materials that release Zn in a controlled manner in the rhizosphere, and that such materials can supply enough Zn for a plant to grow well while reducing Zn losses (4). Mechanisms of cuticle uptake or mucilage-mediated root uptake and translocation to different plant parts are currently being studied by members of BPP CESAM in collaboration with CICECO and by colleagues at GET-Toulouse. Results of these investigations will allow to propose a rationale for the synthesis of nano-enabled structures that can lead to desired fate at the plant interfaces and to assess the real efficacy of nano-enabled nutrients and fungicides.

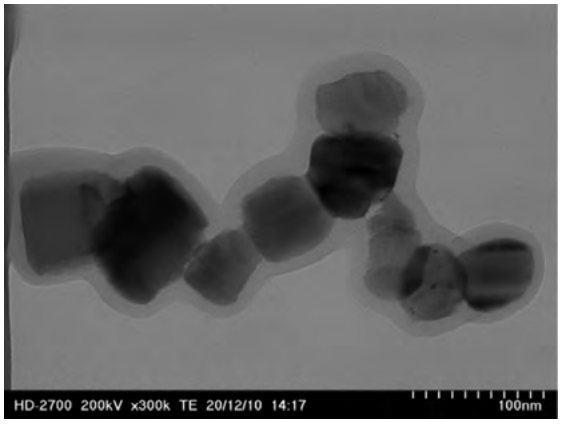

FIGURE 1
Transmission electron microscopy image of ZnO NPs coated with basil seed mucilage. (Author: Matheus Miranda).

FIGURE 2
Application new developed materials to plant leaves.

Funding:
This work was supported by the project AgriTarget (POCI-01-0145-FEDER-029258 and PTDC/BAA-AGR/ 29258/ 2017) funded by FEDER, through COMPETE2020 - Programa Operacional Competitividade e Internacionalização (POCI), and by national funds (Portuguese OE), through FCT/MCTES.