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Optimizing Greenhouse Corn Production: What Prevents Calcium Deficiency?

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What prevents calcium deficiency?

Calcium deficiencies of corn, often called “buggy-whipping,” are fairly common in a greenhouse. The most common and troublesome calcium disorder occurs in the seedling stage. Emerging leaves are damaged and don’t unfurl. Distortion and twisting results as newer leaves try to push through the damaged leaves (see Figure 1). Sometimes the plant recovers, but too often the grower must carefully unfurl the leaves manually to save it. Certain genetic lines exhibit the disorder more than others, and it is much more prevalent in low light of winter.

A second disorder blamed on calcium deficiency can appear during the rapid growth stage of the plant, typically in summer, with serrated edges of new leaves. This seems to be more environmental than genetic, and plants typically grow out of it. It is difficult to tell if it is a calcium disorder or a burning of the leaf edge as xylem sap is forced out of leaf through a process called guttation (see Figure 2). Guttation, prevalent in grasses, has been linked to leaf damage from salts in the fluid (Ivanoff, 1963).

Calcium is taken up passively by roots, so transpiration rate affects calcium level in plants. Once in the plant, calcium cannot be translocated into other tissue. This is why disorders typically show up in newly forming tissues when environmental conditions disfavor transpiration. In a northern greenhouse, this may mean low light of winter, accompanied with high humidity due to the greenhouse cooling vents staying closed for long periods. Even if calcium levels in the plant as a whole are sufficient, sometimes the plant can’t get enough calcium into rapidly expanding tissue, where it is needed for cell wall growth, among other functions. Poinsettia Bract Edge Necrosis and tomato Blossom End Rot are two classic greenhouse calcium disorders.

Calcium management methods include making sure adequate calcium is supplied while creating an environment to improve transpiration, including proper humidity and air movement. To ensure adequate calcium is applied, one research company starts corn plants in small containers so that they are watered more frequently, using a solution of 400 ppm Ca. A similar method is described in the protocol of the Iowa State University Plant Transformation Facility (Anonymous, 2009), including nutrient solution recipes.

Nolan Shumway of Purdue Botany department has nearly eliminated calcium disorders of corn by installing supplemental light system in the greenhouse capable of adding 600-700 µmol/m²/s.
Since this is not economically feasible for many facilities, we pursued other means. Interestingly, our attempts to match the daily light integral, or solar accumulation, of Shumway’s system by applying 400 µmol/m²/s light from fluorescent lamps for 24 hours only made the calcium disorder worse.

Using corn lines that exhibited calcium deficiency immediately after germinating, we looked at applying calcium to the plants, to the root medium or the seeds themselves (see Experiments 19, 21-24 in Materials and Methods). Though some of these methods are effective with poinsettia and greenhouse tomato, none worked with these corn lines. The methods included: calcium sprays, calcium soil drenches, calcium solutions in the whorl, calcium seed soaks, ultrasonic seed treatment followed by calcium seed soaks.

The only improvement we saw was by lowering temperature during germination and early growth (see Table 1). This came at the cost of growth rate. Plants at the lower temperature were a full leaf stage behind the plants at higher temperatures and were much shorter (data not shown). We suggest this may be just one more tool for the toolbox.

Putting it all together, it may make sense for researchers to identify genetic lines prone to this early calcium disorder and set up a special propagation area. This would limit the extra labor and equipment expense to just these lines. The area could have a combination of supplemental light of 600 µmol/m²/s, a transplanting protocol, high-calcium fertilizer, optimum air movement, and the capability for lower temperatures, if required.

Figure 1. Left: Calcium disorder of young corn seedling. Right: Disorder in summer greenhouse during rapid growth stage, either calcium deficiency or guttation damage.
Table 1. Percentage of plants exhibiting Ca deficiency symptoms requiring manual unfurling to keep plant growing in different temperature and light environments of Experiment 20.

<table>
<thead>
<tr>
<th>Condition</th>
<th>High light 425 µmol/m²/s</th>
<th>Low light 145 µmol/m²/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>26.7°C day / 21.1°C night</td>
<td>65*</td>
<td>50**</td>
</tr>
<tr>
<td>Greenhouse</td>
<td></td>
<td></td>
</tr>
<tr>
<td>26.7°C day / 21.1°C night</td>
<td>21</td>
<td>42</td>
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<tr>
<td>Growth chamber</td>
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<td>23.9°C day / 23.9°C night</td>
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<td>4</td>
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<tr>
<td>Growth chamber</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21.1°C day / 15.6°C night</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Growth chamber</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Ambient greenhouse light with approximately 100 µmol/m²/s HID supplementation for 16 hours daily.
**Same as “High light” treatment but with 50% shade covering.

Figure 2. Guttation in corn leaves, when xylem sap is forced through leaf hydathodes through root pressure.