4R nutrient stewardship

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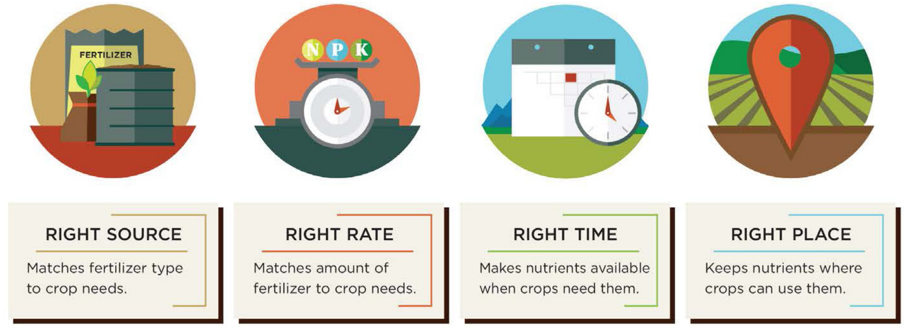

Calcium: Improved plant health and nutrition

through 4R management

Calcium is an important nutrient for all crops. Soil calcium concentration and availability to crops is influenced by pH, CEC, soil type, and the concentration of other minerals in the soil. The solubility of the calcium source is important to consider when making a calcium application. The source, rate, timing, placement, and environmental conditions must be considered to implement the 4Rs for improved plant performance, yield, and crop quality. Earn 0.5 CEUs in Nutrient Management by reading this article and taking the quiz at www.certifiedcropadviser.org/education/classroom/classes/696.

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In the 1958 first edition of *Soil Fertility and Animal Health*, the author called calcium "the premier of the soil's nutrient elements," noting the importance of calcium for production of proteins, protection against microbial pathogens, cellular growth, and plant reproduction. Specifically, calcium provides stability and rigidity of plant cell walls and is essential for root development and function (St. John et al., 2013). Dicotyledonous plants (like cotton and soybeans) have a greater calcium requirement (0.5 to 2.0% of dry matter; St. John et al., 2013) than monocotyledonous (corn and grasses) plants (0.3 to 1.25%) and are therefore more likely to exhibit calcium deficiency and disorders. Generally, calcium has low mobility in plants since it becomes a component of cell walls and membranes. Visual deficiency symptoms occur at the new growing points for both roots and shoots. Additionally, poor leaf canopy, bud development, or the shedding of blossoms result without available calcium.

Calcium concentration in the soil varies depending on soil type and mineralogy. Crops grown on sandy soils with low cation exchange capacity (CEC) are more likely to exhibit calcium deficiency although calcium deficiency can occur in all soils. The availability of soil calcium is

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related to the calcium concentration from the soil CEC and the soil pH, which can influence calcium availability from mineral sources like calcium carbonate. When creating a calcium management program, it is important to know not just the soil's calcium content, but also the solubility of the calcium entering the soil solution for root uptake. Insoluble calcium sources may not meet the needs of the plant if the soil pH is not acidic.

Calcium deficiency in tomatoes (**above**) and corn (**right**).

Sources of calcium

Calcium is present in some fertilizers and soil amendments. However, calcium sources have a wide water solubility range, and as a result, differ in plant availability. Common sources of calcium like lime (calcium carbonate) and gypsum (calcium sulfate) have low solubility, and the calcium becomes available to the plant over a long period of time, months to years, depending on particle size of the material applied. Other sources like calcium nitrate or calcium chloride are highly soluble and available for crop uptake immediately (Easterwood, 2002). In high-value tree and vegetable crops, there are specific growth stages that require calcium uptake; therefore, soluble calcium sources are applied. Generally, calcium nitrate is soil-applied as a dry fertilizer or fertigated as a fluid fertilizer. Calcium chloride is mainly a foliar-applied source.

Crop health and calcium

Cell wall structure depends on available calcium. Without adequate calcium, cell membrane structure, function, and integrity can be lost and influence nutrient and water uptake by the roots (Palta, 1996). Increasing the calcium concentration in onions, apples, pears, and potatoes has been shown to increase crop quality, reduce plant disease and the impact of environmental stress, and limit development of diseased tissue during storage (Palta, 1996; Raese and Staiff, 1990). In onions, it was found that increased plant calcium concentration increased freeze tolerance and decreased leaking of potassium from cells (Palta, 1996). However, as with any nutrient application, the response of the onion crop depends on soil type and calcium availability in the soil prior to application.

Calcium can be supplemented to fruit trees as a foliar application or applied to the soil. Soil-applied calcium is assimilated by tree roots, shoots, and leaves, but depending on application rate and timing, more calcium can be used for the fruit. The calcium uptake for apple fruit occurs in a narrow window where 90% of uptake occurs four to six weeks after bloom. Given this short period of time, calcium for fruit uptake is often supplemented by foliar application of calcium sources, such as calcium chloride.

Does soil-applied calcium perform favorably for the tree and fruit? Results from a five-year study were published in the *Good Fruit Grower Magazine* (Raese, 1995) where ammonium nitrate fertilization of apple trees was compared with calcium nitrate. The calcium nitrate trees produced 11.4 boxes of fruit per tree, and the ammonium nitrate produced 10.3 boxes per tree. Agronomically and economically, adding calcium with a nitrate nitrogen source was favorable with the same rate, timing, and placement. Earlier research on apples and pears reported that tree vigor was higher with the soil application of ammonium nitrate and the incidence of fruit disorders was decreased when calcium nitrate was applied as the nitrogen source (Raese and Staiff, 1990).

4R management of calcium for potatoes

Research has established that calcium can be taken up by the potato plant roots and potato tuber roots. Increasing calcium concentration in the tuber is related to increased tuber quality (Kleinhenz et al., 1996). Here are some 4R guidelines to consider in addition to the solubility of calcium sources, differences in the response of potatoes based on variety grown, and the ability of the plant to take up calcium through multiple pathways.

Source and rate

As mentioned above, there are a variety of calcium sources with varying levels of solubility. Lime, one of the most common calcium sources, and often applied to increase soil pH, can be a source of calcium for potatoes. However, it should not be used to correct in-season calcium deficiency; it is only suitable for building soil calcium over time in soils with sufficient capacity. When calcium is applied in season or through fertigation, a more soluble form of calcium should be used, such as a calcium nitrate (Palta, 1996). Research has demonstrated that the calcium concentration in potato tubers can be increased even in soils that contain sufficient calcium concentrations for potato plant growth (Kleinhenz et al., 1996; Palta, 1996). In these soils, soluble calcium rates that resulted in an increase in potato tuber calcium concentration and reduced tuber imperfections and diseases ranged from 100 to 200 lb/ac (Kleinhenz et al., 1996; Palta, 1996).

Timing

When considering timing of calcium application for potatoes, it is important to remember that tuber bulking occurs late in the season and that soil type influences availability and the length of time it remains in the soil. In sandy soils, calcium can be leached into the soil and out of reach by the tubers due to irrigation or rain if applied too early in the season (Palta, 1996). When assessing single versus split application of soluble calcium sources in sandy soils, research indicates split applications, twice during the bulking period, resulted in higher tuber calcium concentration compared with a single application (Kleinhenz et al., 1996). In irrigated systems where soluble calcium can be injected into irrigation lines, spoon-feeding calcium to potatoes also increases tuber calcium concentration (Palta, 1996).

Placement

Potato roots take up water and nutrients, but do not provide these resources to the tubers. Instead, potato tuber roots take up water and calcium after development (Palta, 1996). Split applications of soluble calcium sources, where the calcium remains in the hill close to the tubers for a longer period of time, resulted in half the number of defective tubers compared with when all of the calcium was applied at hilling (Kleinhenz et al., 1996). Balancing the available calcium concentration and water applications or rainfall water in the area of the tuber is important to increasing calcium uptake and improved tuber quality.

Conclusions

Calcium is an important nutrient for all crops, but in fruiting crops, it is closely related to the quality of the crop harvested and to the quality of the crop through storage. Soil calcium concentration and availability to crops is influenced by pH, CEC, soil type, and the concentration of other minerals in the soil. The solubility of the calcium source is important to consider when making a calcium application. As with all nutrient management programs, we must consider the source, rate, timing, placement, and environmental conditions to implement the 4Rs for improved plant performance, yield, and crop quality.

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