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Calcium and Manganese Deficiency

Calcium and Manganese are two soil abundant elements that are often not as plant available and may be deficient in plant cells. Calcium is used in cell wall membranes and often becomes limiting during critical pollination periods when cells are rapidly dividing. Manganese is used in photosynthesis to split the water molecule (H_20) into H^+ and OH^-.

Grain and fruit size are determined by calcium after pollination. The cell division process proceeds rapidly, lasting 5-40 days but most grain crops have a 10-14 day cell division window. Cell division occurs exponentially (2-4-8-16-32-64 etc.) as cells divide so calcium may become deficient quickly after pollination. After cell division, grain or fruit fill occurs as the cell is filled with proteins, sugars, and water. A lack of calcium can limit cell division, grain or fruit size, and reduce yields.

Blossom end rot in tomatoes is an example of a common calcium deficiency but the same concept applies to grain and fruit crops. Calcium generally is not soil limiting; however, poor calcium plant absorption may be due to high soil potassium, low boron, and/or low manganese. To evaluate boron and calcium deficiency, look for the "zipper" effect on leaves. Slightly pinched indentations (zippers) is on the edge of leave indicate boron is lacking to move calcium to the middle of the leaf. A zipper in the middle of the leaf indicates calcium deficiency in plant cells. As plants grow rapidly, start looking for these signs.

Calcium applications need to be timed for peak crop demand. For fruit trees, the best time to apply gypsum (calcium sulfate) or limestone (calcium carbonate) is in the fall not spring so that it is plant available. For grain crops, the 4R's for gypsum are right rate: 200-300#/A, right place: broadcast, right source: quarry gypsum or wallboard grade without metal contamination, and right time: 30-45 days before pollination on corn and soybeans. Microbial activity makes these nutrients plant available with adequate moisture and warm temperatures.

Soil manganese levels are generally high but may not be plant available. People often confuse manganese (a micronutrient) with magnesium (a secondary macronutrient). Poor soil health or low microbial activity along with high applications of glyphosate (chelates or ties up manganese) can reduce plant available manganese When plants absorb water, manganese splits the water molecule for optimal photosynthesis. Sunlight supplies the energy, carbon dioxide supplies the

back bone for sugars and proteins, chlorophyll is the mechanism for making the transformation, and then water is split by manganese to keep the process of photosynthesis humming along for optimal yield. Carbon dioxide and a lack of manganese often limit photosynthesis to 10-20% of optimal levels.

Many plants are manganese deficient which is common in soybeans under dry conditions. Soil manganese(Mn^{2+}) is the most plant available at a soil pH of 5 to 7 but gets tied up in alkaline soils where pH is greater than 7 (neutral). The easiest way to observe manganese deficiency is to observe the plant leaf veins. If the veins are yellow or light green compared to the space in between the veins (interveinal space), manganese may be deficient at low levels. Healthy plants have vibrant green plant leaves and the veins should be the same color as rest of the interveinal leaf space. Plant tissue analysis at 21-40 parts per million (ppm) are adequate with levels below 21 ppm considered deficient and fertilizer applications of .2 to .5#/A manganese can be foliar applied.

Improving soil health is a way to make manganese plant available. In corn and soybean rotations, the lack of plant diversity and over use of some pesticides (glyphosate) promotes oxidizing microorganisms like *Fusarium* that can limit manganese availability. Beneficial soil microbes for manganese reduction to a plant available form (Mn^{2+}) include *Bacillus, Geobacter,* and *Pseudomonas* bacteria (Syvia et al. 2005). A diversity of cover crops enhances microbial activity that can limit the oxidizing soil microbes. Cover crop species like oats, sorghum species, and flax greatly enhance mycorrhizal species that can efficiently move not only phosphorus but many other micronutrients (zinc, copper, manganese) to plant roots for absorption. Maximizing cell wall division by having adequate calcium and maximizing photosynthesis with adequate manganese for optimal photosynthesis are all important in getting the highest yield. The following information was synthesized from two articles written by John Kempf.