24 Copper Nutrition in North Dakota Crops

24.1 Copper in plant nutrition

Copper (Cu), like Zn, Mn, Fe, and B is classified as an essential micronutrient. Copper is almost always present in the soil as Cu^{2+}, and is typically found within the crystal lattices of primary and secondary soil minerals, and in soil organic matter. The concentration of dissolved Cu in soil solution is very low, and is typically most often found in and tightly associated with soluble organic matter complexes. Soil organic matter can supply crops with a lot of Cu^{2+}; however, soils with an elevated level of organic matter (peats) can complex the Cu^{2+} too tightly making it unavailable to the crop. Although the total Cu concentration of high organic matter soils (>10% OM) is sufficient for crop growth on paper, they commonly require the application of supplemental Cu. In comparison to other cations, Cu^{2+} is held very tightly to clay exchange sites, and is not readily available for plant uptake.

Fortunately, the Cu requirement of most crops is very small. Most plants have a Cu content between 2-20 ppm in dry matter, which is about 1/10 of the typical Mn dry matter content. Once Cu is taken up into the plant, usually via a plant exudate chelation process, it is considered an immobile nutrient. However, when wheat has an adequate supply of Cu, it is able to translocate some of the Cu into its grain, most likely via an association with another translocated organic compound. Copper is a constituent of several important enzymes, and also plays a key role in several oxidation-reduction reactions due to its ability to readily donate an electron during oxidation, going from Cu^{2+} to $Cu^{2+} + e^-$. Examples of some important enzymes which contain Cu, or require Cu to function, are plastocyanin, superoxide dismutase and amine oxidases. Variations of these enzymes are crucial to both N metabolism and in protecting the plant from free radical damage.

24.2 Copper deficiency in crops

In Alberta, Canada, a large area in the grey-wooded soil region is naturally copper deficient. Small grain condition and yield, particularly for wheat and barley, were shown to vastly improve with an application of $CuSO_4$ (called locally 'blue-stone') (Mahli & Karamanos, 2006). In Cu deficient soils, certain small grain diseases such as stem melanosis and ergot, can increase in both their presence and severity. Sterility of anthers and pollen in wheat and barley can be common symptoms of a Cu deficiency. This results in an increase in the time leading up to flower expression, which exposes the plant to an increased risk of ergot and fusarium head blight (Franzen et al., 2008; Graham, 1975; Graham, 1983).

In North Dakota, Cu rate and source experiments in spring wheat and durum resulted in yield increases and a reduction in both the incidence and severity of fusarium head blight (*Fusarium graminearum* and *Fusarium* spp) at several locations (Franzen et al., 2008). However, the reduction in head disease was less than that achieved with an application of a fungicide labelled for fusarium head blight protection and control (Paul et al., 2008). Yield increases in spring wheat and durum in North Dakota Cu rate and source studies were confined to sandy loam to loamy sand textured soils with low organic matter (<2% OM). The most common soil series that exhibited a positive response to a Cu application was eroded Arvilla (Sandy, mixed, frigid Calcic Hapludolls)

Given the spatially "spotty" presence of low organic matter, sandy texture of soils in North Dakota that have a tendency to result in Cu deficiencies, the application of Cu fertilizers should only be considered a site-specific exercise. North Dakota soils with an OM level between 2% and 8% are unlikely to respond to any additional application of Cu. If copper (Cu) deficiency is suspected, or if the field has a history of Cu deficiency, a preplant broadcast application of 5 pounds Cu per acre as copper sulfate prior to planting small grains is sufficient. Alternatively, Cu may be applied in-season as a copper chelate, such as Cu-EDTA at an equivalent rate of 1 qt per acre (14% Cu), applied to small grains around the V4 growth stage, which is also sufficient to correct deficiency.

24.3 References for copper nutrition in crops

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