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Silicon□mediated manganese tolerance of cucumber: the apoplastic modulation

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An impressive body of Si research could be found in the literature despite the fact that, from a biochemical perspective, Si is a “monotonous” element largely uncharged and unreactive at physiological pH (forming mostly silicates and SiO_2 polymers). However, the detailed role of Si in plants remains unexploited, particularly the potential for its practical application. One of the main properties of Si intensively explored is the protection mechanism(s) against biotic and abiotic stresses, especially heavy metal stress. To investigate the effect of Si application on the Mn binding potential of the leaf apoplast, cucumber plants were grown in nutrient solutions with optimal (0.5 μM) or excessive (100 μM) Mn concentrations with or without Si supply to roots. Leaves were subjected to fractionated extraction of Mn revealing a relative distribution of Mn fractions in cucumber leaves: water-extractable (WE) Mn represents the soluble fraction in the cell walls; the protein-bound (PB) Mn fraction originates mostly from the symplast; while the cell wall-bound (CWB) Mn fraction represents Mn which is fixed to the wall structure. After the high Mn supply (100 μM), the concentration of WE Mn was 10-fold higher compared to control, while the relative proportion of the WE Mn fraction decreased from 56% in control to 23% in high Mn treatment. Si application did not affect WE and PB Mn fractions in the control treatment but significantly decreased these fractions in the high Mn treatment. On the other hand, the CWB Mn significantly increased in the leaves of Si-fed plants. Data obtained by fractionated Mn extraction are consistent with the relative proportion of free and bound Mn, estimated from the recorded electron paramagnetic resonance (EPR) signals of Mn^{2+}. The EPR spectrum of a high spin Mn^{2+} showed the characteristic six hyperfine lines whose intensity correlated with Mn treatments and, consequently, leaf concentrations of Mn. The results presented here demonstrated that Si supply increased the Mn binding properties of leaf cell walls in cucumber plants with simultaneously decreasing of the free apoplastic Mn^{2+}, indicating the protective role of Si in smothering harmful (inter)actions of free Mn^{2+} within plant tissue. Taken together, the leaf apoplast plays the central role in modulation of Mn toxicity and Si enhanced Mn tolerance in cucumber.

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