Effect of $nTiO_2$ and $nCeO_2$ nanoparticles on gene expression, germination, and early development in plants

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Abstract

Ten agronomic plant species and *Arabidopsis thaliana* were exposed to different concentrations of the metal oxide nanoparticles (NPs) TiO_2 or CeO_2 (0 - 1000 mg L^{-1}) and monitored to examine effects on germination rate and early seedling development. Endpoints measured included germination percentage, cotyledon emergence, and seedling root length. Nine and 5 of the 11 species responded to $nTiO_2$ and $nCeO_2$, respectively. Both positive and negative effects on germination and early growth were observed in response to the nanoparticle suspensions, depending on the species. In *A. thaliana*, gene expression was quantified along with germination and early seedling development. Genomic responses to both particles included upregulation in genes involved in oxidative stress, and also those involved in early growth and development. But unlike nTiO2, exposure to nCeO2 resulted in upregulation of genes associated with various transporters, and downregulation rather than upregulation of several genes associated with photosynthesis. The specific differences in gene expression in response to nTiO2 and nCeO2 suggest that modes of action for the two metal oxide NPs may be different. The subtle effects on germination rate and early seedling growth indicate that the two NPs may influence early-stage processes that alter specific developmental events during a plants life cycle. Finally, our results indicate that the standard germination test, which is commonly used for toxicity screening of new materials, may not be adequate to identify the subtle physiological changes that occur in terrestrial plants in response to nanoparticle exposure.