Micronutrient Management for Prairie Farmers

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Interest in micronutrients has been considerable over the past decade. Although we have seen significant research over the years in the prairies since the 1960's and particularly in the early to mid-1980's, then again since 2000, it remains difficult to interpret the data because of differences in treatments, products, and responses. However, when we look at the data as a whole, it becomes clear as to what sort of approach to take to minimize the financial risks associated with either not recognizing the deficiency or applying product that may not provide an economic return.

This presentation is proposed as a reasonable approach to micronutrient management in the most common circumstances of Canadian prairie producers. This approach begins with the role of micronutrients, ways of recognizing a deficiency, and deciding how to correct the deficiency if needed.

1. **Where Micronutrients fit in the Big Picture.**

Micronutrients, such as copper, manganese, zinc, boron, and iron are only called micronutrients because they are needed in smaller amounts than that of macronutrients. 'Micro', therefore, is not used to describe the level of importance of these nutrients, because they are just as important as any of the 'macro'nutrients, such as nitrogen, potassium, potassium and sulfur. It has been very difficult to conduct research on micronutrients because in many instances, it is difficult to find fields with deficiencies and fields that exhibit those deficiencies in a consistent manner or even on a scale that allows for the classical, properly replicated experiments to fit. On this evidence alone, one might conclude that micronutrient deficiencies are not widespread.

However, we also have data that would indicate that micronutrients are not widely deficient in the prairies. Enviro-Test Laboratories has looked at their Saskatchewan data, collected over the 1990's, finding that of the soil samples submitted for micronutrient analysis, only 12% were categorized as deficient in copper and less than 1% were deficient in any of the other commonly tested micronutrients such as zinc, iron, manganese or boron (Tables 1 and 2). It is probable that even less of our soils are actually deficient in these nutrients, if you remember that the extra cost in testing for micronutrients should mean that at least some of these were submitted with a suspicion of micronutrient deficiency, so they are not entirely representative of all soils in Saskatchewan.

In fact, research done in the mid-80's estimated that there may be as many as 1,000,000 acres in Saskatchewan that are Cu-deficient and three times this in Alberta. Manitoba has also seen its share of documented deficiencies. So, prairie soils can indeed be micronutrient deficient, however, the acres are limited. In Manitoba and Alberta, likely the greatest concerns have been over copper deficiencies in certain cultivars of wheat and zinc deficiencies in dry beans. In

Saskatchewan, most concerns have been over copper and wheat. Throughout the prairies, although there have been concerns about boron and canola, it has been very difficult to scientifically document responses and there remains much controversy over appropriate soil test methods. Since less than 1% of soils are likely to be deficient in any of the micronutrients other than copper, I will focus the rest of this discussion on that of copper (Cu).

Table 1. Micronutrient Critical Levels Used for Saskatchewan Soils by Enviro-Test Laboratories, 2000.

	Micronutrient levels in parts per million (ppm)		
Nutrient	**Deficient**	**Marginal**	**Sufficient**
Copper[a]	<0.4	0.4-1.0	>1.0
Iron[a]	<2.5	2.5-4.5	>4.5
Zinc[a]	<0.25	0.25-0.5	>0.5
Manganese[a]	<0.5	0.5-1	>1
Boron[b] 1) High B-using crops	<0.35	0.35-0.6	>0.6
2) Low B-using crops	<0.25	0.25-0.5	>0.5

[a]Using the DTPA method of analysis.
[b]Using the Hot Water method of analysis.

Table 2. Percentage of Saskatchewan Soils Submitted to Enviro-Test Laboratories, Saskatoon* for the 1992-2000 Crop Years, Testing Deficient, Marginal or Sufficient.

Micronutrient	**Deficient(%)**	**Marginal(%)**	**Sufficient(%)**
Cu (deficient <0.4 ppm)	11	38	51
Fe	<1	<1	100
Zn	<1	11	89
Mn	<1	<1	100
B, low B-using crops	1	8	91
B, high B-using crops	3	12	85

* Data from 21,600 samples.

2. Recognizing a Copper Deficiency.

There are several indicators of Cu deficiency and since few, if any of these, are singularly infallible, it is wise to consider an approach where you look for multiple evidence. ‘Multiple evidence’ could include any combination of the following:

a. **Suspect Soils.** Generally, Cu deficiencies occur in soils where there was little Cu to start with, this being organic soils or sandy soils. These soils have very little Cu associated with the material that was inherent to their original development or parent materials.

b. **Suspect Crops.** Of all the major prairie crops, wheat is the most sensitive to Cu deficiency, so this is the crop in which a deficiency should show up first. Other cereal crops may also show deficiencies. If you suspect a deficiency in another crop, but have not seen this in wheat first, keep your mind open to other reasoning.

c. **Soil Tests.** If you have a soil test report that says 'deficiency', check first what method was used to test the soil, then find out the level at which they call the soil, 'deficient'. This 'deficient' level is called the 'critical level' by soil test labs. Generally, local labs are using a 'DTPA analysis' to test for Cu, iron, manganese and zinc. This method has been proven to generally reflect the portion of Cu in the soil that is available to uptake by plant roots. This common method may produce similar data from one lab to another; however, the labs will interpret the data differently, providing suggestions of deficiency at different levels. Research across the prairies, and particularly in Saskatchewan, has shown that it is quite likely that you will generate an agronomic and economic wheat yield response to Cu fertilizer application if the soil, tested by DTPA analysis, shows available Cu is at less than 0.4 parts per million. Since some labs are producing recommendations for Cu applications at higher levels, call your local lab for clarification.

You may also see the descriptive term, 'marginal' along with 'deficient'. There are a variety of meanings and uses for this term. Quite often, it means that there is a possibility of generating a yield response if a nutrient is applied, but there is more risk that there will not be a response. Also, it may mean that since it is assumed that the submitted soil sample is a composite of many sub-samples, the result may be a mixture of deficient and sufficient Cu levels to produce something in between. Ultimately, since all nutrients are quite variable in the field, and Cu in particular, soil test results should be used reasonably in combination with other evidence.

d. **Visual Symptoms.** Visual symptoms can be very helpful in diagnosing a Cu deficiency. If you see these occurring in patches within a field, rather than throughout, they are indicative of Cu deficiency. At mid-season, you may see that the flag leaf is twirling like a ringlet or pig's tail or curling and splitting. Some of the most easily seen symptoms of a severe deficiency are seen at harvest time: stem melanosis (browning), stem bending, and missing kernels. You may see brown irregular-shaped patches in a ripe wheat field and when you look closely at one of the plants, the stem and possibly the head is dark brown. Sometimes you will have, in addition, or on its own, a symptom of stem bending, as if the head is so heavy, the stem has curled over like an upside-down 'u' to accommodate the weight of it. However, if you find that the heads, in fact, contain shriveled and/or few grain kernels, this is very likely a Cu deficiency. Copper is important to the formation of lignin (adding strength of a stem), therefore the stem-bending symptom. Copper is also important to the proper formation of pollen grains and anthers, therefore the symptom of shriveled or absent kernels.

e. **Plant Tissue Analysis.** Quite often, if you see a symptom and want to confirm it is a Cu deficiency, a good way to accomplish this during the growing season is to collect either or both plants and soils in and out of the affected patches. By analyzing the plants or soils in and out of the patches, you can get a direct comparison of values for all nutrients. If it is a Cu issue, you should see definite differences, if not, you may find that the tests reveal another issue you hadn't considered.

f. **Yield Response.** The ultimate proof of a nutrient deficiency is, in fact, to produce a yield response when a nutrient is applied. If you are tempted to apply Cu but wish to be quite certain that you will get economic return for your investment, apply a foliar strip of Cu fertilizer to the wheat crop prior to flag leaf. Confirm the response by visual differences and if possible, weigh the harvested grain in side-by-side strips, with and without Cu application.

3. **Fertilizer Application Strategies.**

The basic question for those planning to apply Cu fertilizer is, 'will it pay?' If you have gone through the steps of confirming, by looking for multiple evidence, that you have a true Cu deficiency then it is likely that it will pay to apply Cu, particularly if wheat is going to remain in your crop rotation. However, some methods and products have been more successful than others, as shown in local prairie research over the past 25 years. Here are some considerations:

a. **Soil or Foliar Applications?** There are several soil and foliar fertilizers on the market. Overall, the broadcast and incorporated application of 3.5-5 pounds of Cu per acre as Cu sulphate (bluestone) has proven to be the most consistent economical way of correcting a deficiency. This is an application that will show economic benefits for at least 20 years because you are effectively putting Cu 'in the bank'. The cost of product will likely be approximately $16 per acre, and then by adding the costs of application and incorporation, there develops a large up-front cost for future yield benefit and ease of mind. You may be asking, 'if this amount lasts for 20 years, why not just put less on every year?' Unfortunately, at these very low rates of product, it has been generally accepted that you are not going to get coverage of the soil with lower rates, and you won't get the long-term benefit with the small amount. Meanwhile, you still have the high cost of incorporation. However, a scientific paper is just being published that would say lowering the rate to 2 pounds per acre could achieve equal responses, at least in the early years, so this provides another alternative, as long as incorporation is still adhered to.

Is this application with a one-time incorporation acceptable for a direct seeder? Perhaps, incorporation can mean an opportunity to use an alternative weed control method in the same operation. On the other hand, it also means incorporating weed seeds, perhaps several years' worth and disrupting your overall production system. This is perhaps where the greatest advantage of foliar applications exists, that of direct seeding systems. The results from foliar Cu applications are not quite as consistent as the standard soil application described above, but they do tend to be more effective than other methods of Cu application. Since the Cu is applied to the crop itself, it is only effective in the year of application, the product costing approximately $10 per acre, without the benefit to future years. However, you will likely only have to apply each year you grow your wheat or if the deficiency is great enough, other potentially deficient crops, such as barley and oats. Likely, some of the inconsistency of response to foliar Cu is growing conditions, however, little research has been done to find out.

b. **Granular Cu Fertilizers.** When considering a soil-applied Cu fertilizer, the granule type, form, size, solubility and placement will all play a role in their success. Central to all these issues is the behavior of Cu in soil, the most important of which is extremely limited movement. The plant available form of Cu in prairie soils is found as a positively charged ion, which will readily attach itself to plentiful negatively charged components in the soil. Clay particles and organic matter are primary sources of negatively charged soil components and most of our soils contain plenty of both of these to hold tightly onto the Cu, not allowing plant roots to easily access it. This is another reason why foliar applications are thought to work well in some circumstances – you avoid attraction of Cu to clay and organic matter by applying the Cu to the plant itself.

Once again, the traditional way of treating a Cu deficiency has been to broadcast and incorporate 3.5-5 lbs per acre of Cu as Cu sulphate. Incorporation into the root zone is important, due to the lack of movement you can expect Cu to have on its own. The smaller the granule and the more soluble, the greater its physical availability to roots. Copper oxysulphates, developed because this product is less corrosive to equipment than Cu sulphate, unfortunately compromise the solubility of the sulphate form by blending with a less soluble oxide form. Unfortunately, not all oxysulphates are created equal and it is not always obvious just how soluble the oxysulphate is that you are considering buying. Recently, some have become available that would be considered quite soluble (>60%). Research from Manitoba has shown that one of these products is very effective.

It has been reasoned that placement of Cu within the seed row, like is done for phosphorus, should work well. However, it is very difficult to find research showing positive responses to granular Cu, when seed placed. This could be because most granules, at the low rates that they are applied, are placed quite far apart and sporadically within the seed row. What about liquids? A chelated liquid product recently was shown to produce very good responses in Manitoba. There, a seed placed 0.5 lb Cu/ac rate of liquid Cu-EDTA was as effective as the broadcast and incorporated Cu sulphate.

Conclusions for Direct Seeders

Of the micronutrients, Cu is the most commonly deficient in the Canadian Prairie Provinces. Since even Cu deficiencies are rare, to lower the economic risks it is advisable to use a multiple evidence approach to confirming that it indeed exists on a specific field or portion thereof. The traditional and proven method of correcting a Cu deficiency is broadcasting and incorporating Cu sulphate, but most producers using the direct seeding system see the required tillage operation as unacceptable. The benefit of seed placed Cu, although seeming reasonable to predict, has not been proven successful in controlled experiments, particularly with granular products. However, there could be some promise with liquid products. Of the options most readily available, foliar applications are the most proven successful application strategy for direct seeding systems.

Recent Scientific Journal Articles, experiments based in the Prairies

R.E. Karamanos, Q. Pomarenski, T.B. Goh and N.A. Flore, 2004. The effect of foliar copper application on grain yield and quality of wheat. Canadian Journal of Plant Science (*in press*).

R.E. Karamanos and T.B. Goh, 2004. Effect of rate of copper application on the yield of hard red spring wheat. Communications in Soil Science and Plant Analysis *(in press)*.

R.E. Karamanos, T.B. Goh and J.T. Harapiak, 2003. Determining wheat responses to copper in prairie soils. Can. J. Soil Sci. **83**: 213-221.

R.E. Karamanos, T.B. Goh and T.A. Stonehouse, 2003. Canola response to boron in Canadian prairie soils. Can. J. Plant Sci. **83**: 249-259.

Recent SSCA Conference Proceedings

Karamanos, Rigas E., 2001. Micronutrients and Direct Seeding.

Provincial Bulletins

Manitoba-Agriculture. 1999. Soil fertility guide.

Alberta Agriculture Food and Rural Development. 1999. Copper deficiency: diagnosis and correction.

Saskatchewan Agriculture and Food. 2000. Micronutrients in crop production.

Recent Soils and Crops Workshop and Manitoba Soil Science Society Meeting Proceedings

Flaten, P.L., B. Green, and P. Routledge. 2000. Micronutrient trends in Saskatchewan. University of Saskatchewan.

Flaten, P.L., R.E. Karamanos, and F.L. Walley. 2003. Copper Fertilization of Wheat on Soils with Marginal Copper Levels. University of Saskatchewan.

Flaten, P.L., F.L. Walley, and R.E. Karamanos. 2002. Mobility of Copper Fertilizers in Soils. University of Saskatchewan.

Karamanos, R.E. 2000. Micronutrients - Update 2000. University of Saskatchewan.

Malhi, S.S., L. Cowell, R. Kutcher, and D. Leach. 2003. Relative Effectiveness of Various Cu Fertilizers in Improving Grain Yield of Wheat after Three Annual Applications on a Cu-Deficient Soil. University of Saskatchewan.

Pomarenski, Q., T.B. Goh, and R.E. Karamanos. 2003. Strategies for Copper Fertilization of Wheat in Manitoba. University of Manitoba.