e-GRO Edible Alert

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Nutrient antagonisms- The potassium-calcium-magnesium relationship

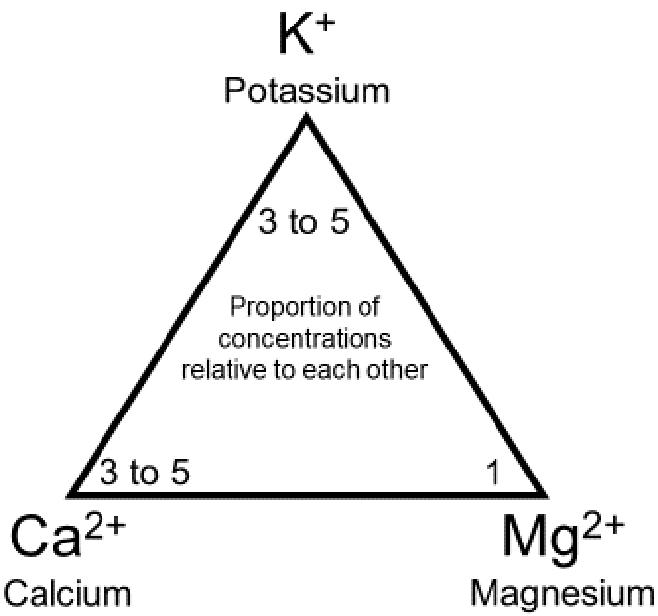

Figure 1. The concentration of potassium, calcium, and magnesium – all positively charged ions or cations- in nutrient solutions can affect the upatke of one another.

Managing mineral nutrition for hydroponically grown crops is essential for maximizing crop productivity and quality. Deficiency symptoms can occur when there are insufficient nutrient concentrations in solution. However, it is also possible to observe deficiency symptoms even when there is a sufficient concentration in the nutrient solution due to nutrient antagonisms. This e-GRO Edible Alert is going to focus on the relationship between potassium (K), calcium (Ca), and magnesium (Mg).

Understanding K, Ca, and Mg

The relationship between K, Ca, and Mg is an important one for hydroponic food crop producers. In order to understand how to manage the relationship between these nutrients it is important to review a little bit of their chemistry.

When fertilizer salts are dissolved into solution, the salts dissociate and nutrients are available in their charged ionic form. All three of these nutrients- K, Ca, and Mg- are all positively charged ions, or cations. Furthermore, in their ionic state they have a similar charge or valance; K is missing one electron and is a monovalent cation (K^{+}) and Ca and Mg are missing two electrons and are divalent cations (Ca^{2+} and Mg^{2+}). In addition to their ionic charge and valance, Ca and Mg nutrients are all taken mass flow when water is taken up by plants. Due to the similar chemical properties of these elements, as well as some being taken up by the same processes for some, these nutrients can compete with one another.

Developing antagonisms

A nutrient antagonism is when an excessive concentration of one nutrient inhibits the uptake of another. Since K, Ca, and Mg have similar properties, and are taken up in a similar fashion, too much of one nutrient can inhibit the uptake of another nutrient. For example, if the concentration of Ca gets too high, it can impeded the uptake of Mg. Or if the K concentration gets too high, Ca uptake can be inhibited. The ideal ratio of K:Ca:Mg to each other in hydroponic nutrient solutions to avoid uptake varies a bit, but is usually 3 to 5 parts K and Ca to one part Mg (3-5K:3-5Ca:1Mg). However, this tends to vary with plants. For example, lettuce and leafy greens do well when Ca and K are balanced with each other, whereas fruiting crops do well with a greater proportion of K.

Antagonism-induced nutrient deficiencies can cause a variety of hydroponic food crop disorders, ultimately reducing productivity and marketability in crops. For example, a K deficiency in tomatoes can results in yellow shoulders, where fruits do not fully ripen. A Ca deficiency in tomatoes and peppers can result in blossom end rot and produces fruits with necrotic portions of fruit where the calyx or petals of the flower was attached, whereas Ca deficiencies in lettuce and other leafy greens can cause marginal necrosis or “tip burn” on leaves. Finally, Mg deficiencies cause chlorosis on leaves and, while commonly observed on tomato plants, it is most problematic for basil.

Creating and maintaining a balance

To keep K, Ca, and Mg in balance in nutrient solutions, the water, fertilizer, and pH adjusters used to make up and maintain nutrient solutions should all be evaluated. By starting out with the right proportions of K:Ca:Mg, and maintaining them throughout production, antagonisms and the deficiencies they induce can be avoided.

Check the quality of water used to make up the nutrient solution. Specifically, look at the alkalinity and hardness. If water alkalinity is high, there will be hardness. It is common for highly alkaline water to come from limestone (calcium carbonate) aquafers. Hardness is a measurement of the combined Ca and Mg of water and is expressed as equivalents of calcium carbonate. The Ca and Mg in water resulting from hardness will be available for uptake by plants, so it needs to be taken into account when formulating nutrient solutions together.

The next thing to consider is fertilizers- how much K, Ca, and Mg will be added to the water from fertilizers? This starts with fertilizer types. If a single-bag fertilizer is used, the proportion of nutrients to one another is fixed. If a two-bag fertilizer is used, there is some opportunity to adjust the concentrations of Ca and K with the calcium nitrate and the second bag with other macro- and micronutrient, respectively. Fertilizers mixed from individual salts are the most flexible, as there is no fixed proportion of nutrients with one another and all nutrients can be adjusted to hit target ratios.

Finally, look at how pH is adjusted. If acid is most frequently used to decrease pH, no K, Ca, or Mg is being added to systems as sulfuric or phosphoric acids are most commonly used and contribute sulfur (S) or phosphorous (P) to nutrient solutions. Alternatively, an alkali or base is added to increase pH, K concentrations may climb with their addition. Potassium carbonate or potassium bicarbonate are commonly used to increase pH, and K increases with their use.

The most proactive approach to managing nutrient antagonisms after mixing fertilizers is to perform regular nutrient solution analyses. When nutrient solution samples are submitted to a commercial laboratory for nutrient analyses, the concentration of each essential element in the nutrient solution is measured and adjustments in nutrient management can be made based on plant uptake and residual nutrient concentrations.

The take-home message

The relationship between K, Ca, and Mg is a unique one due to their interactions with one another. These nutrients are not only essential for plant growth, but their deficiencies can cause specific problems for hydroponic food crops. Avoiding antagonism-induced deficiencies is important for maintaining productivity and quality.

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