Evidence of Sulfur-bound Reduced Copper in Bamboo Exposed to High Silicon and Copper Concentrations

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ABSTRACT

Due to its high growth rate and biomass production, bamboo has recently proven to be useful in wastewater treatment. Bamboo accumulates high silicon (Si) levels in its tissues, which may improve its development and tolerance to abiotic stresses, such as metal toxicity. We examined copper (Cu) absorption, distribution and toxicity and the role of a silicon (Si) supplementation in the bamboo. Bamboos *Phyllostachys fastuosa* were maintained in hydroponics for 4 months and submitted to two different Cu (1.5 and 100 µm Cu^{2+}) and Si (0 and 1.1 mM) concentrations. Cu and Si partitioning and Cu speciation were investigated by chemical analysis, microscopic techniques (cryo-scanning electron microscopy, laboratory based micro X-ray fluorescence spectroscopy) and spectroscopic techniques (X-ray absorption near-edge structure and extended X-ray absorption fine structure).

Inhibitory effects of Cu on plant growth were observed at the highest Cu concentration. Si supplementation reduced the visible toxicity symptoms (chlorosis and brown coloration of roots) but did not significantly modify the Cu concentration. Cu concentration varied over a root>stem≥leaf gradient. Microscopic analysis of root cross-sections revealed that Cu was mostly detected in epidermal cells region, whereas Si had mainly accumulated in the endodermal cell region. Cu was present in two oxidation states: Cu(I) and Cu(II) with different ratios in different plant parts. The main strategies of bamboo to cope with high Cu concentrations in its tissues include: (i) high sequestration in the root, (ii) Cu(II) binding to amino and carboxyl ligands (iii) the formation of Cu(I)S organic compounds, and (iv) the formation of an inorganic Cu(I)S compound that may be involved in Cu storage. Although Si did not significantly improve bamboo Cu tolerance, Si supplementation modified Cu speciation in above-ground parts by increasing the proportion of organic and inorganic Cu(I)S compounds.