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THE ART of AGRONOMY

Hello All,

I am enthused that the sun can and will shine and temperatures can rise above 20F. This week will be a good week to look at some wheat fields. I have been encouraged about what I have seen so far. I have seen nice moisture in the seed slot above and below the seed. With these warmer temperatures forecast we may be able to get a good evaluation. This is a bit exciting for weird people like me. It appears a nice week then we have another chance of moisture. While commodity prices continue to soften the idea of raising more bushels should be the focus if possible. It is incumbent upon us to identify efficiencies to achieve this goal. Now back to our fertility/nutrition discussion.

This will be the last week I will discuss reactions in the soil. Continuing with this theme I will look at micronutrients. To begin with micronutrients are 7 nutrients essential for plant growth in very small quantities. For most of these nutrients the quantities used would be less than 1#/ac. In our area we are typically focused on Zn and Fe. There are two others we should pay attention to as well Mn and B.

Before I delve into the reactions in the soil, I will take a little time to give a brief description the function of each of these in the plant.

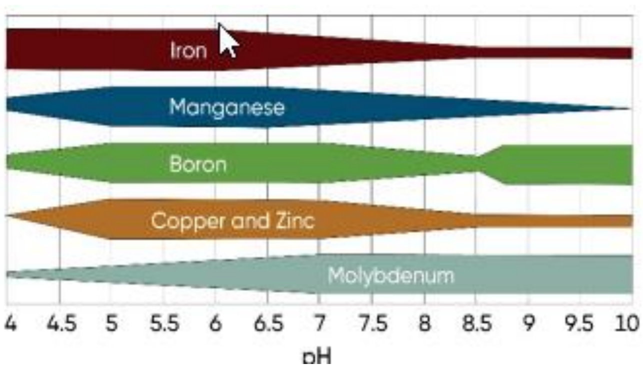
Element and Plant-Available Form		Function in Plant
Boron	H_3BO_3 $H_2BO_3^-$	Important in sugar transport, cell division, and amino acid production
Chlorine	Cl^-	Used in turgor regulation, resisting diseases and photosynthesis reactions
Copper	Cu^{2+}	Component of enzymes, involved with photosynthesis
Iron	Fe^{2+} Fe^{3+}	Component of enzymes, essential for chlorophyll synthesis, photosynthesis
Molybdenum	MoO_4^{2-}	Involved in nitrogen metabolism, essential in nitrogen fixation by legumes
Manganese	Mn^{2+}	Chloroplast production, cofactor in many plant reactions, activates enzymes
Zinc	Zn^{2+}	Component of many enzymes, essential for plant hormone balance and auxin activity

As you can see from the chart above that micronutrients are heavily involved in enzymatic reactions. A few important ones I will expound on a bit more. Zinc for instance is heavily involved in protein synthesis the rate of protein synthesis and protein content is greatly reduced in Zn deficient plants. Zinc is an essential component of RNA polymerase if no Zn is present the enzyme is not activated. RNA degradation results in lower protein content. When considering iron in addition to chlorophyll formation, it is an activator for photosynthesis, respiration and symbiotic N fixation. Manganese assists iron in the formation of chlorophyll but is also critical in the formation of dismutase which is an enzyme that protects the plant from the destructive free radicals formed in the oxidation process converting O2 to hydrogen peroxide which is broken down into water. Without this process the O2 radicle would be very destructive inside the plant. That said, for efficient energy transfer (sunlight – glucose) and metabolic function the presence of micronutrients is both supportive and essential.

Now I will discuss the reactions in the soil which ultimately will govern their plant availability. To help illustrate this see the chart below.

Cations	
Copper	Positively charged - bind to soil particles
Iron	Solubility is greatest under acid conditions
Manganese	Most likely deficient on calcareous soils or soils extremely high in organic matter where strong chelation decreases availability
Zinc	
Anions	
Boron	Negatively charged – subject to leaching
Chlorine	In short supply in areas where they are readily leached and not being replenished by organic matter decomposition
Molybdenum	

As we have learned earlier reactions are based on charges. These charges govern the reactions in the soil. Ultimately availability hinges on the balance between the soil solution, OM, cation exchange sites and the insoluble micronutrient compounds. Soil pH has a great deal of influence on tie up and plant availability as illustrated in the chart below.



In essence, the higher the pH the more tie up and less available for plant uptake. In the case of Zn, Cu and Mn the availability changes 100 x/ unit of pH change. Another more substantial one Fe changes 1000 x / unit of pH change. For a bit more explanation on Fe since it is a bit unique. Iron is insoluble in the oxidized state and can be tied up in the organic matter. Plants have mechanisms to help mobilize Fe and make it plant available. One is characteristic of dicot plants; these plants acidify the rhizosphere by the extrusion of protons. The second mechanism associated with monocots the roots exude compounds called siderophores. The dicot mechanism results in a reduction in the iron in the plasma membrane. The second mechanism does not require this reduction. Even with these mechanisms our mineral soils coupled with the pH make Fe a very challenging micronutrient.

In addition to the pH of the soil being very influential as we all know there are interactions with other nutrients that one must be aware of as well. For example, in soils high in organic P, Mn absorption will be minimized. In addition, excessive N and P values have been linked to impeding Zn uptake as well. In the case of P there is an ideal ratio 10:1 that I like to look at between P and Zn. In addition to these the rooting environment can play a major impact in the uptake of micronutrients. These factors include disease, insects, compaction, salt, drainage, oxygen deficiency and nutrient deficiencies. The chart below lists some common soil characteristics in various crops more sensitive.

Element	Soil Characteristics	Crop
Boron	Sandy soils or highly weathered soils low in organic matter	Alfalfa, clover
Chlorine	Sandy soils with high rainfall, highly weathered soils low in organic matter	Wheat
Copper	Acid peats or mucks with pH < 5.3 and black sands	Wheat, corn
Iron	Soils with high soil pH, soluble salts and/or calcium carbonate levels	Corn, soybean
Manganese	Peats and mucks with pH > 5.8, black sands and lakebed/low-lying soils with pH > 6.2	Soybean, wheat, sugar beets, corn
Molybdenum	Acid prairie soils	Soybean
Zinc	Peats, mucks and mineral soils with pH > 6.5	Corn, soybean

While micronutrient levels in the plant are small the deficiency symptoms due to their function are distinguishable.

Element	General Deficiency Symptoms
Boron	Light general chlorosis, death of growing point, deformed leaves with areas of discoloration
Chlorine	Chlorosis and wilting of young leaves. Deficiency rarely seen on crop plants in field
Copper	Light overall chlorosis, leaf tips die back and tips are twisted, loss of turgor in young leaves
Iron	Chlorosis or yellowing between the veins of new leaves
Molybdenum	Similar to those of ordinary nitrogen deficiency – general chlorosis (yellowing) of young plants, chlorosis of oldest leaves
Manganese	Chlorosis or yellowing between the veins of new leaves (much like Fe deficiency)
Zinc	Stunted growth, reduced internode length, young leaves are smaller than normal

As you look at the chart above it is easy to see why the symptoms manifest as they do. For example, the yellowing of the new leaves between the veins on Fe and Mn which are both essential in the formation of chlorophyll. The death of the growing point and the deformed leaves associated with B which is a key component if cell division and sugar transport. With copper loss of turgor in leaves and Zinc stunted and reduced internode length protein synthesis.

When considering management soil testing is very important. Tissue testing can also give some diagnostic insight. To mitigate we must consider basically three classes of fertilizer to address micronutrients inorganic, synthetic chelates and organic complexes. The inorganic compounds are normally paired with metallic salt sulfates being the most common. These are typically water soluble but are subject to reactions soon after application. The more stable compounds would be the chelated products which we have talked about before, the ionic form on the micro is protected by the chelation agent. The complexing of organic complexing work in the same manner. Both will protect the micronutrient from the reactions with soil minerals. As for making a micronutrient application placement on or near the plant has been shown in various trials to be the most responsive method. This could be near the plant in the rhizosphere with Fe or Zn. Another effective way to address these issues is by a foliar application. This is useful for quick uptake and in many instances can correct a problem immediately. In recent years the implementation of both banding and foliar applications is an appropriate practice.

In conclusion, knowing what micronutrients do in the plant and their reactions in the soil leads helps us better understand how to manage them. Higher yielding crops increases the demand for these nutrients. While they are small in total amounts required, they are critical for metabolic processes in the plant to function optimally.

Well, I better stop here. I have now discussed all the important reactions the soil. We will focus more on nutrition in the coming weeks. One take away is that our soil mineral makeup and pH plays a major role in the reactivity of fertilizer products in the soil. In addition, soil biology is a major player as well and they both work hand in glove. January is nearly over, and things will start happening in short order within the next few weeks. Hopefully at this time next week we will have a better handle on this wheat crop. As always, my goal is to provide fundamentals and context to help you understand fertilizer recommendations, soil reactions and finally nutrition. Remember **Agronomy** is an **Art** particularly when you farm in a desert 3,000 ft above sea level. If you have any questions, feel free to reach out.

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