e-GRO Edible Alert

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Finding the balance: calcium-related disorders in vegetable fruiting crops

Vegetable fruiting crops grown hydroponically are susceptible to physiological disorders related to the uptake and transport of calcium, which can result in reduced yield and fruit quality. Unfortunately, strategies to prevent one type of calcium-related disorder have the consequence of promoting other types of calcium disorders.

This e-GRO Edibles Alert highlights the common types of calcium-related disorders in vegetable fruits at opposite ends of the spectrum, and some simple methods for finding the balance for managing these disorders and minimizing losses.

Blossom-end-rot (BER) is a common calcium-related disorder, shown in Figures 1 through 3, where the tissue near the bottom of the fruit turns soft and collapses and appears to rot. A localized calcium deficiency in the lower part of the fruit is the culprit.

However, strategies to reduce BER increase the likelihood of another calcium-related disorder, called gold speck in tomato and more generally as “spot” for pepper and other crops. This disorder results from the toxic accumulation of calcium deposits in fruits, typically near the top, and is characterized by gold speckling in tomato and soft brown lesions in pepper and eggplant (Figures 4 and 5).

Calcium uptake and transport

To better understand why fruiting crops are susceptible to calcium-related disorders, we need to review how calcium is transported through the vascular tissues of the plant—i.e. the xylem and phloem.

Xylem tissue delivers water and nutrients from the roots to stem and leaf tissues, and calcium is transported through the xylem with the movement of water from transpiration. Calcium concentrations are greatest in leaves compared to other plant organs because the leaves have the highest transpiration rates.

Developing fruits are designed to retain water and have low transpiration rates, meaning low transport of calcium. Fruits receive most of their water and nutrients from phloem tissue; however, calcium transport rates in the phloem are incredibly low (can be 50 to 100 times lower compared to xylem!). Calcium moves slowly in fruits, and calcium concentrations are usually greater towards the proximal end of the fruit (i.e. the top) near the point of entry and lower towards the distal end (i.e. the bottom).

Insufficient calcium transport can lead to BER in fruits even when sufficient amounts of calcium are supplied in the nutrient solution. Increasing the transport of calcium to fruits can solve the problem of BER, but going too far can lead to symptoms of "spot" because of the tendency for calcium to accumulate near the top of the fruit.

Figure 1. Calcium deficiency in tomato fruits caused by blossom-end-rot. Photo from Sonneveld and Voogt (2009).

Figure 2. Blossom-end-rot in sweet pepper. Photo from Sonneveld and Voogt (2009).

Figure 3. Calcium deficiency in eggplant fruits is characterized by soft spots at the lower part of the fruits. Photo from Sonneveld and Voogt (2009).

Figure 4. "Spot" on sweet pepper fruits caused by high calcium concentrations in the middle to upper part of the fruit. Photo from Sonneveld and Voogt (2009).

Figure 5. Gold specks on tomato fruit connected with high calcium concentrations in the upper part of the fruit. Photo from Sonneveld and Voogt (2009).

Blossom-end-rot and "spot" can be difficult to diagnose from tissue nutrient analysis—because of how calcium is transported and because deficiency/toxicity is highly localized in very specific parts of the fruit. Symptoms occur even when concentrations are adequate in leaves, and critical nutrient thresholds in plant tissues depend on multiple environmental/cultural factors making interpretation difficult.

Finding the balance

We often focus on increasing calcium transport to fruits since BER is the more common disorder. However, finding a balance is important, because excess calcium uptake can cause gold speck and "spot" resulting in major fruit quality issues and losses. Below are several general methods for mitigating calcium-related disorders.

- Provide sufficient calcium: The first step is provide enough calcium in the nutrient solution. Common calcium concentrations found in nutrient solutions for hydroponic vegetable fruiting crops are between approximately 2.50 to 6.25 mmol/L (100 to 250 ppm). This can depend on the crop, climate, and growing system. It can be helpful to consult with your fertilizer supplier or extension specialist.
- Balance the potassium:calcium ratio. Excess supply of potassium in the nutrient solution can inhibit calcium uptake/transport and promote BER. In contrast, supplying low potassium can increase calcium uptake/transport and promote gold speck or "spot." We recommend as a starting point to supply a 1:1 potassium:calcium ratio in the nutrient solution to minimize fruit quality issues and losses. Within reason, the potassium:calcium ratio can be increased to reduce gold speck/spot issues, and decreased to reduce BER issues. Supply nitrogen mostly as nitrate (>85% of total nitrogen) with minimal ammonium or urea nitrogen, because ammonium/urea inhibits calcium uptake.

- Increase transpiration, especially around fruits: Increased air movement, reduced humidity, and increased vapor pressure deficit (VPD) will increase transpiration and calcium uptake/transport. This can be achieved using fans, providing high ventilation levels, and with heating/cooling systems. If possible, aim to keep leaves "fluttering in the wind" even in the greenhouse. Remove large and older leaves to increase air movement and reduce humidity directly around the fruit. A VPD of 0.5 kPa or greater can increase calcium in tissues, but much greater than 1.2 kPa may reduce fruit set in crops such as tomato.

- Control soluble salts and electrical conductivity (EC): High soluble salts and root zone EC result from increasing the nutrient solution strength and from poor water quality/insufficient leaching. Growers sometimes increase root zone EC intentionally to increase growth and fruit flavor, but there is a trade-off. High EC reduces transpiration and calcium uptake, promoting BER and reducing fruit yield and quality. Try to reduce EC during periods of high light intensity (i.e. peak daylight hours) and during hot and dry weather to promote water and calcium uptake and minimize plant stress.

- Cultivar selection: A final step is select a cultivar with resistance to BER and gold speck/spot. Cultivars resistant to BER are more efficient at calcium uptake and transport within fruits; however, it is important to note cultural and climate factors can still have dominant effects on calcium transport, and that we cannot overcome poor cultural and climate management practices with cultivar selection.

Literature used:

Sonneveld C. and W. Voogt. 2009. Plant nutrition of greenhouse crops. Springer, The Netherlands.

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