

Effects of copper, gold and silver nanoparticles on *Mentha spicata* L. under field conditions

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Abstract

This study investigated the effect of root application of copper, gold and silver nanoparticles at different concentrations (5, 50, 100 mg/L) on Mentha spicata L. during 28-days field experiment. The plants were watered once with the nanoparticle solutions, which were coated with polyvinylpyrrolidone and had the following sizes: 1–2 nm for silver, 1–4 nm for gold, and 15–70 nm for copper. To determine the patterns of metal nanoparticle accumulation, their content in soil and plant segments was quantified using inductively coupled plasma optical emission spectrometry and atomic absorption spectrometry. Silver nanoparticles exhibited the highest bioavailability, while copper and gold nanoparticles showed low mobility in plants. Irrigation with a 50 mg/L solution of copper nanoparticles led to a 25% decrease in copper content in leaves. Low copper nanoparticle concentrations stimulated chlorophyll synthesis, resulting in a 16% increase. In contrast, a concentration of 100 mg/L significantly inhibited the process, reducing chlorophyll content by 61% compared to control samples. Treatment of plants with gold nanoparticles led to an increase in chlorophyll, ascorbic acid, and glutathione (except for 50 mg/L) content. Gold and copper nanoparticles reduced carotenoid content by 8–45% and 4–61%, respectively. In contrast, silver nanoparticles exhibited a stimulatory effect on carotenoids (increasing their content by 22%), pigments and antioxidants (except concentration at 100 mg/L). The results obtained for Mentha spicata L. demonstrate that the physiological and biochemical responses are strictly dependent on nanoparticle type and concentration. This species-specific response should be considered when developing agricultural regulations for nanomaterial

use.

Keywords: nanoparticles, root irrigation, chlorophyll, carotenoid, antioxidant activity

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