Trends in Micro-Nutrient Soil Test Levels in Saskatchewan

Pat Flaten, PAg[1], Brandon Green, PAg[2], Paul Routledge, PAg[3]

[1]Enviro-Test Laboratories, 124 Veterinary Road, Saskatoon, SK, S7N 5E3
[2]Enviro-Test Laboratories, Bay 3, 1313-44th Avenue N.E., Calgary, AB, T2E 6L5
[3]Enviro-Test Laboratories, 745 Logan Avenue, Winnipeg, MB, R3E 3L5

Micronutrients are used by crops in much smaller amounts than macronutrients but are no less critical to crop development. The commonly tested micronutrients in soils are copper, iron, manganese, zinc and boron.

Interest in the micronutrient status of Saskatchewan soils and crops has increased substantially over the past 20 years. One reason for this interest may be attributed to an increased recognition of micronutrient deficiency symptoms in crops. Another possibility is that both producers and fertilizer dealers are recognizing the need for balanced nutrition when targeting for high crop yields. Also, it appears that the micronutrient fertilizer industry has grown sufficiently to raise the awareness for potential deficiencies.

This paper will present summaries of data collected from farm soil samples submitted for micronutrient analysis and recommendations for the 1992-2000 crop years. This data includes approximately 21,600 soil samples from across Saskatchewan, submitted to Enviro-Test Laboratories in Saskatoon. In the past, data summarized via submitted samples was thought to have been biased towards the geographic areas most thought to be of concern (Kruger et al, 1984). The number of samples now being submitted from across the province should lessen this bias, as shown in Figure 1.

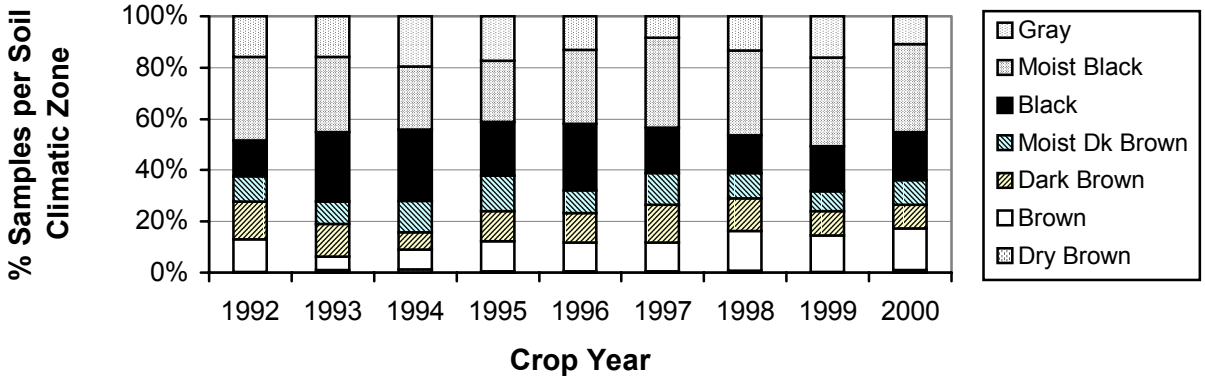

Figure 1. Percentage of soil samples by soil climatic zone, 1992-2000 crop years, Enviro-Test Laboratories, Saskatoon.

These data have been analyzed according to the following criteria: trends in time, geographic trends across Saskatchewan, spatial variability within a field, sampling depth, and soil texture.

Critical Levels for Micronutrients

The following chart provides the basis for judgement of either sufficient, deficient or marginal levels of a particular micronutrient in a soil. This, in turn, generates recommendations for nutrient application. Note that all references to high boron-using crops include canola, mustard and alfalfa. Low boron-using crops include most other crops, such as annual legumes and cereals.

Table 1. Micronutrient Critical Levels Used by Enviro-Test Laboratories, 1999.

	Micronutrient levels in parts per million (ppm)		
Nutrient	**Deficient**	**Marginal**	**Sufficient**
Copper	<0.6	0.6-1.0	>1.0
Iron	<2.5	2.5-4.5	>4.5
Zinc	<0.25	0.25-0.5	>0.5
Manganese	<0.5	0.5-1	>1
Boron 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

The micronutrients most likely to be deficient in Saskatchewan are copper, boron and zinc, in that order (Table 2). This does not imply there are no deficiencies in manganese nor iron, but of the five micronutrients, these are less likely to occur. Therefore, this paper will focus on trends in copper, boron and zinc. Recently, there has been discussion in the agronomic community regarding the appropriate critical levels for copper. Thus, Table 2 reports data using both the 0.6-1.0 ppm marginal range and the 0.4-0.8 ppm marginal range.

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
Cu (deficient <0.6 ppm)	29	36	35
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

Trends in Time

Over in the past five years, requests for micronutrient analysis at Enviro-Test, Saskatoon have grown by 2.5 times. This indicates a greater degree of awareness of the need to monitor micronutrient levels. During the 1992-2000 period, analysis for copper, iron, manganese and zinc was done using the 'DTPA' extraction method. In the case of boron, most data from 1992-1997 and 1999-2000 crop years were analyzed by the 'hot water' extraction method. For the short period between boron was analyzed by the 'ammonium acetate' extraction method.

The data shows a trend of zinc levels declining over time (Figure 2). Average copper levels appear to be relatively stable over time. Boron levels are relatively constant until the last two crop years. This coincides with a return to the hot water extraction method. It is doubtful that the return to the hot water extraction method is the sole reason for the increases in boron, since this was also the method used in the earlier years for this data set and we do not see elevated levels in boron at that time. Although the hot water method is the traditional extraction method for boron in much of North America, it may not reflect the availability of boron or the boron-supplying power of the soil as well as is needed. More research is required regarding soil boron extraction methods for the variety of soils we have in the Canadian Prairies.

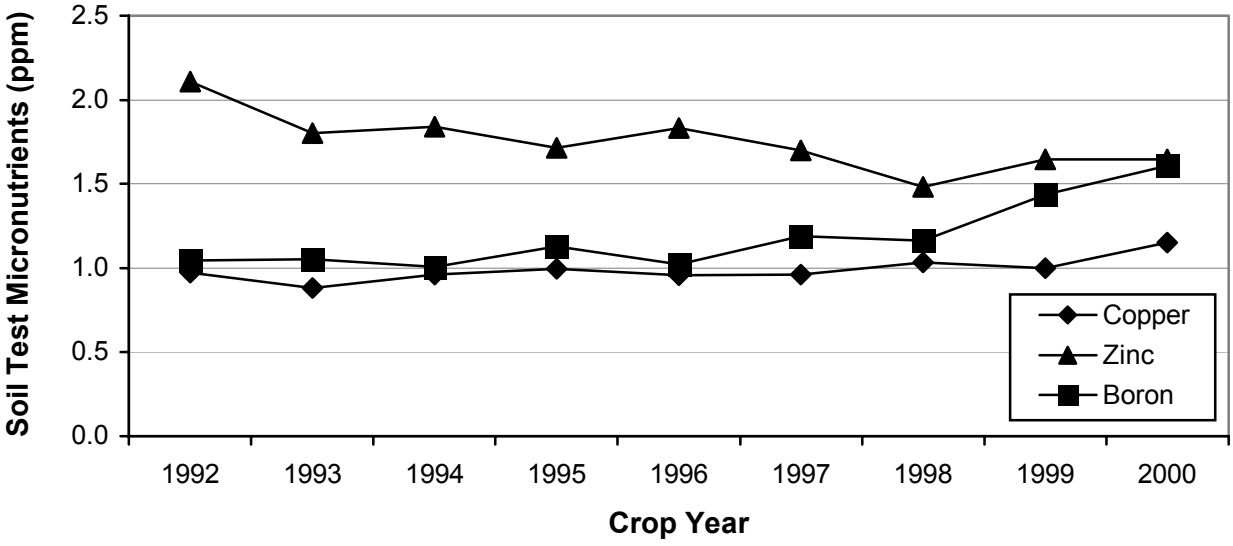

Figure 1. Average Saskatchewan soil micronutrient levels, samples submitted to Enviro-Test Laboratories, Saskatoon for the crop years of 1992-2000.

Trends Across Soil Climatic Zones

Micronutrient availability is affected by environmental, soil and man-made factors. Figure 3 shows the trend of decreasing average copper levels and increasing average zinc levels from the drier to the wetter soil climatic zones. Average boron levels, however, remain relatively constant across the soil climatic zones.

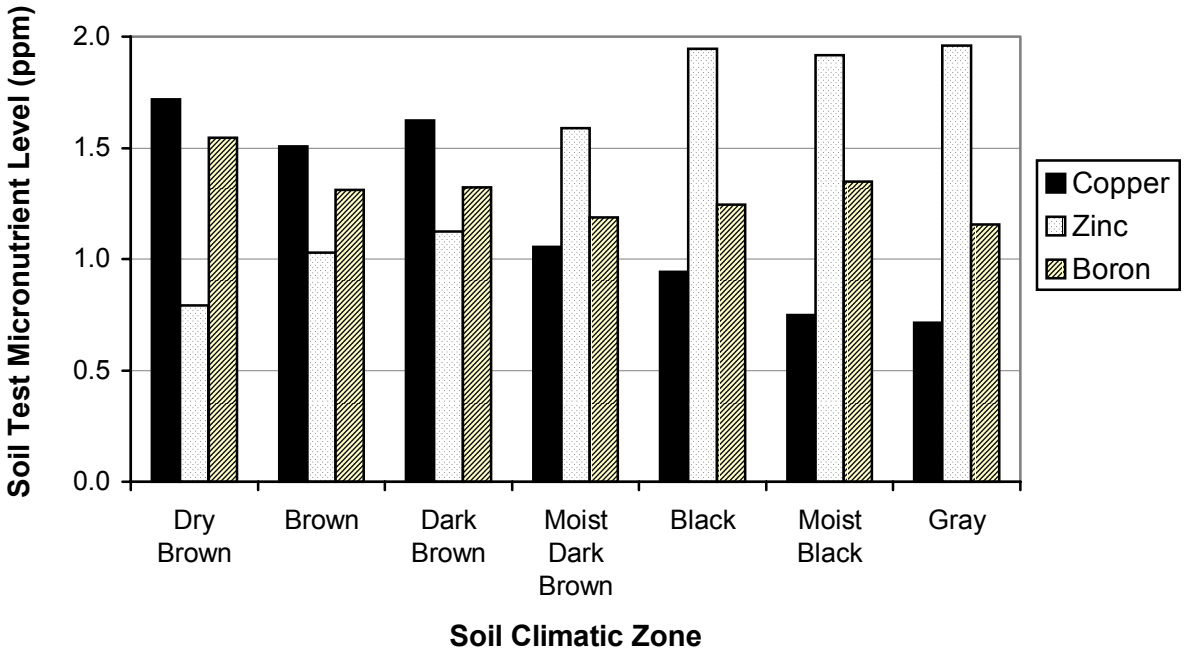

Figure 3. Average available copper, zinc and boron levels vs. soil climatic zones, 1992-2000 crop years, Enviro-Test Laboratories, Saskatoon.

Trends Related to Soil Texture

Available soil micronutrient levels are clearly related to soil texture (Figure 4). Available copper, in particular, is highly related to soil texture. Moving from coarse to fine-textured soils, average copper levels increase. Organic soils, however, supply less copper, showing levels similar to a loam soil.

Boron levels also increase in the finer-textured mineral soils, but are higher still in the organic soils. Zinc is relatively similar in availability within the mineral soils but is higher in the organic soils.

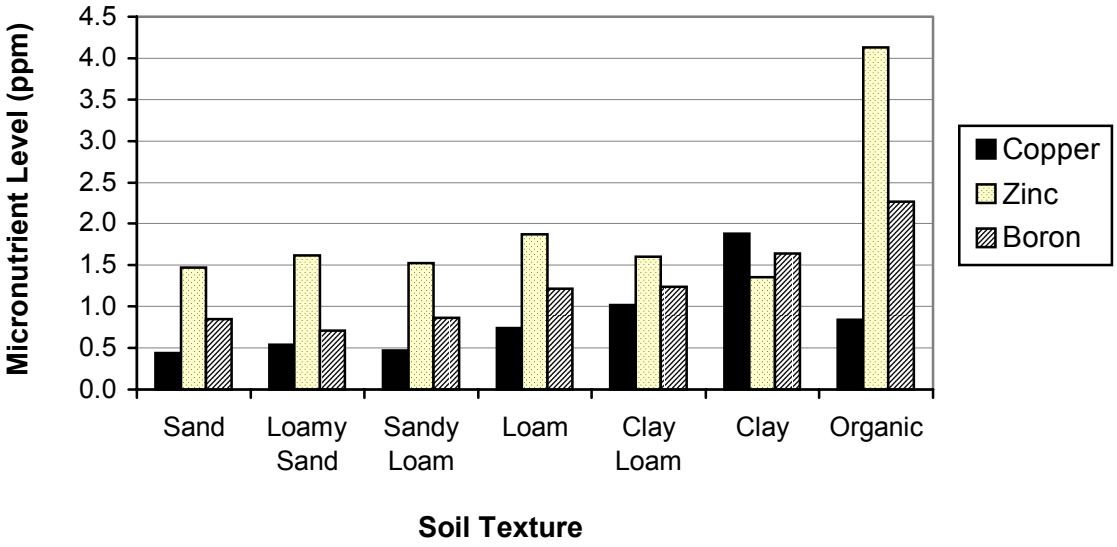

Figure 4. Average copper, zinc and boron levels vs. soil textures in Saskatchewan soils submitted for crop years 1992-2000, Enviro-Test Laboratories, Saskatoon.

Trends Within a Field

At present, most soil samples are a composite of 15 to 22 cores taken from representative areas, normally using mid-slope positions of a field. Fertilizer is then applied at a constant rate across the field. As with macronutrients, micronutrients can vary significantly across the field. Agronomists and producers often note that visual deficiency symptoms first occur in patches in the field. The following nutrient map (Figure 5), developed from a two acre sampling grid, illustrates the variable nature of copper in a 40-acre field near Rosetown, Saskatchewan.

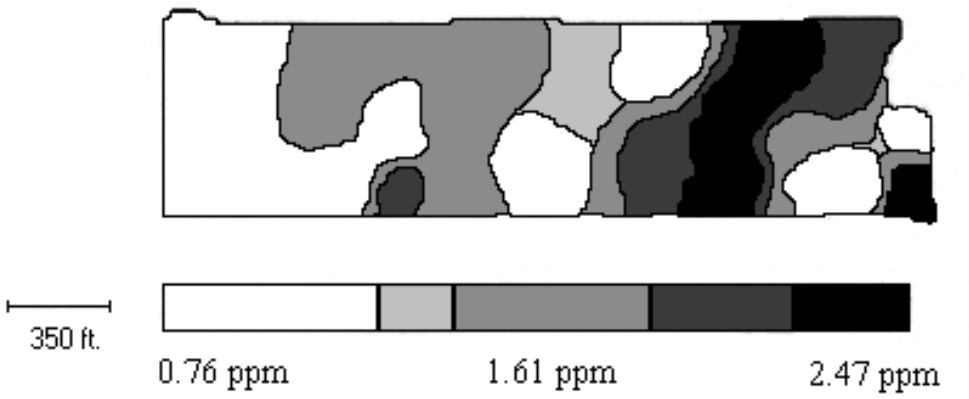

Figure 5. Copper levels in a field near Rosetown, Saskatchewan. (Nutrient map courtesy of Bulani Agro, Rosetown, SK.)

Soil variability within the field impacts the decision-making process regarding micronutrient application. The extent of this variability can also vary from year to year, as affected by precipitation on pH and nutrient leaching. A field marginal for a micronutrient, based on a mid-slope composite soil sample, could well be deficient in parts of the field and sufficient elsewhere. Depending on precipitation and the application of nitrogen fertilizer, the amount of the field that is deficient can vary from year to year. Accordingly, confirmation of deficiency from multiple sources prior to application of micronutrients is prudent. Composite mid-slope sampling may be followed by field scouting, site-specific soil and/or plant sampling and strip trials. Yield expectations and balanced nutrition should also play a major role in the decision-making process.

Trends Related to Depth

All analysis at Enviro-Test Laboratories prior to approximately 10 years ago (then known as the Saskatchewan Soil Testing Lab) was done on 0-6", 6-12" and 12-24" depth soil samples for each field. Since then, the Lab has accepted and encouraged to an extent, single depth sampling. What is the appropriate depth to test micronutrients? Most commonly, samples for micronutrient analysis are submitted as 0-6" or 0-12" samples. Figure 6 shows that on average, copper and boron levels are quite similar either way. Zinc, however, tends to be more concentrated in the 6" samples.

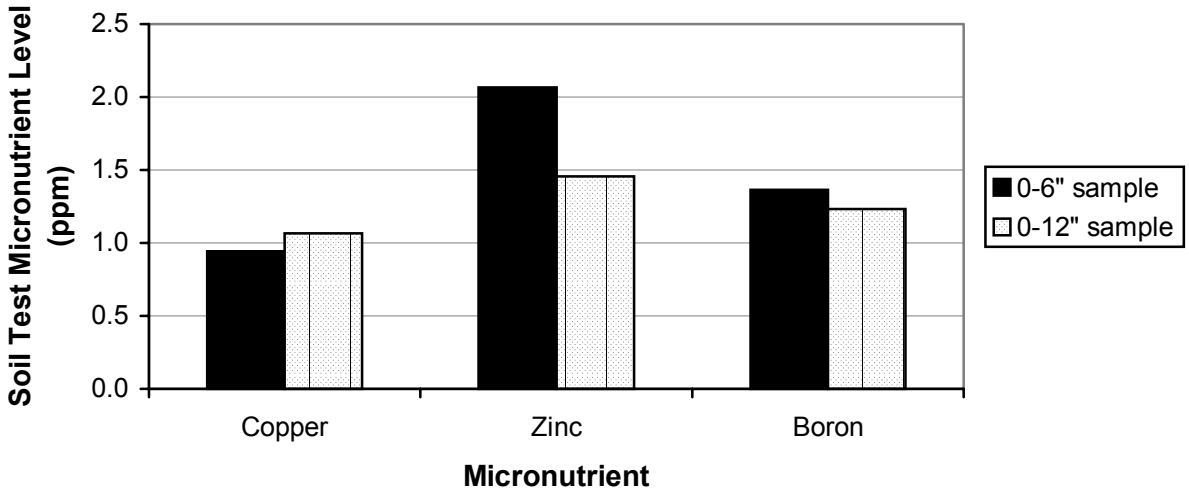

Figure 6. Copper, zinc and boron levels vs. sample depth in submitted Saskatchewan soil samples for the crop years 1992-2000 to Enviro-Test Labs, Saskatoon.

Boron migrates upwards and downwards in the soil profile, with moisture. It is probable that high boron-using crops may at times be deficient in boron if it has leached below the root system during early growth stages. Then, at later stages, the plants can 'grow out' of the

deficiency. In this case, a deeper soil sample may provide a false sense of security. The depth of soil sampled should be taken into account when leaching conditions are encountered.

Summary

Many trends in soil micronutrient levels are easily seen in the summary of analysis of submitted samples to Enviro-Test Laboratories, Saskatoon for the crop years 1992-2000. There has been a significant increase in analysis for micronutrients over the past 10 years. These increases in requests for analysis have been similar across all soil climatic zones. The following are clear trends in the analysis:

1. Copper, zinc and boron are the most likely micronutrients to be deficient, although manganese and iron may be deficient in more local circumstances.

2. Geographically, copper is more likely to be deficient as one travels northeast across the soil climatic zones in Saskatchewan, whereas the opposite is true for zinc. Average boron levels appear to be less related to soil climatic zone alone.

3. Strong relationships exist between soil texture and micronutrients. Higher clay contents tend to show higher levels of available copper and boron. Zinc is not showing particular trends with regard to mineral soil texture. Organic soils tend to have lower copper levels but higher zinc and boron levels.

4. Within a field, levels of micronutrients can be extremely variable, which needs to be taken into account when soil sampling, interpretation of and follow-up to the soil analysis.

Other relationships exist between micronutrient deficiencies and other soil, crop and environmental factors. These will require further examination in order to see a more complete picture of micronutrient trends.

Literature Cited

Kruger, G.A., J.P. Singh, and R.E. Karamanos. 1984. Recent Trends in Micronutrient Research in Saskatchewan. Proc. Soils and Crops Workshop. University of Saskatchewan, Saskatoon, pp.55-91.