Using zinc oxide nanoparticles as fertilizers

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Bean plants used in the study. Credit: Demetrio González Rodríguez

Researchers from Universidad Politécnica de Madrid (UPM) and National Institute for Agricultural Research and Experimentation (INIA) have studied the effects of using zinc oxide nanoparticles on agriculture.

Researchers at the School of Agricultural, Food and Biosystems Engineering (ETSIAAB) from UPM in collaboration with the Ecotoxicology group of INIA, has studied how zinc oxide nanoparticles

affect tomato and bean plants. The effects depended on the type of crop, exposure time, and soil pH.

The results, which have been published in *Science of the Total Environment* journal, suggest that the use of these nanoparticles does not pose a toxicity risk for these crops and this would allow us to use their good fertilizing properties as a source of zinc micronutrient.

The deliberate application of nanoparticles in agriculture, although incipient, is promising. Due to their small size, the nanoparticles have different properties from the same material in their regular size. Essentially, they have a high specific area and a high surface energy that produce changes in its physicochemical, optical and electrical properties, as well as a high reactivity.

These characteristics can be helpful to achieve improvements in the area of agronomy, for instance, to develop more efficient formulations of fertilizers and phytosanitary. More specifically, there is a growing interest in the use of zinc oxide nanoparticle in agricultural formulations by either using their good properties as an ultraviolet light blocking substance or using their fertilizer properties as a source of zinc micronutrient. This micronutrient is essential for the development of plants because its shortcoming would reduce both the performance and the nutritional value of the crops.

However, the use of nanoparticles is not free of certain risks that should be assessed, for example, its possible toxicity and its potential accumulation in feed and food that could mean its entrance to the food chain. One of the main causing mechanisms of the toxicity of nanoparticles is its capacity to develop free radicals or reactive oxygen species that can cause oxidative stress in organisms.

Tomato plants used in the study. Credit: Demetrio González Rodríguez

These changes in the cellular metabolism can be measured by using biomarkers, for example, activities of different antioxidant enzymes.

In order to study the benefits and assess the risk of using zinc oxide nanoparticles in crops, a team of researchers from UPM and INIA has carried out a study that starts giving results. An experiment consisted of cultivating tomato and bean plants in two agricultural soils with very different characteristics (an acidic soil and a calcareous soil with a basic pH) and applying different doses of zinc oxide nanoparticles to study its effects on plants.

The potentially bioavailable fraction of zinc given in nanoparticles was estimated through a chemical extraction of soil with a mixture of weak organic acids that simulated the mixture of acids secreted by the root system of plants. Besides, researchers took leaf samples at different times in order to establish the accumulation of zinc, as well as determining possible alterations of different biochemical parameters (content in photosynthetic pigments and proteins) and samples of biomarkers of oxidative stress.

In addition to the zinc oxide nanoparticles, two other products traditionally used as fertilizers were used to supply zinc to crops: zinc oxide powder with a conventional particle size and zinc sulfate, which provides the micronutrient ion.

Results show that zinc oxide nanoparticles can affect oxidative stress biomarkers, but the effects depend on the plant species, exposure time and soil pH. In general, the effects on crops were more pronounced on acid soils than on calcareous soils in the case of the bean crop and the opposite in the case of the tomato crop.

A highlighted effect was that there were no significant differences between the two soils regarding the traditional treatment (conventional zinc oxide and zinc sulfate), neither in the amount of zinc have potentially bioavailable on soil, neither in the accumulation of the mineral in the leaf and neither in the possible toxicity for both plant species.

Ana Obrador, the female researcher responsible for the UPM project says: "from the experiments carried out so far, we cannot still conclude that the use of zinc oxide nanoparticles as fertilizers provides additional advantages compared to the compounds used traditionally. It is necessary to keep studying other variables such as the distribution of zinc used in the soil and plant as well as to carry out other tests with different soils

and types of nanoparticles (other sizes and coatings)."

More information: Concepción García-Gómez et al. Comparative effect of ZnO NPs, ZnO bulk and ZnSO 4 in the antioxidant defences of two plant species growing in two agricultural soils under greenhouse conditions, *Science of The Total Environment* (2017). DOI: 10.1016/j.scitotenv.2017.02.153

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