Plant Nutrition, Stress, and the Forgotten Element, Silicon

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Plant Nutrition
<table>
<thead>
<tr>
<th>Macronutrient</th>
<th>Micronutrient</th>
<th>Other</th>
<th>Mammals</th>
</tr>
</thead>
<tbody>
<tr>
<td>K</td>
<td>Fe</td>
<td>Na</td>
<td>F</td>
</tr>
<tr>
<td>Ca</td>
<td>Mn</td>
<td>Co</td>
<td>I</td>
</tr>
<tr>
<td>Mg</td>
<td>Zn</td>
<td>Si</td>
<td>Se</td>
</tr>
<tr>
<td>N</td>
<td>Cu</td>
<td></td>
<td>Cr</td>
</tr>
<tr>
<td>P</td>
<td>Ni</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>S</td>
<td>B</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cl</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mo</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Beyond the Numbers:
Root cells vs. ours
“I doubt that there exists in any other system presented for scientific or practical study a comparable degree of complexity. Indeed, scientifically considered, this complexity occasionally takes on an almost appalling aspect.”

Dennis R. Hoagland
Permeability vs. active transport

“...ideas concerning permeability do not in themselves suffice...Salts can be pumped...with the use of metabolic energy, in the utilization of which an aerobic respiratory system is involved.”
1. Ions are pumped into root (and other) cells by metabolically driven processes.

2. Ions are accumulated against electrochemical diffusion gradients.

3. Their transport is not indiscriminate but selective.
Hoagland solution concentrations vs. soil solutions. J.H. Teakle.
Solution culture
High-affinity mechanisms
Root morphology
“Terrascentian”
Plant Nutrition

Its status here and elsewhere
Stress
Aquatic vs. terrestrial plants
<table>
<thead>
<tr>
<th>Condition</th>
<th>Aquatic</th>
<th>Terrestrial</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steady water availability</td>
<td>Yes</td>
<td>No</td>
<td>Variable on Land</td>
</tr>
<tr>
<td>Physical homogeneity of the medium</td>
<td>Yes</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Chemical homogeneity</td>
<td>Yes</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Large temperature fluctuations</td>
<td>No</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Gravitational pull</td>
<td>No</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Need for long-distance transport</td>
<td>No</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Mobility</td>
<td>Yes</td>
<td>No</td>
<td>For terrestrial plants: Yes for propagules</td>
</tr>
<tr>
<td>Mycorrhizae</td>
<td>No</td>
<td>Yes</td>
<td></td>
</tr>
</tbody>
</table>
Deficiencies

Absolute

Induced

Excesses

Heavy metals;
other elements

Salts, Na
Silicon

A plant nutritional oddity
Silicon absorption by wheat
Silicon absorption by wheat

![Graph showing the uptake rate of silicon by wheat in relation to solution Si (mM). The graph includes a curve that asymptotically approaches a maximum uptake rate, denoted as V_max.](image)
Silicon absorption by wheat

![Graph showing silicon uptake rate against solution concentration. The graph includes data points for Si uptake from Si only solution, Si uptake from solution containing Ge, Ge uptake from solution containing Si, and the sum of Ge and Si from fitted curves.](Image)
Si(OH)$_4$

$(\text{OH})_3\text{SiOSi(OH)}_3$

$\delta^{28}\text{Si}$ (p.p.m.)
Comparison with K transport
The role of silicon is defense
Defense: Physical
Si(OH)$_4$ or OH - Si - OH

Silicic acid
SiO₂  Silica
Wheat trichomes with/without silica
Defense: Chemical
Secondary Metabolites: 200,000. Terpenoids, alkaloids, phenolic compounds

Silicon: an inorganic secondary nutrient

Up- and down- regulation of genes
Present Status
Conclusion
Support

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