Micronutrients and Our Soils

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Introduction

Total quantities of micronutrients used in crop nutrition are small as evidenced by the data of Table 1 for a corn yield of 10,000 kg/ha. These are average values from several sites throughout the north central region of the U.S. There is no certainty that the amounts expressed are actually required since luxury consumption may have been involved with some of the elements in the plants analyzed. In farming situations where only grain is removed the depletion rate for most is small indeed, especially with substantially lower yields of grain crops than for this high yielding corn.

Table 1. Quantities of micronutrients needed(?) for a corn crop of 10,000 kg/ha

Element	Grain	Stover
	kg	
B	.04	.12
Cl	Trace	Trace
Cu	.02	.08
Fe	.10	1.8
Mn	.05	.25
Mo	.005	.003
Zn	.17	.17

Wide variations exist in the amounts of micronutrients found in different rock materials in the earth's crust and the ultimate soils developed thereon (Table 2). Considering amounts removed by crops from the Table 1 example it would seem that plenty reserves of several of the nutrients exist in soils for at least hundreds of years of cropping. Total quantity of nutrient in soil, however, is an uncertain indicator of nutrient availability to a crop and rather soil chemical and crop physiological phenomena dictate whether or not sufficiency exists with a given soil/crop combination.

Table 2. Abundance of micronutrients in rock and soil materials (after Krauskopf)

Element	Igneous Rocks		Sedimentary Rocks			
	Granite	Basalt	Limestone	Sandstone	Shale	Soils
	ppm					
B	15	5	20	35	100	7-80
Cu	10	100	4	30	45	10-80
Fe	27,000	86,000	3,800	9,800	47,000	10,000-100,000
Mn	400	1,500	1,100	10-100	850	20-3,000
Mo	2	1	.4	.2	2.6	.2-10
Zn	40	100	20	16	95	10-300

Substantial research was done on micronutrient needs of crops in Nebrask during the 1950's and into the 1960's when this was the 'in' thing to do. Results from these studies, however, showed that micronutrient deficiencies for optimum yields occurred only on a very small percentage of the state's arable lands. Such deficiencies were obviously of major significance to the limited soil areas involved, but with nutrient limitations to yield being more commonly associated with N and/or P the soil fertility research of the state in recent times has focused primarily around those two elements.

Although farmers have received recommendations for use of several of the micronutrients, soil fertility investigations have revealed positive evidence of deficiency and crop response only to the elements Zn and Fe in certain Nebraska soils to date. There is some further shaky evidence of B shortage for alfalfa and sugar beets under very isolated soil conditions. Accordingly the staff of the Nebraska Experiment Station are convinced that the issue of micronutrient needs has been exaggerated in our state where the major portion of the arable area is constituted of soils developed on deep loessial material. Where problems do exist soils are usually very sandy and low in organic matter content, highly calcareous to the surface, compacted, saline, or sodic (alkali) in character.

Zinc

Zinc deficiency was first recognized and corrected by Zn fertilization in Nebraska in 1955. Crops which have evidenced need for supplemental Zn are especially corn and field beans with some recorded responses of grain sorghum and soybeans. Alfalfa, wheat and spring small grains have proved much more tolerant such that no responses have been found in research trials conducted to date. Sources of the element are native soil minerals, the small amount in exchangeable form on the soil's exchange complex, that contained in animal and crop residues returned to the soil, and that applied as fertilizer. Amounts involved in the total crop even for high-yielding crops are small indeed, e.g., in the order of 11 ounces/ha for a 10,000 kg/ha corn crop (Table 1).

Shortage of the element has been recognized most extensively on highly calcareous soils of low organic matter content and especially where compacted by land grading for irrigation or conservation practice. Very sandy soils low in organic matter, both acid and calcareous, are also suspect when brought under intensive irrigated corn production. The addition of high P rates to soil of marginal Zn availability is known to accentuate the Zn nutrition problem.

Zinc fertilizer is marketed in several different chemical forms that can be categorized as follows: organic chelates, organic non-chelates, insoluble inorganics, and soluble inorganics. Agronomic effectiveness of the different forms has varied with soil condition and application method, and a wide range exists among the various materials in cost per unit of Zn. The insoluble inorganics like ZnO and $ZnCO_3$ are least expensive but quite ineffective unless very finely divided. Because of the difficulty in uniformly spreading a small quantity of such finely ground material it gives best performance when adsorbed onto the surface of granulated or suspension primary fertilizer material to be applied. They have performed well also in polyphosphate solutions, with Zn additions up to 2% of the total material. The soluble inorganics like $ZnSO_4 \cdot x\ H_2O$ serve effectively as Zn fertilizer, but also need to have rather fine particle size for uniform crop accessibility due to the low mobility of the Zn ion in soil. Some fertilizer N provided in the zone of inorganic Zn placement in the soil has also proved beneficial to crop uptake of the element.

Insofar as mobility in soil is concerned the non-chelated organics evidence no more movement than the inorganics, but the chelated organics move readily in the direction of soil moisture flow. Because of this characteristic the common Zn chelates on the market will provide a maximum crop response with a notably lower rate of Zn applied. Most studies suggest an approximate 4-5 times greater utilization efficiency than inorganics per unit Zn with a smaller ratio for sandy soils, but residual effects are substantially less with the chelates. Cost effectiveness thus dictates that price for the chelated Zn unit should not exceed 4-5 times that of the inorganic as a general rule.

Zinc carriers may be broadcast and incorporated into the seed zone before planting or be applied in a band near the seed row. Recommended rates in accordance with soil test value for broadcast inorganic Zn carriers are presented in Table 3. When banded near the row along with some N about half these amounts are recommended. Suggested chelate rate is 1/4 to 1/5 that of inorganics although chelates are not recommended for calcareous soils. A further oft-noted factor is that field beans are more likely to respond to Zn when following sugar beets than after any other crop.

Table 3. Soil test Zn values and suggested rates of inorganic Zn for corn and field beans.

Soil test level	DTPA Zn soil test	UNL Zn index test[1]	Zn rate to apply Calcareous Soils	Zn rate to apply Acid Soils
	ppm	ppm	kg	kg
Low	< 0.5	< 3	11 - 16	5 - 8
Medium	0.6 - 1.0	3.1 - 4.5	6 - 11	3 - 5
High	> 1.0	> 4.6	0	0

[1] Test involves extraction with 0.1 N HCl at 1:25 soil solution ratio. Shaking time is 1/2 hour following 16 hours equilibration. Index is ppm Zn adjusted to a common sum of cation value of 25.

Iron

Iron chlorosis of several crops and many ornamental plants has been a long recognized problem throughout the Great Plains, including western Nebraska. The soils involved generally contain large amounts of total Fe and deficient plants usually are high in total Fe indicating that the phenomenon exists from reactions within the plant and not from lack of Fe in the soil. For this reason, soil applications of most Fe compounds are not very effective on a field scale with rates and carriers that are economic to the farmer. Provision of acidifying material along with iron products in the zone of placement has given good results in some cases, likewise incorporation of the salt in a polyphosphate solution, but inconsistencies in responses have precluded the provision of firm recommendations for such soil treatments. It has not been possible to calibrate an Fe soil test effectively in Nebraska to date, so where Fe testing is attempted the DTPA extraction developed by Colorado State University is employed using the calibrations established for that state (Table 4).

Table 4. Nebraska Fe Recommendations

DTPA Soil Test ppm*	Soil Test Level	
< 2.5	Low	(Foliar 1-2% solu. ferrous sulfate, (Fe-138, Hamp-Iron 845 in 20-40 (gal. water/ha. Over row early (and often as needed.
2.6-4.5	Med	
> 4.5	High	----

*Values tenuous; usually best to base decision on crop appearance (chlorosis).

Chlorosis due to Fe occurs almost without exception on calcareous soils in Nebraska. Salinity along with the excess lime presence accentuates the problem as does cool, wet weather during the early part of the growing season. Most susceptible crops to the malady are grain sorghum, field beans and soybeans among those commonly grown in this state. Rarely is Fe deficiency observed in alfalfa, wheat, and spring small grains even on highly calcareous soils and only certain corn hybrids have proved susceptable. In fact, it is not uncommon to observe Fe deficiency symptoms in grain sorghum and Zn deficiency in immediately adjacent corn on the same soil.

Chemical carriers of Fe include inorganic $FeSO_4 \cdot 7H_2O$, IronSul (jarosite + H_2SO_4), and a number of Fe chelates. Best fertilizer responses occur with foliar application which should be started early in the crop season and continued as many times as needed to eradicate the deficiency symptoms. An approximate 1% solution is normally employed providing 1-2 kg Fe/ha. Spray mechanism needs to be positioned to effect as complete coverage of the plant as possible, requiring from 22-44 gallons/ha.

The Fe problem in crop nutrition, however, remains an enigma. Where possible, the best resolution is to change to a less susceptible crop on those soil situations where Fe chlorosis is known to occur.