Calcium Nutrition in Plants

FACT SHEET

Calcium in plants is quite similar to calcium in people – it is essential for good growth and structure. Calcium does not move easily throughout the plant, once it is incorporated into cell walls, it does not move out again. The health and integrity of the cell membrane is very critical to the survival of the plant and it is well understood that cell membrane cannot be maintained without adequate supply of calcium. If the level of Ca associated with the membrane is reduced the membranes become leaky resulting in the loss of cell compounds and eventually death of the cell and plant tissue.

Calcium is not only an integral component of the cell wall but also is the glue that holds cells together in pectin linkages between cells. Calcium in addition to its role in cell structure also plays a role in regulating various cell and plant functions as a secondary messenger. This function as a secondary messenger assists in various plant functions from nutrient uptake to changes in cell status to help the plant react to the impact of environmental and disease stresses.

As a divalent cation (Ca^{2+}), it is required for structural role in the cell wall and membranes, as a counter-cation for inorganic and organic anions in the vacuole, and as an intracellular messenger in the cytosol. Calcium moves by mass flow and is taken up by roots from the soil solution and delivered to the shoot via the xylem.

Soil pH and Plant Calcium Needs

Adjusting soils pH based on soil test is basic in soil fertility. Without adequate soil pH nothing else works properly in regards to plant nutrient uptake and plant nutrition. However it should not stop at this, as soil pH alone is not always the best indicator of soil calcium levels. In many cases soil tests that have a pH above 6.2, a buffer pH is not performed on the soil. In the case of a crop that requires calcium for quality, total calcium availability is more important than soil pH.

The ideal %saturation for Ca should be around 70% for most crops and even at that level some crops will require more calcium. A soil that has C.E.C. under 7, a pH of 6.4 and a buffer pH of 6.9 would only have %Ca of around 60% which would not be adequate for most specialty crops. Soils with C.E.C. between 7 and 15 with buffer pH of 6.9 would have % calcium of 70%. Soils with C.E.C. greater than that would need pH around 6.6 to 6.7 to have adequate calcium supply. These soils with a buffer pH of 6.9 would only have about 65% calcium, which would not supply enough calcium in many cases.

In the case of many soils pH is elevated by more than Calcium. Mg for example will elevate pH more than calcium and in some cases where pH looks good the calcium is deficient for good crop performance and calcium availability.

Maintaining the proper balance between calcium and magnesium requires understanding the difference between soil types and predictable availability of the cations. In soils with C.E.C. < 7 a Ca:Mg in meq. should be 3:1; and in soils with C.E.C. between 7-25 Ca:Mg in meq should be 5:1; and soils with C.E.C. > 25 Ca:Mg

A & L CANADA LABORATORIES, INC.

2136 Jetstream Rd.
London, ON N5V 3P5

Phone: 519-457-2575
Fax: 519-457-2664
Aginfo@alcanada.com
www.alcanada.com

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in meq should be 6:1. Always maintaining a K:Mg in meq between .2-.35 which is not always that easy.

This understanding of Ca:Mg helps identify many production issues with crops that are paid for based on quality and shelf life more than total yield.

In many cases correcting these levels of K,Mg, and Ca becomes difficult and it becomes a matter of managing these soils. One such management of such soils often requires low-level application of calcium materials to supply calcium regardless of pH.

Calcium as a Secondary Messenger

Calcium also plays a role in the plant very similar to a hormone in the regulation of various cell functions. One such function is in the regulation of the protein pump that regulates the uptake and movement of nutrients into the root and throughout cells within the plant. This process is called facilitated diffusion and is the means by which the majority of all nutrients are taken into the plant. In this process calcium stimulates the enzyme calmoldulin, which activates the protein pump that is involved in this process of nutrient uptake. Also auxin-regulated cell elongation seems to require Ca^{2+} as a secondary messenger. (*Marschner*).

Calcium and Photosynthesis

In the chlorophyll molecule, embedded in the protein is a catalytic centre of photosynthetic water oxidation, which is composed of a Mn_4Ca cluster. As light is absorbed, this catalytic centre drives the photosynthesis process.

Calcium and the Aluminum Connection

Calcium as mentioned already is important for a number of life processes within the plant. At the root level stimulation of the protein channels that take up nutrients in facilitated diffusion, calcium is the secondary messenger that activates this process. Adequate availability of Calcium at the root surface is required for this process to work effectively. The mucilage that is secreted by the root cap is high in calcium and endogenous regulators of extension growth, which aids in facilitated diffusion. Aluminum toxicity (greater than 400 ppm.) attacks the root cap reducing the secretion of mucilage and disrupting both the cytoplasmic calcium and the calcium in the mucilage.

Raising pH reduces the amount of Al that is released and made available to the root, or using calcium materials close to the root such as gypsum will reduce the aluminum toxicity.

Aluminum plays an even greater role in total cation disruption. Aluminum not only disrupts the availability of Ca but also Mg however it does not interfere with K, except for reducing root efficiency.

In crops such as potato where Mg is important for quality such as total solids aluminum will reduce available Mg increasing potential for early die and poor uptake of P. Also by not interfering with K uptake, the K:Mg relationship in the plant could reduce total solids.

In forages, which have a feed quality issue with K:Mg, Al interfering with the uptake of Ca and Mg and not K leads to an increase in K/(Ca+Mg) ratio in shoots. This increases not only the risk of a calcium or magnesium deficiency or both but also the potential risk of grass tetany in ruminants. Alfalfa is a luxury consumer of K and will be taken up by the plant even with low levels of K availability in soils. When Ca and Mg are in balance, and good yields are achieved and if the K:Mg ratio is maintained this condition is not a problem.

As a part of the A&L Canada soil test Al levels are part of the basic test. An Al level of greater than 400 ppm. begins to create problems with Al toxicity to plants and the tie up of P in some soil types. Buy far for total improvement of soil health, liming to reduce aluminum is the best long-term solution.

Calcium and Heat Stress

Heat stress in general tends to increase stem length while reducing leaf size and area in a number of crops. As temperatures increase beyond 34^o Celsius for most crops net photosynthesis declines. Calcium is able to mitigate heat stress effects by improving stomatal function and other cell processes. Calcium is also believed to have an influence on the development of heat shock proteins that help the plant tolerate the stress of prolonged heat.

Calcium and Disease

In plant nutrition calcium is often referred to as the plants first line of defense. Many organisms that infect plants do so by penetrating the cell tissue with enzymes known as pectinase, which dissolve pectin's. The higher the calcium content in plants the higher the concentration of pectin's holding cells together and the greater the ability to withstand these enzymes. In some cases the pectinase that the pathogen secretes is oxalic acid, which sequesters calcium from the leaf to form calcium oxalate. In these cases increased calcium levels in leaf tissue or calcium foliar applications can greatly decrease the pathogens ability to invade the leaf.

Adequate levels of calcium in plants also aid in the plants ability to isolate an infection by suberifying the infected area. This is a process called Demarcation or the ability to isolate the point of infection by suberification as a reaction to the wound.

Calcium and Crop Quality

It has long been understood that calcium plays a major role in the quality of many crops. The following is a list of some of those crops where calcium has a big impact on the quality and shelf life.

Crop	*Symptom*
Apples	**Bitter pit**
	Cork spot
	Cracking
	Internal Brownspot
	Low-temperature Breakdown
	Senescent breakdown
	Water core
Beans	**Hypocotyl necrosis**
Brussel Sprouts	**Internal browning**
Cabbage	**Internal tipburn** **Club root**
Lettuce	**Tipburn**
Carrots	**Cavity spot**
Celery	**Blackheart** **Tipburn**
Onions	**Soft rot** **Botrytis**
Strawberries	**Botrytis**
Pears	**Corkspot**
Peppers	**Blossom end rot**
Potatoes	**Internal browning** **Hollowheart** **Storage disorders** **Low solids** **Skin quality**
Tomatoes	**Blossom end rot**
Watermelon	**Blossom end rot**