Trace Minerals: Beyond NPK

An example of healthy, loose soil with good air, water and nutrient exchange.

As a biological farmer, I've always addressed the need for trace minerals in my soils and in my crops. They are often limiting factors not only for yield, but also for plant health. But now it seems trace minerals are gaining more and more notice in the conventional world as well. Even before the reports came out about the herbicide glyphosate (the main ingredient in RoundUp) limiting the availability of some trace minerals, conventional farmers were starting to look at the need for sulfur, boron and occasionally zinc in some crops. With the recent press over glyphosate tying up manganese, more conventional farmers are addressing the need for this nutrient and noticing the negative effects that occur when it is deficient.

Even though it has taken an outbreak of crop health problems caused by mineral deficiency to get them there (you can't keep growing a 200 bushel/acre corn crop and only apply NPK because eventually limitations will occur), I'm happy to see trace minerals getting noticed in the conventional farming world. I've always believed that a crop needs more than just three minerals, NPK, to grow. When all of the minerals are present, exchangeable, and in balance in the soil, that's when we get a healthy, high-yielding crop.

by Gary F. Zimmer

A PROGRAM FOR HEALTHY CROPS

Growing healthy crops means doing many things right: adding compost and manures, both green and brown; not overdoing or underdoing tillage; rotating crops; growing a diversity of plants; balancing soil nutrients; and feeding the crop plenty of available calcium and a balanced supply of at least 12 other minerals.

Even though we only need relatively small amounts of them, trace elements are big contributors to plant health. Plants need traces for a variety of physiological functions, and when those traces are lacking, plant health suffers. There is a thin line, however, between sufficient use of traces and overuse. Overuse can fall into a category of insecticide or fungicide.

Copper is a good example of a mineral that acts as a fungicide when it is applied at heavier doses. I target 5 ppm for copper in the soil, but I once visited an avocado orchard in Australia where copper sulfate was heavily used to keep down fungal diseases and the soil test showed copper levels of close to 1,300 ppm! It was amazing to me that the avocado trees, or the grass and clover growing under them, weren't exhibiting any obvious health problems. At that high level of copper, issues with copper toxicity in plants will usually start to show up.

I believe that a range of 5 to 10 ppm is a good target for copper in the soil. I used to set my target level for copper on a soil test at 2 ppm, but have recently increased that to 5 ppm, in part because at the 2 ppm level, my feed tests were low on copper. There just wasn't enough copper in the soil for the plants to be able to take up an adequate amount. I like to see 15 ppm in my forages as a minimum, but that is rarely achieved. Copper is an important mineral for animal health, and needs to be present in feed and food. In my opinion, the most efficient and cost-effective way to get copper into feed or food is to get it from the soil.

This is true of all trace minerals, not just copper. It's important to have enough available trace minerals in the soil to grow a healthy crop, but you also don't want to overdo it.

WHAT IS THE RIGHT AMOUNT TO APPLY?

I believe that it's accepted knowledge that there is a certain soil sufficiency level of many minerals, trace elements included. Soil testing can help us learn whether our soils are at, above, or below those sufficiency levels, but it's important to remember that soil testing isn't perfect. Numbers can vary from year to year just based on small differences on how the sample was taken, or how the lab ran their tests. Also, labs don't all use the same methods of testing so results from one lab can be very different from results from another lab. Split a sample and send some of it to six different labs and you'll get six different numbers back because the testing protocols and extraction methods are all slightly different.

In addition to variations due to differences in testing, there are also variations based on soil type. Sandy soils with a lower pH and lower nutrient holding capacity are at one extreme, while low organic matter clay soils with a high pH are at the other extreme. Do both of these soil types need the same amount of added nutrients? Sandy soils can't hold enough nutrients to grow a good healthy crop without added inputs. High pH, low organic matter clays may be short on biology and soil structure, making it difficult for plants to access what's there.

And what about crop removal? How does that affect the need for traces? Alfalfa, for example, may require more boron than oats. Expected yields and rainfall levels would also affect how much and which elements need to be added.

Mineral interactions can also make trace minerals more or less plant-available. For example, zinc and phosphorus function best at a ratio of 1 part zinc to 10 parts phosphorus. So a soil sufficiency level for zinc of 5 ppm might be one lab's recommended amount, but if the phosphorus level in that soil is 100 ppm, then the zinc level needs to be at least 10 ppm in order for plants to be able to access that zinc.

All of this variability means it's difficult to find a number that is the right "minimum amount" of a trace mineral to have in your soil. I don't want to make this overly complex, but each farm should have a plan in place for micronutrient application based on their soil type, the level of minerals in their soil, and the types of crops they're growing. Regular soil and plant tissue testing along with a good dose of common sense can help a farmer determine the right amount of trace minerals needed for their situation. But one thing is true for all farms: you can't keep growing high yielding crops and keep them healthy and not deal with traces.

What about overdoing trace minerals? Are we worried about people getting sick from toxic levels of trace minerals? I don't think that's a big concern, except possibly in the cases when trace elements are used in large quantities for disease or insect control. Even then, the plant would be affected long before someone consuming it would notice any negative side effects.

Adding trace minerals is an important part of the biological farming system. If we as farmers do everything we can to get soils healthy and mineralized with lots of nutrients, and we keep mineral levels balanced in the soils and in our crop fertilizers, we find we have less need for plant protection like herbicides and insecticides. That is biological farming: using natural methods to prevent disease, not just fighting diseases after they show up. So I could say that my farming method serves as a chemical-use prevention system.

Micronutrient	Benefits it provides
Zinc	Improves phosphorus utilization Regulates plant growth Increases leaf size Increases corn ear size Promotes silking Hastens maturity Contributes to test weight
Manganese	Improves nitrogen utilization Plays an important role in pollinization Needed for oil production Aids in energy release in cells
Iron	Needed for chlorophyll production Plays a role in photosynthesis
Copper	Helps to regulate the plant immune system Controls mold and fungi Important in photosynthesis Increases stalk strength
Boron	Increases calcium uptake Necessary for sugar translocation within the plant Promotes flowering and pollen production Essential for cell division and plant growth

USE OF TRACE MINERALS ON ORGANIC FARMS

Micronutrient use in organic agriculture is an allowed but controlled practice. Though micronutrients, or trace minerals, are allowed for use under the National Organic Program (NOP) standards, the NOP also states "soil deficiency must be documented by testing." This means that you have to prove you need trace minerals before you can or should use them. I believe that this is a wise practice for *every* element, not just trace minerals. Soil tests should be taken to guide farmers on how much of any element to apply, including calcium from lime. If you're short of a nutrient, add it, and if you have enough, don't add any more. That's the purpose of soil testing and should be a farmer's objective: to identify limiting factors and address them. A feed test or plant tissue test is also advised, as it gives additional clues needed to build a soil fertility program and provide the needed minerals.

SOURCES

Trace minerals can be found from many different sources, and in several different forms. Trace minerals can be found as sulfates, carbonates, or silicates of zinc, copper, iron, manganese, molybdenum, selenium and cobalt. They can be soil applied, sprayed on, or mixed with other things. Foliar-applied traces will feed your crop, but they won't do anything to fix a deficiency in the soil. For example, a liquid solution of one pint of 8% zinc won't change soils (that's less than 1/10th of a pound per acre), but it will feed the crop a little zinc. If I want to raise the level of micronutrients in my soil, I would use 5 lbs of zinc sulfate, 10 pounds of manganese sulfate, 4 pounds of copper sulfate and 1 pound of actual boron per acre.

To address a soil deficiency of a trace mineral, apply a balanced fertilizer with traces for four to five years and then retest your soil to see how you're doing. If the trace minerals are finely ground and mixed with other things, particularly a carbon source, distribution will be easier and more uniform, and the minerals will be held in a more plant-available form. Having a low-pH carbon-based fertilizer will also improve the effectiveness of the fertilizer and increase plant-availability.

You may need to adjust the levels of micronutrients you're adding if you have a little extra of one or more minerals, or you may just need to reduce the rate of the blend. It's also important to test the plant, because levels in the soil won't change quickly, but small changes in the amount of available micronutrients will show up more quickly in the plant.

In addition, I like to use natural mined minerals from different sources to provide those minerals we don't test for, and yet are still needed by plants. Kelp is a good example of a mineral source that contains more than just the 12 minerals we test for on a soil test. Kelp comes from the ocean and contains over 70 different minerals. If budget wasn't a factor, I would include kelp in all my fertilizer programs. If you have a garden or grow high value crops of any kind, applying 200 lbs of kelp per acre each year is not a bad idea. And kelp isn't the only material that provides these minerals — there are also other natural materials from the sea or from underground that contain a wide range of different minerals.

GLYPHOSATE & TRACE MINERALS

There has been a lot of talk in the farming community this year about possible side effects from using glyphosate (the main ingredient in RoundUp and other herbicides). Retired professor Don Huber of Purdue University has published several papers in the last few years about the effects on soil life and plant health from glyphosate in the soil.

According to Dr. Huber's research:

• Glyphosate does not break down in the soil. After it is sprayed on plants, it eventually gets to the soil where it remains indefinitely.

• Glyphosate kills many types of soil microbes, including the ones that make micronutrients plant-available.

• Glyphosate strongly chelates, or ties up, micronutrients in the soil, including copper, iron, magnesium, manganese, nickel and zinc.

• Glyphosate also chelates with gypsum (calcium sulfate).

Once glyphosate is tied up in the soil it becomes inactive, however phosphate makes glyphosate active again.

There are some researchers who doubt that there is anything to worry about from glyphosate. If your plants are robust and healthy and your yields are holding steady or climbing, you may not have a problem with micronutrients. However, if you use glyphosate and are seeing problems with diseases, insect

attack, early maturity or lower yield, you may very well have a problem with glyphosate persistence in your soil. Dr. Huber's research also suggests that glyphosate is toxic to many kinds of helpful organisms and stimulates many types of plant pathogens, and that it compromises a plant's natural defense mechanisms.

Recently, articles were published in the *Farm Journal* and in *CropLife*, two conventional farming magazines, about the importance of micronutrients. Whether it's from tie-up with glyphosate, the lack of plant diversity and life in the soil, or just years and years of crop removal, more and more farmers are starting to see micronutrient deficiencies in their crops, or at least get a response from adding them to their soils. It's interesting to see that farmers and agronomists in the conventional world are becoming aware of the problem. Now the question becomes: how do we deal with it?

Whether or not you believe that glyphosate is causing problems on your farm, having sufficient trace nutrients in your plants is an excellent way to reduce limiting factors and boost crop yield and health.

CONCLUSION

When things are working right, you can grow healthy, nutritious crops with very little need for chemicals. But in order to do this, you can't starve your plants of any mineral, especially traces. At Midwestern Bio-Ag, we manufacture homogenized trace element blends for a crop fertilizer, blends that make up 25 percent to 30 percent of the fertilizer additions on most farms. The traces are finely ground and added to a base of carbon (either humates or compost), rock phosphates, calcium and sulfur. It is a dry blend, balancing soluble to slow-release for all-season use. This blend can then be applied with better distribution of the trace minerals, and with the minerals hooked to something (the carbon source) so they don't tie up as easily in the soil. This method of delivery also allows us to distribute the micronutrients more efficiently and makes them easier to handle so they can be used by many types of farms on many different crops. On certain soils where we are really short of some elements, such as zinc, we can add extra of that individual trace element as needed. If the soils are extremely high in some trace elements, we would be limited on the use of these blends, but that is extremely rare and even in those situations we have to consider crop removal of traces, exchangeability, and plant uptake.

Because of the high cost of trace minerals, most farms do not overapply them, even if we knew what "overapplication" looked like. We haven't perfected a system to know the exact numbers needed for each mineral, and when you add that to all of the variables involved in sampling, testing, and applying the small amounts of trace minerals used, you can see that this isn't an exact science.

The best approach is to use common sense when applying trace minerals. A common sense plan includes:

• Testing both soils and plants.

• Having a plan in place for maintaining (using crop fertilizers) and building (using soil correctives) mineral levels for many nutrients, including traces.

• Putting in place a monitoring system that over time watches for extreme excesses and maintains soil levels and ratios.

With this type of system in place, plants should stay healthier, and there should be fewer disease and insect problems. Trace minerals aren't the only thing the farmer needs to address to grow a healthy crop, but they are a major factor.

I want to grow nutrient rich, tasty, and cleanly raised foods following a sustainable farming method. Keeping the trace element levels in the soil at sufficiency level and providing the crop with an adequate diet of plant-available traces makes sense, and is the Midwestern Bio-Ag program.

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