

# Micronutrients – When Should Do We Use Them?

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## **Introduction**

Early work on micronutrients on the prairies dates back to the sixties and identified zinc (Zn), copper (Cu) and manganese (Mn) as potential problem micronutrients. Early work also identified organic (peat) soils as a primary target for micronutrient deficiencies. However, this work also demonstrated that the vast majority of prairie soils were adequately supplied with micronutrients for cereal crops.

Currently, a number of products and practices are being used or recommended for use without proper experimentation or through experimentation carried out in other parts of North America or the world. Occasionally, the “need” and use of a product or a practice are recommended simply by deduction. Micronutrient maintenance or maintenance of an appropriate nutrient “balance” are also often quoted reasons for micronutrient applications without any experimentation to support such claims.

## **When Should We Use a Micronutrient?**

### ***General***

Micronutrients should be used when an **economic** benefit for the **producer** is realized either through yield or quality improvement.

### ***Boron (B)***

Hot-water extractable B (HWEB), which was initially developed by Berger and Truog (1939) and was subsequently modified by Wear (1965) and Gupta (1979), still remains the prevalent method for assessing soil “available” B. HWEB levels of <0.35 ppm are generally considered as deficient (Sims and Johnson 1991). Recent work (Karamanos et al. 2003b) demonstrated that canola did not respond to B application on 40 sites, even on soils containing <0.15 mg kg<sup>-1</sup> HWEB and with control canola yields of up to 63 bu/acre, thus suggesting that responses to B are rare on prairie soils and in any event hot water extractable B is not an appropriate index to identify B deficiencies.

***When Should We Use Boron?*** Almost never! Possibly on recently broken land on transitional sandy soils with very low organic matter.

### ***Copper (Cu)***

Copper represents the micronutrient that most research has been carried out on in western Canada. There are a reported three million acres of potentially Cu deficient soil in Alberta (Penney et al. 1988) and just over one million acres in Saskatchewan (Kruger et al. 1985). Copper deficiencies have also been established on organic (peat) soils in Alberta (Hartman

1992), Saskatchewan (Karamanos et al. 1985a, 1991) and Manitoba (Reid 1982; Loewen-Rodgers et al. 1983).

A recent compilation of research data on wheat, barley and canola from Saskatchewan and Alberta (Karamanos 2000; Karamanos et al. 2003a) verified a critical level of 0.4 ppm for cereals and 0.3 ppm for canola, respectively. Although responses to Cu have been reported for other crops, such as oats (Malhi et al. 1987), alfalfa (Kruger et al. 1984) and flax (Karamanos et al. 1986), the database for these crops is insufficient to draw critical levels from. Commonly, the same criteria are applied equally to all types of soils, although studies have shown that clay soils do not respond as readily as sandy loams or loamy sands (Penney et al. 1988). Liang et al. (1991b) showed a close relationship between “available” Cu and soil clay content using sequential fractionation techniques. Penney et al. (1993) showed very little differences in sensitivity to Cu deficiency among five commonly grown wheat varieties in Alberta over seven site-years.

***When Should We Use Copper?*** When **cereals** are grown on soils with **light texture** (sands, loamy sands and sandy loams) with **low organic matter**, high to very high pH (>7.8) and a **soil test** (measured by DTPA) **of less than 0.4 ppm** (0.8 lb/acre in 0-6” depth or 1.2 lb/acre in 0-12”). Rarely would a whole field be deficiency in its entirety.

#### ***Iron (Fe) and Molybdenum (Mo)***

Iron and molybdenum are the two least researched micronutrients in prairie soils primarily because the parent material from which these soils have been developed is rich in these micronutrients. There are anecdotal reports of calcium induced iron chlorosis in trees and garden vegetables in certain areas as well as Cu-Mo imbalances in east central Saskatchewan and west central Manitoba due to excessive levels of Mo in pasture soils that result in molybdenosis in cattle (Stewart and Racz 1977). No calibration work has been carried out on these two micronutrients.

***When Should We Use Iron and Molybdenum?*** On agricultural crops, **never**.

#### ***Manganese (Mn)***

Responses of common crops to manganese on mineral soils in the prairies are extremely rare. Therefore, researchers have been unable to compile enough soils and/or sites to carry out calibration work. On the contrary, extensive work has been carried out on organic (peat) soils in all three Prairie Provinces (Reid 1982; Loewen-Rodgers et al. 1983; Karamanos et al. 1985a; Karamanos et al. 1991; Hartman 1992). Karamanos et al. (1985a, 1991) have proposed the use of Mn/Cu ratio to assess the status of organic soils in these two micronutrients. Ratios of Mn/Cu less than 1 indicate Mn and those above 15 Cu deficiency, respectively. This approach, however, requires modification of the extraction ratio used in the DTPA method from 1:2 to 1:5 soil:DTPA-extractant. Germida et al. (1985) developed a simple microbial bioassay to assess the manganese status of organic soils.

***When Should We Use Manganese?*** On well-drained **peat** soils **with very low Mn levels** (<5 ppm), especially if high Cu fertilizer rates are used.

## Zinc (Zn)

Extensive work on Zn was carried out with beans in Alberta (McKenzie et al. 1999), beans and flax in Manitoba (Loewen-Rodgers 1983; Goh and Karamanos 2004) and a variety of crops in Saskatchewan (Karamanos et al. 1984b; Kruger et al. 1984; Singh 1986; Singh et al. 1987). Singh et al. 1987 carried out 17 field trials on soils containing as low as 0.25 ppm DTPA-extractable Zn but were unable to verify the commonly used critical level of 0.5 ppm as a valid criterion to assess cereal responses to Zn. Since responses could not be obtained with cereals on soils containing as low levels of Zn as 0.25 ppm, the authors concluded that the critical level for cereals (except corn) on prairie soils is no greater than 0.25 ppm. In subsequent studies using <sup>65</sup>Zn and fractionation techniques, Liang et al (1990; 1991a) demonstrated that DTPA is unsuitable for assessment of “available” Zn in Saskatchewan soils. However, no further work has since been carried out to derive an appropriate criterion for assessing “available” Zn in prairie soils. Undoubtedly, lack of responses of common crops to Zn provided no incentive for further research in this area. McKenzie et al. 1999 derived a critical level of 3.0 ppm in coarse soils and 1.5 ppm in medium to fine soils dry bean production under irrigation in southern Alberta. However, earlier work with irrigated wheat, barley and canola in southern Alberta showed no responses of these crops to Zn (McKenzie and Middleton 1991).

***When Should We Use Zinc?*** On **beans** and possibly **corn** grown under irrigation on soils with **light texture** (sands, loamy sands and sandy loams) with **low organic matter**, high to very high pH (>7.8) and a **soil test** (measured by DTPA) of **less than 0.5 and 0.25 ppm** (1 lb/acre in 0-6” depth or 2 lb/acre in 0-12”) , respectively.

### ***Summary of Interpretive Criteria for Western Canadian Prairie Soils***

Results of calibration work of micronutrient soil tests carried out in western Canada are summarized in Table 1.

Table 1. Soil testing criteria for assessing “available” micronutrients in prairie mineral soils.

Nutrient	Extraction method	Crop(s)	Level, ppm	Description	Comments	Economic benefit
Boron	Hot-water	All	Unknown	Inappropriate method of assessment	Criterion of 0.35 ppm irrelevant	None
Copper	DTPA <sup>1</sup>	Cereals	>3.5	Toxic	Unconfirmed	--
			<0.4	Deficient	Sandy to loamy soils	60-80% probability >95% when <0.2 ppm
			0.4-0.6	Marginal	No economic benefit	<10% probability
Manganese	DTPA	All	0.25-0.4	Marginal	No economic benefit	None
			Unknown	Criterion of 1 ppm irrelevant	None on mineral soils	
Zinc	DTPA	Cereals, oilseeds	<0.25	Marginal	Inappropriate method of assessment	<10% probability
			<0.5	Deficient		75% probability
			<0.5	Marginal		50% probability

<sup>1</sup> Lindsay (1991)

### ***Plant Analysis***

Calibration work for plant tissue test criteria with western Canadian varieties and under prairie conditions is extremely limited. Provincial soil fertility sub-councils or sub-committees and individual laboratories have derived a variety of criteria from research in other regions of North America or the world and with some varieties that may be irrelevant to western Canada. Oddly enough some “provincial” criteria thus derived appear very strongly impeded in today’s agronomic practices in the prairies. Karamanos et al. (1984a) were successful in deriving diagnostic criteria for manganese in oats, but Karamanos et al. (1986) and Penney et al (1993) were not successful in establishing plant tissue tests for copper in cereals, canola and flax in western Canada. Therefore, much work is needed in this area if “relevant” plant tissue criteria for western Canada are to be derived. Thus, plant tissue analysis is of use only when “good” and “bad” parts of a field are compared and even that with extreme caution.

### ***Micronutrient Products***

Although this presentation does not deal with correction of micronutrient deficiencies, a summary of the recommended methods of application of some general categories of products is provided in Table 2.

### ***Are Micronutrients Needed on Micronutrient Sufficient Soils for “Optimum” Balance to Achieve Maximum Yields?***

A number of either soil or foliar applied multi-micronutrient products that are extensively used in other parts of the world have penetrated the western Canadian market based on the premise that their use aids a holistic approach to growing crops. Further claims address an optimum “balance” of all nutrients and especially micronutrients in achieving maximum yields. Indeed an optimum balance of applied nutrients may be of extreme importance in many parts of the world but very little information does exist for western Canadian conditions.

We carried out thirteen experiments with wheat and twenty-one with barley from 1989 to 1994 to ascertain whether “targeted” or “non-targeted” use of a single 5 lb/acre foliar application between tillering and boot stage of 15-20-20 (also containing 2% S, 0.15% Cu, 0.01% Fe, 0.01% Mn, 0.08% B, 1% Zn and 0.0005% Mo) provided an effective means of alleviating micronutrient deficiencies or simply increased yield due to a “balanced” nutrition.

A single application of 15-20-20 to wheat and barley crops resulted in statistically significant yield increases in two of thirteen, five of twenty-one, respectively.

Economic returns, excluding application cost, are shown in Figures 1 and 2. “Non-targeted” application of micronutrient mixes at all sites to provide a “balanced” nutrition of crops proved both agronomically inefficient and economically nonviable under western Canadian conditions. Yield increases were both small and unpredictable even when exceptionally high yields were obtained and are similar to those obtained in a study with 23 experiments where two cent coins were thrown on a plot to simulate a \$5.50 per acre treatment” (Figure 3) and were contrasted to an “untreated” control, i.e., they represent random events not related to the treatment.

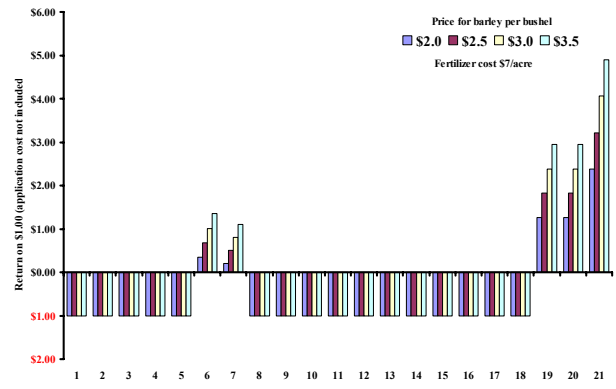
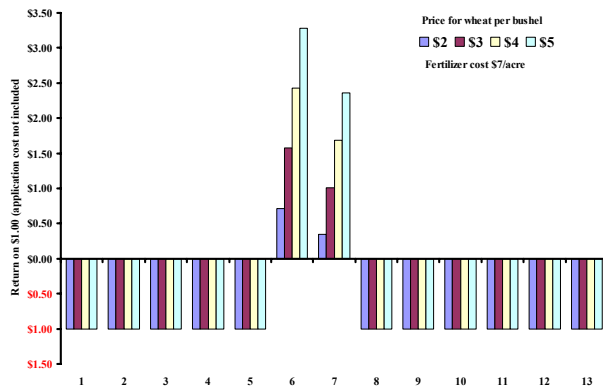


Fig. 1. Responses of barley to foliar application of 15-20-20.

Fig. 2. Responses of barley to foliar application of 15-20-20.

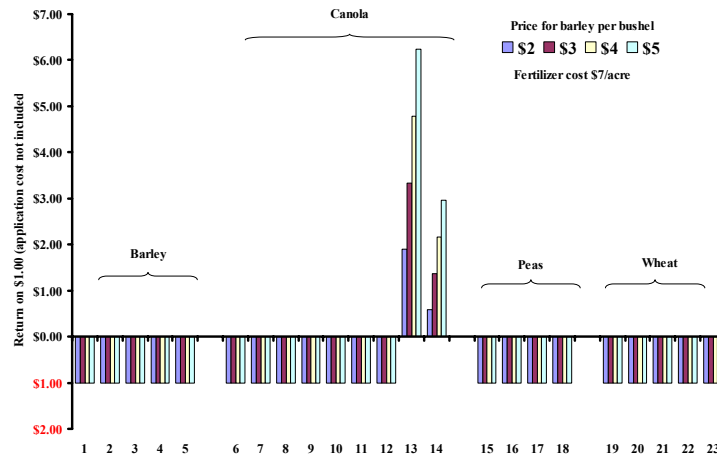


Fig. 3. Responses of crops to “two-penny” per plot treatment.

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Table 2. Recommended methods of application of generalized categories of micronutrients products.

Nutrient	Fertilizer form	Time of soil application	Broadcast & Incorporate	Band	Seed-place	Foliar	Selected References
Copper	Sulphate	Spring or fall	3.5 –5 lb Cu/acre	Not recomm.	Not recomm.	Not recomm. <sup>1</sup>	Karamanos et al. 1985b; 2005 Karamanos et al. 1986 Penney et al. 1988
	Oxysulphate >60% solubility	Fall	5 lbCu/acre	Not recomm.	Not recomm.	Not recomm.	Karamanos et al. 1986; 2005
	Oxysulphate <50% solubility	Spring	0.5 lb Cu/acre <sup>2</sup>	Not recomm.	0,25-0.5 lb Cu/acre <sup>3</sup>	0.2-0.25 lb Cu/acre <sup>4</sup>	<sup>2</sup> Karamanos et al. 1985b; 1986; <sup>4</sup> 2004 and Penney et al. 1988 <sup>3</sup> Pomarenski et al. 2003
Zinc	Sulphate	Spring or fall	3.5 –5 lb Zn/acre	Not recomm.	Not recomm.	Not recomm.	Singh et al. 1987; Goh and Karamanos 2004
	Oxysulphate <50% solubility	Fall	5-10 lb Zn/acre	Not recomm.	Not recomm.	Not recomm.	Westfall et al. 1998
	Chelated	Spring	1 lb Zn/acre	Not recomm.	Needs verification	0.3-0.4 lb Zn/acre	Karamanos et al. 1984b Singh et al. 1986; Goh and Karamanos 2004
Manganese	Sulphate	Spring	50-80 lb Mn/acre <sup>5</sup>	Not recomm.	4-20 lb Mn/acre	Not recomm.	Karamanos et al. 1984a Karamanos et al. 1985 b Karamanos et al. 1991
	Chelated	Spring	Not recomm.	Not recomm.	Not recomm.	0.5 – 1 lb Mn/acre	Karamanos et al. 1984a Karamanos et al. 1985 b Karamanos et al. 1991
Boron	Sodium Borate	Spring	0.5 –1.5 lb B/acre	Needs verification	Not recomm.	0.3 – 0.5 lb/acre	Karamanos et al. 1984a;

<sup>1</sup>Although foliar applications of copper sulphate are effective, the product is extremely corrosive.

<sup>5</sup>Broadcast and incorporated rates of manganese are generally uneconomical.