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PHYTOTOXIC EFFECT OF ZnO NANOPARTICLES ON *RAPHANUS SATIVUS* L.

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Zinc oxide nanoparticles (ZnO NPs) have been used as a promising micronutrient fertilizer for various crops. However, elevated levels of Zn in the soil might lead to hyperaccumulation in plant tissues causing phytotoxicity. In this study, the effect of ZnO NPs on *Raphanus sativus* L. was evaluated based on plant growth and variations in selected plant metabolites. ZnO NPs were synthesized by the wet chemical method, and the successful synthesis of NPs was confirmed using Powder X-Ray Diffraction (PXRD), Fourier Transform Infrared Spectroscopy (FTIR), and Scanning Electron Microscopy (SEM). SEM images showed that ZnO NPs have a spherical-shaped morphology with an average particle diameter of 70 nm. *R. sativus* did not show any significant toxic effect up to 100 mg/l at the seed germination stage, but at higher concentrations (300 - 1,000 mg/l), root and shoot lengths were significantly reduced. However, the percentage of seed germination was not affected even at 1,000 mg/l. Seedlings grown in acid-washed sand showed that ZnO NPs increased shoot, root lengths and shoot dry mass by 21.5, 50.9, and 52.9%, respectively, even at the highest concentration tested (10,000 mg/l). A dose of 1,000 mg/l ZnO NPs increased the soluble protein content, carbohydrates, chlorophyll a, chlorophyll b, total chlorophylls, carotenoids, and antioxidants by 24.7, 58.5, 38.0, 42.2, 39.9, 11.2 and 7.7%, respectively without affecting the indole acetic acid content. The Zn internalization was confirmed by Atomic Absorption Spectroscopy (AAS), indicating that *R. sativus* can hyper-accumulate Zn at high concentrations (0.36 mg g^{-1} and 1.76 mg g^{-1} at 0 and 10,000 mg/l, respectively), showing insights on health issues regarding Zn toxicity in consumers. Accordingly, treatments below 1,000 mg/l seem to show nontoxic effects on *R. sativus*.

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Keywords: Micronutrients, Nano fertilizer, Phytotoxicity, ZnO Nanoparticles