Product Information Bulletin

The Hurricane Hydroponics Comprehensive Nutrient Solution program provides calcium and magnesium during both the vegetative and flowering stages. But there are times when supplemental use of HURRICANE CAL-MAG may be beneficial or required to balance calcium, nitrogen, potassium, magnesium and iron levels to ensure optimum vegetative growth and reproductive maturity as well as to compensate for unexpected calcium, magnesium or iron mineral deficiencies experienced during crop development.

Hurricane Cal-Mag (3-0-0) is a carefully engineered calcium, magnesium and iron plant supplement formulated specifically to provide growers with the means to address mineral deficiency related disorders in hydroponic production systems -- providing the best opportunity for consistent performance and unparalleled results.

Growers involved with hydroponics are well aware that it is a production system that requires constant monitoring and adjustment. Nutrient requirements, input strategies and nutrient interactions are all a part of a successful nutrient solution strategy. The composition of elements in nutrition designed for hydroponics is quite different from that for soil. It is imperative that nutrients developed specifically for hydroponics be used in a hydroponic system.

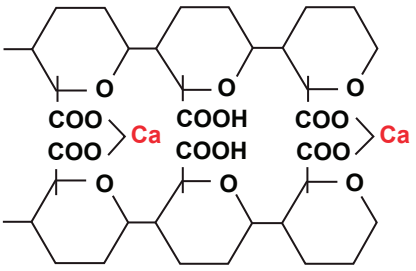
It is true that growers involved in hydroponics do not have to worry about the vagaries of nutrient availability from soil sources, but hydroponic crop production **dictates that the grower provide all the nutrients required to meet the changing demands by the plant throughout production.** Dealing with deficiencies and preventing excesses is an everyday experience in hydroponics. Let's examine two very important essential elements that are prone to become deficient -- **Calcium and Magnesium**.

Calcium

Role in Plant Development

Calcium is widely recognized as a critical secondary nutrient, necessary for the growth, stability and function of cell membranes. It is often referred to as a "glue" or "cementing agent" that binds adjacent cells together -- contributing to strong stems and leaves on all plants. Calcium also plays a role in activating enzymes and is considered essential for cell growth and division.

When calcium is taken up by the plant, it contributes to the formation of pectin (calcium pectate), the glue that binds cell walls together.



Calcium Pectate

This intercellular layer of glue-like material is a component of middle lamella. It is the first formed layer during cell division (cytokinesis) and is essential to the strength, stability, rigidity and function of plant vegetative and reproductive structural architecture.

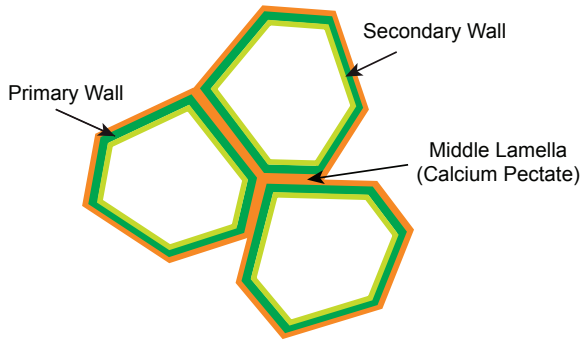


Illustration of location of calcium pectate in middle lamella of cell cluster.

Healthy vascular systems are dependent on calcium, allowing the plant to be able to take up water and all the other essential minerals more efficiently.

Once incorporated in cell tissue, calcium becomes immobile. Therefore a continuous supply of calcium is necessary throughout the plant's life cycle to participate in the strengthening of plant vascular systems, producing thicker stems and building new cell walls at the growing tips.

Calcium Deficiency

Because calcium is immobile in plant tissue, adequate levels of calcium are normally incorporated in most hydroponic nutrient strategies. A lack of calcium availability in nutrient solutions is normally not a principle cause of calcium deficiency.

Most problems with calcium deficiency are related to its physical transfer to sites within the plant. Indeed, calcium deficiencies are often manifested in tissues that have low relative rates of transpiration compared with other parts of the plant.

Calcium is present as a divalent cation (Ca^{2+}) in soil solutions or nutrient solutions. Ca enters the root along with mass flow of water (passive transport) and follows apoplastic (extracellular) or symplastic (intracellular) pathways to the xylem.

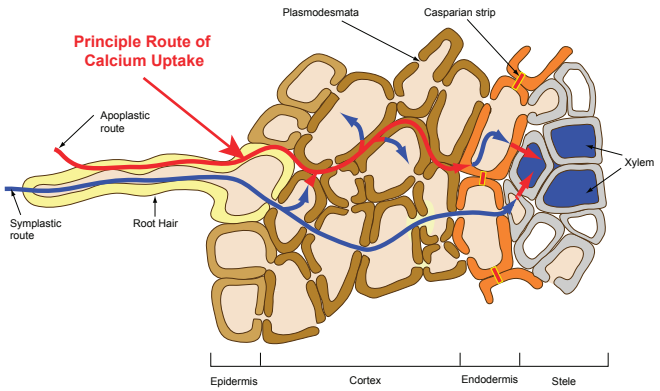


Illustration showing principle route of calcium absorption by plant root.

The apoplastic or symplastic pathways have distinct characteristics. The Ca^{2+} apoplastic flux is significantly dependent on the transpiration rate. Movement through this extracellular route usually depends on movement through weakened or developing casparian strips (used by the plant to block passage through the apoplastic route).

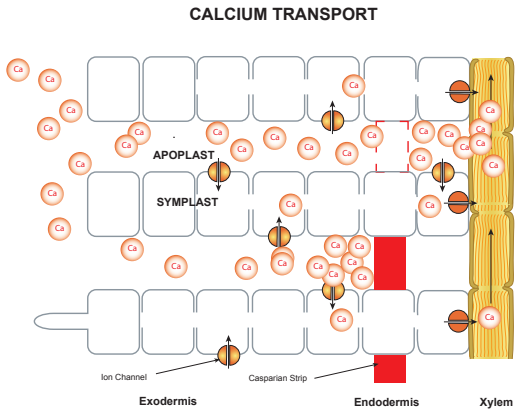


Illustration showing preference of Ca^{2+} for the apoplastic route to xylem. Note that grapic shows penetration through damaged casparian strip and blockage of Ca^{2+} where casparian strip is present. This forces slower entry via symplastic route.

The apoplastic pathway is relatively non-selective for divalent cations so competitive exclusion via this pathway by other cations is possible.

The symplastic pathway is more selective and controls Ca^{2+} transport into the xylem via transport channels that allow entry based on the demand for Ca^{2+} in the shoot, not mass flow.

It is likely that the proportion of Ca^{2+} transported via the symplast is much lower than that of the apoplast.

Since calcium ions are transported principally in the xylem, any factor which either influences calcium's route to the xylem (primarily via the apoplast) or the transpiration flow through the xylem tissues themselves will affect calcium nutrition.

Plant physiologists point to the competitive effects of a high concentration of other cations in the apoplast as a likely cause of calcium deficiency disorders. High levels of potassium, sodium, magnesium or ammonium in the solution have been identified as cations that can compete with calcium for space in the apoplast and lower entry levels of calcium in the xylem.

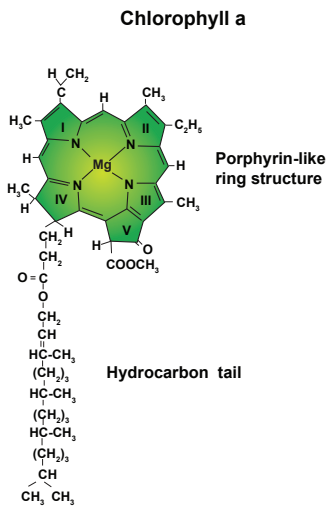
Stress factors such as salinity, low root temperature or excessive humidity can reduce transpirational flow and reduce transportation of Ca2+ to plant demand sites.

Inert substrates such as coco-coir, soilless mixes, etc. or using reverse osmosis water can also contribute to calcium deficiencies

Magnesium

Role in Plant Development

Magnesium plays two very essential roles in the processes of photosynthesis and carbohydrate metabolism.



Magnesium is needed by plants to form chlorophyll. It is the central ion of the chlorophyll molecule. It therefore has a primary role in the light collecting mechanism of the plant and the production of plant carbohydrates (sugars).

A chlorophyll molecule has a hydrophobic "tail" that embeds the molecule into the thylakoid membrane. The "head" of a chlorophyll molecule is a ring called a porphyrin. The porphyrin ring of chlorophyll, which has a magnesium atom at its center, is the part of a chlorophyll molecule that absorbs light energy.

Magnesium is also involved in the capture of the carbon dioxide that provides the carbon for glucose manufacture.

It helps activate the enzyme ribulose-1,5-biphosphate carboxylase oxygenase (RuBisCO), which catalyses the incorporation of carbon dioxide into molecules that are involved in photosynthesis.

Magnesium serves as an activator in carbohydrate metabolism. Magnesium activates more than 300 known enzymes in plant cells, including enzymes that load sugars for transport throughout the plant.

Magnesium's ability to activate metabolic enzymes is critically important during crop production as it is used to satisfy carbohydrate energy needs of the plant are elevated (increased respiration) during periods of rapid vegetative growth and during flowering and heavy fruiting.

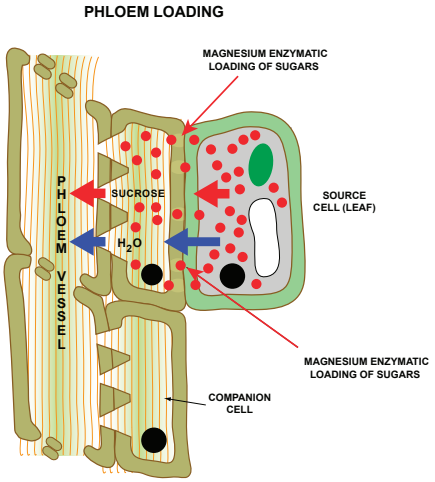


Illustration showing magnesium actovated enzymatic loading of source cell sugars into companion cells for movement to other parts of the plant via phloem vessels.

Magnesium Deficiency

There are interactions between $Mg2^+$ and other ions that can impact plant availability. High K^+ and Ca^{2+} levels have been shown to lower Mg^{2+} availability in plants.

In addition to competing for apoplast binding sites, K^+ can compete against magnesium for ion channel entry ways. Ammonium (NH_4), and sodium (Na^+) have also been identified as potential competitors to magnesium absorption.

Magnesium deficiency disorders can manifest themselves as plant growth inhibition, acceleration of aging, reduced productivity and diminished quality.

Magnesium deficiency disrupts the loading of sucrose into phloem, resulting in carbon accumulation in source leaves. It also reduces carbohydrate metabolic enzyme activation that further leads to carbon accumulation in source leaves. Over accumulation of carbon in source leaves in turn, leads to feedback inhibition of the photosynthesis rate and reduces chlorophyll concentration.

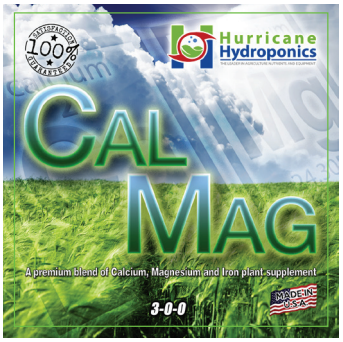
Impairment of photosynthetic CO_2 fixation also leads to an accumulation of unused electrons in the chloroplast, resulting in ROS generation and photo-oxidative damage to chlorophyll and chloroplast membrane lipids.

Unlike calcium, magnesium is a mobile element. If a deficiency is detected, magnesium is moved from older leaves to new leaf sites. So magnesium deficiency is normally observed in older, bottom leaves.

Inert substrates such as coco-coir, soilless mixes, etc. or using reverse osmosis water can also contribute to magnesium deficiencies.

Hurricane Hydroponics

CAL-MAG



Successful hydroponic crop production is dependent on maintaining proper plant nutrition. Base nutrient systems go a long way at achieving this goal. But growing conditions, nutrient uptake and plant responses can change throughout plant development creating elemental deficiencies.

The Hurricane Hydroponics Comprehensive Nutrient Solution program provides calcium and magnesium during both the vegetative and flowering stages. But there are times when supplemental use of **HURRICANE Cal-Mag** may be beneficial to correct or prevent nutrient deficiencies as well as to compensate for calcium draw from different media such as coco coir fiber.

Hurricane Cal-Mag Plus is a specialty supplement designed to provide growers with the ability to introduce a balanced nutrient solution with optimized ratios of calcium, magnesium, nitrogen and iron into vegetative and flowering stages of plant growth -- ultimately increasing yield during flowering or plant maturity.

Hurricane Cal-Mag is formulated to properly balance the calcium to magnesium ratio so excessive magnesium doesn't accumulate in leaves and become toxic to plants.

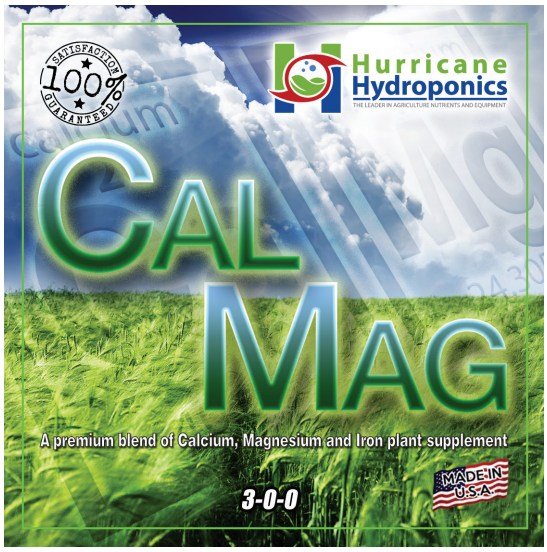
HURRICANE CAL-MAG can be used throughout all stages of plant growth and development and can be used with any nutrient brand.

HYDROPONIC/SOILLESS MIXES USE

Normal: Use 2 ML per gallon of water.

Aggressive: Use 4 ML per gallon of water.

Additional information and suggested usage charts are available at www.hurricanehydroponics.com.



Give your crops a chance to show what they can do.

All Hurricane Hydroponics' nutrients and supplements comply with AAPFCO standards.

Hurricane Hydroponics
THE LEADER IN AGRICULTURE NUTRIENTS AND EQUIPMENT

WWW.HURRICANEHYDROPONICS.COM
1.888.358.5278
SUPPORT@HURRICANEHYDROPONICS.COM