

Site-Specific Nutrient Management

For Nutrient Management Planning To Improve Crop Production, Environmental Quality, and Economic Return

Presentation Script: Calcium and Magnesium - Chapter 6

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... and justice for all

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Calcium and Magnesium Management

Slide 1.

This module will cover the most important concepts of calcium and magnesium management in agricultural systems to provide for profitable crop production. Since it is impossible to go through specific scenarios for all regions of the U.S., general concepts regarding calcium and magnesium management will be presented. Even though these principles apply for most regions, viewers are encouraged to review locally developed recommendations for these nutrients.

Slide 2.

Calcium and magnesium are considered secondary nutrients because they are less commonly yield limiting than the macronutrients and less frequently require fertilization. Yet, they are required by crops in relatively large amounts. Calcium and magnesium occur in the soil as soluble divalent or double-charged cations, on cation exchange sites, and in primary minerals. The major processes in calcium and magnesium cycling are plant uptake, exchange, precipitation, weathering, and leaching. Calcium and magnesium dynamics in the soil are quite similar to potassium. Like potassium, plants absorb the soluble ionic forms from soil solution, which is then replenished from exchangeable and mineral calcium and magnesium. The most notable difference between the calcium and magnesium nutrient cycles and potassium is the absence of clay fixation with calcium and magnesium.

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Calcium is essential for plant growth, cell division, and cell enlargement. It is a component of cell membranes and is important for developing the plant's root system, shoot tips, and storage organs. Calcium aids in pollen development and helps plants retain foliage. Calcium strengthens cell walls, helping to reduce bruising and plant disease. An adequate supply of calcium produces food crops which are less susceptible to handling damage and have a longer shelf life. Fruit and vegetables will also have a higher nutritional value. Crops deficient in calcium can have growth disorders. Since calcium does not move readily within the plant, calcium deficiencies appear in the growing points and younger tissues. Calcium deficiencies may result in the death of the plant's growing point. It may also cause blossoms and buds to drop prematurely.

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Calcium is usually the dominant basic cation in soil cation exchange reactions, typically accounting for more than 70% of base saturation. Base saturation represents the percentage of the cation exchange capacity occupied by basic cations, and increases with increasing soil pH. Exchangeable calcium exists in equilibrium with the soil solution, and it replenishes soluble calcium used during plant uptake or lost by leaching. Low exchangeable calcium content in the soil often causes acidity problems due to low base saturation before actual calcium nutrient deficiency becomes an issue. Where soil acidity is a problem, liming soils with limestone is a common practice and thus supplies plant available calcium. Because of its divalent charge, calcium acts as an ionic 'glue'. Calcium's electrostatic attraction with negatively charge clay particles promotes aggregation of soil particles through a process called flocculation.

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Magnesium plays a critical role in nearly all parts of plant metabolism and protein synthesis, is an activator of enzymes, and an essential constituent of chlorophyll. It also aids in the formation of sugars, oils and fats. Deficiency in magnesium leads to reduced photosynthesis, which limits crop yields. Plants require less magnesium than calcium, but deficiencies are more common because less magnesium exists in the soil solution and on the soil exchange complex. Magnesium deficiency usually appears on older plant leaves first; the leaf tissue between the veins turns yellow or reddish in color, while the veins remain green. Severe deficiencies will cause leaf margins to curl.

Slide 6.

Mineral forms of magnesium are relatively resistant to weathering and represent a large fraction of total soil magnesium. Magnesium can also be present in calcareous surface and subsurface soils as magnesium carbonate, which frequently occurs along with calcium carbonate. Although calcium and magnesium share the same exchange processes, magnesium sorbs less strongly than calcium to soil colloids and therefore is more prone to leaching, particularly in sandy soils. As a divalent cation, magnesium competes with calcium, potassium, and ammonium for plant absorption and cation exchange sites. As with calcium, magnesium helps with soil flocculation and soil structure, but to a lesser extent. Magnesium deficiencies generally occur when the other cations dominate the soil exchange complex along with low magnesium concentrations. A magnesium deficiency problem in cattle is called grass tetany. This deficiency is due to

insufficient magnesium in forage fed to livestock. Often feeds are supplemented with magnesium salts to supply adequate magnesium. In soils with low available magnesium, lime application to acidic soils often supplies adequate magnesium, except when the form used is pure calcitic lime. Fertilizers such as potassium-magnesium-sulfate and epsom salt can be applied if soil pH is already at adequate levels.

Slide 7.

The figure shows calcium and magnesium quantities in the harvested portions of common agricultural crops. The amounts increase with harvest of forages and crop residues compared to grain.

Slide 8.

An often used approach for determining if the soil supply of calcium and magnesium is sufficient to meet crop needs is soil sampling and extraction with ammonium acetate or Mehlich-3, and then evaluation of the amount measured against critical levels. Because most U.S. soils contain more than adequate levels of calcium and magnesium for most crops, no generally accepted critical level has been established. Therefore, although an estimate of exchangeable calcium and magnesium sometime is routinely measured, many universities do not publish soil test calcium or magnesium interpretations. There are exceptions, and an example is calcium testing for potato production due to issues with tuber density. Another example would be soil testing to help avoid development of grass tetany, where knowledge of soil test magnesium and potassium would be useful especially when high rates of potassium are needed. Soils typically have large available levels of both nutrients because calcium and magnesium are replenished by limestone application, and soils with free lime (carbonates) will have natively high levels. If someone is interested in the soil cation exchange capacity level, then routine soil testing can be used to estimate cation exchange capacity by summing the dominant exchangeable cations. However, the calcium to magnesium ratio is not a viable basis for fertilization with calcium or magnesium. Having sufficient levels of exchangeable calcium and magnesium (through soil testing) is the proper method of evaluation.

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Calcium and Mg sources should be applied prior to or at planting time. Generally, in-season applications of Ca and Mg are not recommended for most crops. Broadcast with or without incorporation is the most frequent way of applying these nutrients, especially when using lime as

Ca and Mg sources. Banded applications with the planter can also be used but only at lower rates to correct slight deficiencies.

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Application of calcium and magnesium occurs most commonly through liming practices. In production agriculture and the limestone trade there is no widely accepted definition regarding limestone types, however, limestone containing $> 70\%$ CaCO_3 is usually referred to as calcitic and that containing 10% or more MgCO_3 is considered dolomitic. For either type, the remaining carbonate material is CaCO_3 or MgCO_3 . With limestone classified as either calcitic or dolomitic, there is application of both calcium and magnesium as these are contained in all limestone materials. Therefore, as long as acidic pH problems are corrected through liming, calcium and magnesium supply will be maintained and at amounts more than removed with crop harvest. Once removal has occurred with years of crop production, and with concurrent low soil pH, liming once again supplies needed calcium and magnesium. Soils that have naturally high pH in the neutral to basic pH range, and those with free calcareous lime, have more than adequate levels of these nutrients.

Slide 11.

The table presents the most common limestone and fertilizer sources of calcium and magnesium.

Slide 12.

Secondary nutrients such as calcium and magnesium are no less essential to plant growth than the primary nutrients. However, the mineralogy and texture of many U.S. soils maintain high levels of available calcium and magnesium. An exception would be sandy soils in association with fertilization need of certain crops, for example potato, or interaction with application of other nutrients like potassium. Because plants require relatively small amounts of these nutrients and leaching is a minor loss, calcium and magnesium deficiencies are rare but do occur in specific soil conditions and crops. In addition, liming soils to neutralize acidity and increase soil pH also add plant available calcium and magnesium, thus reducing the probability of deficiency and need for fertilizer application.