COMMENT AND LETTERS TO THE EDITOR

The Suspension Effect and Its Relationship to Ion Uptake by Excised Roots

A recent article in the SSSA Proceedings touched on the suspension effect and its relationship to ion uptake by excised roots (2). The data were offered as a response to one of our papers which dealt with the suspension effect in clay systems (1) and appeared to refute our findings and conclusions. Several factors such as limited surface “contact,” failure to displace adsorbed ions from the roots, and the use of a cation-anion resin tend to minimize differences in uptake between a resin and an equilibrium solution phase and account for Olsen’s failure to observe a suspension effect. The limited surface “contact” is by far the most critical factor, the simple fact being that the amount of “contact” between exchanger and root surfaces obtained with the ion exchange resin Olsen used is negligible compared to that obtained with clay sols.

The resin that Olsen used, Amberlite MB-3, is a mixture of cation- and anion-exchange resins, 40% of the resin particles being IR-120 H, having a cation-exchange capacity of 1.9 meq/cm³ or 4.3 meq/g. His resin phase contained 16.67 g of the MB-3 resin. Consider the surface area of the cation portion of this resin with that of the clay contained in an equal volume of 1% bentonite suspension. If all of the resin were 50-mesh size (he used 20-50 mesh), the IR-120 portion would have an external surface area of 0.182 m² and the total volume of the 16.67 g of resin would be 37.7 ml. The clay in an equal volume of 1% bentonite suspension would have an external surface area of 60.3 m², assuming 20% external surface @ 800 m²/g clay. In other words the clay suspension contains over 330 times as much surface area available for root “contact.”

The equivalents of exchangeable cations in the “effective volume” around the plant root for these two cases are shown below assuming a 1% bentonite suspension, CEC = 80 meq/100 g, and root radius of 2.5 × 10⁻² cm.

<table>
<thead>
<tr>
<th>c (Å)</th>
<th>Clay</th>
<th>Resin</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>1.3 × 10⁻¹⁰</td>
<td>5.4 × 10⁻¹⁵</td>
</tr>
<tr>
<td>50</td>
<td>6.5 × 10⁻¹⁰</td>
<td>1.4 × 10⁻¹²</td>
</tr>
<tr>
<td>100</td>
<td>1.3 × 10⁻⁹</td>
<td>5.4 × 10⁻¹³</td>
</tr>
</tbody>
</table>

The calculations were made for effective distances, c, we believe are within the range over which adsorbed ions are likely to occur. Further calculations are biased in favor of the resin since we considered only the 50-mesh resin which has the largest specific surface and have assumed maximum contact with perfect arrangement around the root, an assumption which can hardly be true when some chemical interaction occurs without first diffusing to the root surface. Also, we have considered only a portion, say ¼, of the effective volume of the resin. The effective volume is approximately:

\[ V \approx \pi (3/4 ac^2 - 7/24 c^3) \]

where: \( a = \) radius of resin or root and \( c = \) effective distance. Assuming that the average radius of the barley root was 0.5 mm, no more than six rows of the smallest resin beads can be arranged around a root segment of the 0.5-mm diameter resin particles, 40% of which will be cation exchanger particles, can be arranged along a 1-cm root segment.

Considering the case where the root is in a clay suspension, the effective volume around the root is approximated by:

\[ V = \pi (2 ac + c^2), \]

where \( a = \) radius of root and \( c = \) effective distance.

The suspension effect appears to us that uptake from the two phases was the same in Olsen’s experiment not because surface area achieved with the resin being used is insignificant, but because the amount of contact achieved with the clay was so much larger than that with the resin.