Nutrient Profile: Calcium

By Dr. Doug Soldat, *Department of Soil Science, University of Wisconsin-Madison*

Rising fertilizer costs and declining budgets have led many superintendents to take a second look at the efficiency of their fertility program. This article focuses on the function of calcium in soils and plants. The information will be useful to golf course superintendents for making choices about when and how to make the most efficient use of calcium given the plethora of products and management options available today.

Functions of Calcium in Plants

Calcium is found in turfgrass tissue in concentrations ranging from 0.2 to 1% of dry weight, similar to plant levels of sulfur, magnesium, and phosphorus. A large proportion of that amount is found outside the cell wall and provides a structural role by linking pectin chains together like cross bracing in a building frame. When the plant decides to expand a cell, it decreases the calcium concentration outside the cell which loosens the pectin chains allowing the cell to grow. After cell expansion, the plant will transport more calcium to the cell wall to re-solidify the pectin chains. It is easy to distort this information by saying something like: "the more calcium that is available to the cell the stronger the cell walls become." Obviously, if calcium is *deficient* in the plant, applying calcium would likely improve the integrity of cell walls. However, if a *sufficient* supply in the soil is available, cell walls will not continue to strengthen as more calcium is applied.

Calcium has a much different role inside the cell than on the outside. Inside the cell, calcium concentrations are kept very low. This is because calcium acts as a messenger within the plant and plays a very important role in triggering certain reactions. A recent example of how calcium is used as a signaling molecule in plants was described by Du et al. (2009). These researchers reported that calcium binds to a specific protein (calmodulin) to form a compound which triggers the formation of salicylic acid which is known to increase disease resistance but decrease growth. The popular press reported this story under the headline "In fight against pathogens, calcium helps plants make their own aspirin". While technically correct, this headline gives the impression that adding calcium to plants increases their disease resistance. The scientific report did not study the effects of adding calcium to plants on disease resistance; rather the researchers used genetic tools to determine that calcium plus a calmodulin protein was the compound that signaled the plant to produce aspirin (salicylic acid).

The question remains: Can applications of calcium to turfgrass increase disease resistance or stress tolerance? There is very little research that attempts to answer this question. The only study on this topic I was able to find was published by Jiang and Huang (2001). These two turfgrass researchers found that Kentucky bluegrass and tall fescue treated with calcium in the greenhouse had increased levels of antioxidants and greater turf quality during a period of prolonged drought stress. They applied 400 mg/L calcium (from $CaCl_2$) in a liquid solution to the leaves for three days in a row. The plants were not mowed. While this work is promising, no field research has duplicated these results.

Functions of Calcium in Soils

Another common reason to apply calcium relates to soil physical properties. It is well known that high levels of sodium will cause soil particles to disperse resulting in essentially chemical compaction of the soil. The only solution to alleviating this problem is to apply calcium to displace the sodium ions and return the soil to an improved condition. However, sodium problems are very rare in this part of the US, and usually associated with areas where road salt runoff is a major issue in the spring. However, golf courses irrigated with treated wastewater often have elevated soil sodium levels, and for these courses, using calcium (gypsum) is a vital management technique. It is easy to misrepresent this information by stating that calcium applications will improve soil structure and infiltration. This is only true if there is a high level of sodium in the soil prior to the calcium application. If sodium levels are below 5% of base saturation, adding calcium will not improve soil physical properties.

There is a widespread soil testing philosophy called the Base Cation Saturation Ratio. This philosophy argues that there are ideal ratios of calcium, magnesium, and potassium in the soil; and having the ideal ratio provides benefits to the physical and biological health of the soil. There is no scientific evidence to support this claim in agriculture (Kopittke and Menzies, 2007) or in turfgrass (St. John and Christians, 2007). Often the result of following such a philosophy is the continual application of calcium, magnesium, and potassium in a futile effort to achieve the "ideal" cation balance.

Managing Calcium in Plants and Soils

Often soil testing is the first step for making management decisions about potassium and phosphorus. Calcium is usually reported on a soil test, but really one only needs to look at the pH to determine if calcium will be sufficient in the soil. Some soil test reports call undue attention to calcium levels or calcium saturation in the soil. For example, I viewed a soil test report from a sand green that noted that exchangeable calcium levels were high and that calcium availability is likely low. This is complete nonsense! Exchangeable and available are synonymous; if exchangeable levels are high, availability is high. The same report went on to claim that soluble calcium levels are lower than desirable and this was because calcium reserves in the soil are inadequate. Even more unbelievable! The exchangeable level that was just previously deemed too high is the "calcium reserve" for solution Ca which is now being deemed "inadequate". The higher the soil exchangeable calcium, the higher the soluble calcium in the soil will be. This is basic soil science but apparently some soil testing outfits have ulterior motives that conflict with science. My advice is to avoid over-interpretation of soil test results. If pH is below 5.5, apply lime. If pH is above 5.5, do not worry about the availability of calcium to the turf.

Let's imagine that the company that provided this soil testing masterpiece went on to recommend the application of a liquid calcium chelate. The chelate contains 8.0% calcium and the label recommends it be applied at 6 oz/M. If we push a pencil for a minute, we find that this rate will apply 0.038 lbs Ca/M. If your irrigation water contains 70 mg/L Ca (a common value for most of southern and eastern WI), then this amount of calcium will be applied with 0.1 inches of irrigation. Continuing to push the pencil around, we also find that there is the same amount of calcium in the water a 150 gallon spray tank as in the product that is added to the water in the tank. To pile it on, rainfall adds 0.8 lbs Ca/M each year in this region. Therefore, it doesn't make sense to spend a lot of money to make calcium applications this small. Future research may find that these small applications can improve stress tolerance in field situations, but right now we don't have the data to justify these applications.

In summary, the best ways to manage calcium are:

1. Keep soil pH >5.5 by applying lime as needed
2. Apply gypsum when sodium levels exceed 5% of the base saturation (this is a conservative level)
3. Foliar applications of calcium may be beneficial during stressful conditions, although field confirmation is lacking.

Other points to remember when considering making a calcium application are:

1. Application of most liquid calcium products result in a very small dose of calcium
2. Most irrigation water in Wisconsin contains a lot of calcium and annual inputs from irrigation and rainfall are about 2-3 lbs Ca/M.

References

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