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## Deep-Flow Hydroponic Culture: Copper Toxicity at 8 $\mu\text{M}$ (0.13 ppm) in Tomato

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# Deep-flow hydroponic culture: Copper toxicity at 8 $\mu\text{M}$ (0.13 ppm) in tomato

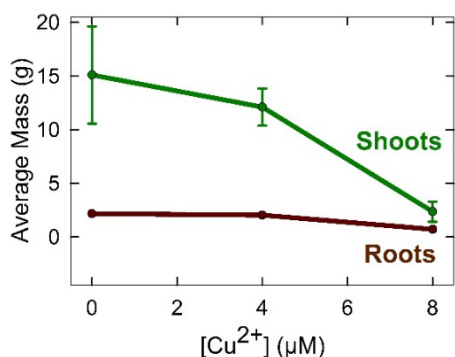
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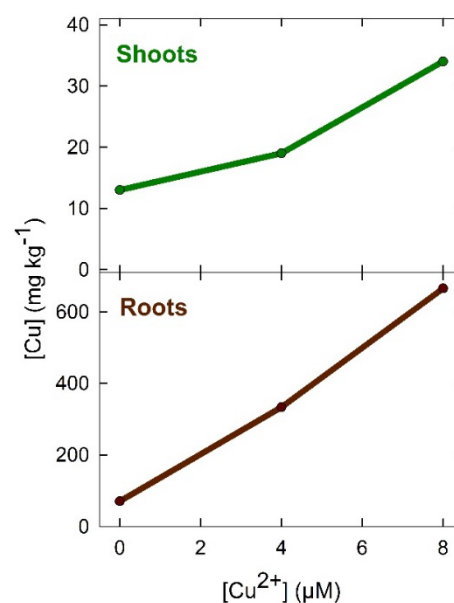


Plants have more than 100 copper-containing proteins. About half of the Cu in plants is in the chloroplast, bound to plastocyanin, where it helps absorb oxygen radicals. Cu is considered adequate in solution at 2 to 4  $\mu\text{M}$  (0.03 to 0.06 ppm). The requirement for Cu is so low that it can sometimes be supplied from contamination. The effect of higher levels is not well studied. Here we report the effect of Cu at 0, 4, and 8  $\mu\text{M}$  (0, 0.06, and 0.13 ppm Cu) in tomato (*Solanum lycopersicum*) in a deep-flow hydroponics system.

The solution was made from reagent grade chemicals and reverse osmosis water. Added Cu was not chelated and therefore bioavailable in solution. The pH was controlled at 5.8. We were surprised to find that adequate Cu was supplied by contamination in this system (zero added Cu).



Increasing solution Cu concentration increased Cu in leaf tissue and dramatically increased it in root tissue. This is characteristic of plant exclusion of Cu at the root surface. Shoot and root dry mass were significantly reduced in the 8  $\mu\text{M}$  treatment. The roots of plants grown in 8  $\mu\text{M}$  Cu had reduced elongation and were brown colored (photo taken on the day of harvest).



This study demonstrates the potential growth reduction from a solution Cu concentration of 8  $\mu\text{M}$ . The Utah hydroponic solution now uses 2  $\mu\text{M}$  for all crops. This has been adequate to provide 5 to 10 mg Cu kg<sup>-1</sup> (ppm) in leaf tissue of all crops.

0  $\mu\text{M}$  Cu<sup>2+</sup>



4  $\mu\text{M}$  Cu<sup>2+</sup>



8  $\mu\text{M}$  Cu<sup>2+</sup>

