BACKGROUND TO MICRONUTRIENT REQUIREMENTS IN ALBERTA

Jean-Michel Crépin
Norwest Soil Research Ltd.
Edmonton, Alberta

INTRODUCTION

There have been various but somewhat sporadic investigations of micronutrient deficiencies in Alberta over the last thirty years. These investigations were oriented towards problem solving or diagnosis and were carried out mostly by Alberta Agriculture and the Federal Research Stations.

While there have been a few reported cases of micronutrient deficiencies in soils, resulting in loss of production of cereal, oilseed and forage crops, most of the emphasis in trace element research has focussed on the effect of the low concentrations of these elements in soils on the resulting deficiencies in animal diets.

Even if it were possible to improve the quality of feed by the application of trace elements to soils, it is more economical to add the required elements directly to the animal feed. Therefore, the agronomic advantages of micronutrient applications on soil and/or the foliage of the plants have mostly centered around increased biomass production rather than quality.

MICRONUTRIENT FERTILIZATION IN ALBERTA

Micronutrients were applied to an estimated 250,000 acres of land in Alberta during 1982. While most of the applications were made on irrigated land, an estimated 50,000 acres of dry land crops were also fertilized with some trace elements. The areas fertilized with the various trace elements are shown in Table 1. These figures were compiled from information provided by Niagara Chemicals, an important supplier of agricultural chemicals, and by other major suppliers.

TABLE 1

Extent of Micronutrient Fertilization in Alberta

Element	Acreage
Zinc	150,000 - 200,000
Boron	50,000 - 70,000
Copper	4,000 - 6,000
Molybdenum	< 1,000
Manganese	< 1,000

Zinc is by far the major element of interest. In many instances, zinc deficiencies have been induced by high phosphate applications, especially in the sugar beet growing area of the province.

Crops which have been fertilized with micronutrients include: corn, sugar beets, potatoes (mostly under irrigation), alfalfa (with and without irrigation) and canola (mostly on dryland).

Until recently, the interest in micronutrients emanated mostly from problem-related cases. However, farmers have recently been subjected to considerable advertising and research literature which has increased their awareness of the plants' requirements for trace elements.

YIELD RESPONSE TO MICRONUTRIENT FERTILIZATION

Deficiencies can be produced accidently or deliberately, and diagnosed in the greenhouse: but this is difficult in the field because of soil variability and because roots are not confined to a small volume of soil.

(a) Manganese

Manganese deficiencies have been identified in various areas of the province but apparently have been limited to soils high in organic matter. In most cases, the deficiencies which occurred early in the growing season disappeared later during the summer. These deficiencies were observed in oats and barley - but barley crops were rarely affected severely.[5]

Nyborg[4] experimented with barley, wheat and oats on a poorly drained soil (High Prairie Series) containing 12% organic matter and having a pH of 7.0. The serious deficiencies he observed (Table 2) were corrected by switching to less sensitive varieties of oats. Many of these early varieties are no longer used.

TABLE 2

Yield of Cereal Grain on a Manganese Deficient Soil (Nyborg)

Cultivar	% Yield Without Added Mn*	
	Whole Plant	Heads Alone
Olli Barley	101	100
Parkland Barley	98	105
Thatcher Wheat	86	84
Saunder Wheat	75	72
Glen Oats	64	45
Exeter Oats	49	19
Victory Oats	45	0
Abegweit Oats	37	5

* Yield with added Mn set at 100%.

The deficiency symptoms of manganese are often found in greenhouses in early spring along outside walls, and cannot be related to manganese concentration in soils.

The highest concentrations of manganese found in Alberta occur on neutral, poorly drained soils in the Gray Soil Zone which are high in organic matter.(2) However, manganese **toxicity** is common on acid soils and is usually corrected by the application of lime.

(b) **Iron**

Iron deficiencies in agricultural crops are rare in Alberta. Iron deficiencies have been found in certain shrubs and are common in roses grown under greenhouse conditions in Alberta.

(c) **Boron**

Some response to boron application has been observed on Luvisolic soils. The most common crops affected are alfalfa and canola.

In this experiment, boron deficiency was certainly the most important factor affecting growth. Some field experiments carried out by the staff of the Beaverlodge Research Station have demonstrated the effect of boron on the seed set of canola. In the central part of the province, boron deficiency symptoms have been observed when soils remained very dry for an extended period of time, but they disappeared following rainfall.

TABLE 3

Greenhouse Experiment on the Effect of B, Mo and Lime on Canola Grown in an Acid Luvisolic Soil (Nyborg)

Treatment	Estimated Seed Set (%)	Yield of Immature Plants (g/pot)
Nil	5	23.4
B	100	35.7
Mo	10	23.5
Lime	10	25.8
Lime + B	100	39.8
Lime + Mo	20	26.4

(d) **Copper**

Copper deficiencies in oats, wheat and barley were observed in Central Alberta by D.R. Walker of the Lacombe Research Station; they occurred primarily on peat soils.[5] A yield response from copper application to the soil was obtained with barley growing on a calcareous black soil. However, the lack of deficiency symptoms in the plants indicated that the response was possibly due to fungicidal or bactericidal effects of the added copper.

(e) **Zinc**

Yield responses to zinc applications are common in southern Alberta, especially on irrigated crops and on soils which have received high applications of phosphate fertilizers over the years.

R. Gaudiel of the Alberta Horticultural Research Centre in Brooks has been studying zinc deficiencies on dry beans. One experiment (1981) showed significant yield increases, but the same experiment in 1982 appears to have shown less dramatic differences.

TABLE 4

Susceptibility of Dry Beans to Zinc Deficiency
Bow Island, 1981 (R. Gaudiel)

Varieties	% Yield Increase Due to Zinc
Viva	24.9
Seafarer	303.4
Sanilac	147.1
Pinto III	53.8
D 76067	7.7

This experiment indicated that, as was the case with manganese, some varieties are more susceptible than others to zinc deficiency. This is probably true of other micronutrients.(3)

CONCENTRATION OF TRACE MINERALS IN ALBERTA SOILS

The most thorough survey of the background concentrations of micronutrients in various Alberta soils was conducted by M. Dudas and S. Pawluk in the mid-1970's. The researchers were interested in obtaining information on the concentrations of heavy metals in cultivated soils. The study had an environmental connotation and was not concerned with agronomic impacts. Therefore, the soil extractant chosen was not the one that researchers in most provinces are now using to study micronutrient responses.

While the extractions were carried out with 1 N HCl and cannot be directly compared with results obtained with DTPA or DTPA-TEA, the data suggests that some soils are possibly deficient. The high standard deviation of zinc in results from the Gray Soil Zone would indicate that there are potential Zn deficiencies in those areas. Solonetzic soils and the well-drained soils of the Gray Soil Zones have less copper than other soils. Manganese levels are very high in comparison with levels recorded using other extraction methods, and are therefore difficult to evaluate in terms of plant requirements.

The correlation between concentrations of micronutrients in the soil and in the plant has always been difficult to establish. Dudas(2) found that the differences he observed in soils (Table 5) were not reflected in plant analyses (Table 6).

TABLE 5

Average Content of Heavy Metals in Ap Horizons of Alberta Soils (Dudas)

Soil		Elements		
		Copper	Manganese	Zinc
Brown	Well drained	5.2 ± 1.0	230 ± 24	5.7 ± 0.61
	Poorly drained	7.4 ± 1.4	290 ± 80	13 ± 2.7
	Solonetz	2.8 ± 1.0	180 ± 36	10 ± 5.0
Black	Well drained	3.8 ± 0.27	270 ± 24	13 ± 4.5
	Poorly drained	5.3 ± 1.0	220 ± 80	19 ± 4.4
	Solonetz	3.3 ± 0.67	230 ± 57	19 ± 4.8
Gray	Well drained	1.8 ± 0.58	260 ± 90	11 ± 9.8
	Poorly drained	4.7 ± 1.3	460 ± 160	26 ± 21
	Solonetz	2.6 ± 0.25	230 ± 64	9.2 ± 2.2

TABLE 6

Average Content of Heavy Metals in Barley Grain (Dudas)

Soil		Elements		
		Copper	Manganese	Zinc
Brown	Well drained	9.1	18	27
	Poorly drained	9.7	16	45
	Solonetz	9.4	14	35
Black	Well drained	9.2	14	37
	Poorly drained	9.2	14	40
	Solonetz	10.0	19	48
Gray	Well drained	9.1	16	36
	Poorly drained	9.7	12	27
	Solonetz	9.3	13	36

In a three year study of nutrients in soil and the plant tissue of the associated greenhouse crops in southern Alberta, J. Ashworth also found poor correlation between soil and plant levels.

TABLE 7
Correlation Between Soil and Tissue Concentrations (Ashworth)

Element	Crop Data for Which the Correlation is: Positive	Negative
P	Roses	
Ca		Chrysanthemums, Cucumbers
Mg	Chrysanthemums	Tomatoes
Fe		Cucumbers
Cu		Chrysanthemums
Zn	Cucumbers	
B	Chrysanthemums	
Mn	Chrysanthemums	

It is interesting to note that chrysanthemums, which are relatively fast growing plants and therefore shallow-rooted, display most of the correlations.

IMPORTANCE OF MICRONUTRIENT RESEARCH IN ALBERTA

Most researchers in Alberta recognize that micronutrients are not generally required for most of our crops on the majority of our soils; these soils seem to have a sufficient supply of trace elements to meet crop requirements. Also, response levels are difficult to establish on a consistent basis, even on the same site year after year.

Responses from trace element application seem to be affected by factors such as:

1. Plant species and variety
2. Climatic conditions - soil moisture
   - soil temperature
3. Stage of growth
4. Soil chemical and physical characteristics.

One of the major problems in soil testing for micronutrients is the poor correlation which exists between soil and plant levels. The factors above, as well as root penetration and antagonistic situations, must also be considered.

In horticulture and sylviculture, plant tissue analyses have generally been used successfully to measure trace element uptake levels.

This is seldom done in dryland farming operations mostly due to the fact that corrective measures are either difficult to take or uneconomical.

While deficiencies are rare, low or marginal levels in the soil have reduced the quality of the feed and food produced. With intensification of agriculture, one can expect greater demands on soil reserves. Furthermore, fertilization as well as liming and cultural practices may affect nutrient balance and plant uptake. It is important to remember that there were very few potassium deficiencies in Alberta twenty years ago and that sulfur analysis was only started in 1968 by the Alberta Soil and Feed Testing Laboratory. Application of these elements is now quite common, as is applying nitrogen after summerfallow.

With deficiencies in trace minerals in feedstuffs becoming more prevalent, it is likely that the soils will become depleted with time. Research should therefore be focussed on those marginal soils rather than on the soils which are definitely showing responses. It is becoming important to predict rather than cure.

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