What's new with micronutrients in our part of the world?

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Introduction

The importance of micronutrients for production of a variety of crops in the North-Central region of the U.S. has been recognized for many years. When needed, these essential nutrients can have a substantial positive impact on production. However, neither the need for nor the importance of each micronutrient is universal across the region. Importance (need) is greatly affected by crop, soil properties, and production environment.

With traditional thinking over the years, thoughts have focused on band, broadcast, or foliar applications. There are always questions about source and rate. There are, however, some new questions and ideas about the use of micronutrients in fertilizer programs for modern crop production. In contrast to concerns about management of nitrogen, phosphate, and potash in various production environments, micronutrient management has not recently been the focus of many soil fertility research programs.

Approach

Rather than focus on details of one or more research projects, this presentation will attempt to take a quick look back; then, consider what might be in the future for micronutrient management as indicated by results of recent research efforts.

Time does not allow for a discussion of more recent research with all micronutrients. The majority of the more recent research activity has focused on the application of zinc (Zn) and iron (Fe). So, the majority of the discussion will deal with these two micronutrients with some mention of manganese (Mn) and copper (Cu). Research activity with boron (B) has been dormant and this micronutrient will not be included in the discussion.

Small Amounts: Substantial Response

Any nutrient required in small amounts to achieve optimum plant growth is, by definition, a micronutrient. This is illustrated by two examples. In the first, zinc was applied in a suspension fertilizer in a band close to the seed and corn was grown in a field where the soil test for zinc was classified to be very low (0.30 ppm with the DTPA extractant). (Table 1).

The response to zinc, regardless of source, was substantial. Yield was doubled by the low rate of 0.1 lb. zinc per acre. It would not be realistic to expect a response of this magnitude in all corn fields where a need for zinc is indicated via soil testing. These results illustrate the value of very low rates when a micronutrient is deficient. When soil testing shows a need, the application of a micronutrient, zinc for example will be profitable.

In this research, uptake of zinc by young corn plants was also measured (Table 1). Uptake calculated in terms of micrograms of zinc per plant increased as the rate of applied zinc increased. The effect of rate of applied zinc on uptake did not parallel the effect on yield.

When averaged over all rates applied, uptake was greater when EDTA was used. Uptake from the other sources was about the same. Zinc uptake, however, does not correspond to yield. There is research data to show that zinc uptake is highly influenced by the probability of root incorporation. Therefore, greater uptake can be expected when either fluid grades or suspensions are used.

A second example is summarized in Table 3. In this study, manganese was applied in a band for soybean production. The numerical value for the soil test for manganese is not known. There can also be some question about optimum rate. Optimum yield may have been achieved with a rate of manganese lower than 10 lb. per acre.

Banded Application Popular For Corn

In general, the broadcast or banded application of micronutrients has been the most popular method of application when soil testing indicates the need. With the increasing popularity of fertilizer placed near the corn seed at planting, there is also the opportunity to apply zinc in this way. This near seed placement usually involves the use of fluid materials and the corresponding evaluation of fluid zinc sources was needed.

Those evaluations are in progress in Minnesota in a study initiated in 2005. For this study, these fluid sources of zinc (Nulex, Tra-Fix, Origin) were applied with 10-34-0 either in contact with the seed or on top of the seed at rates to supply 0.1 and 0.5 lb. zinc per acre. When applied on top of the seed, there was approximately 0.5 inches of soil between seed and fertilizer.

Corn emergence was evaluated by counting plants in 20 ft. of row at four to five weeks after emergence (Table 4). The emergence is reported as % of the control which was 10-34-0 without zinc applied at a rate of 5 gallons per acre in contact with the seed. Neither zinc source, rate of zinc applied, nor placement had a significant effect on emergence. For most treatments, emergence was 95% or more of the control. Based on the results of this study conducted in 2005 and repeated in 2006, it appears that the three fluid sources of zinc that were evaluated had no negative effect on emergence.

Corn yields from this study are summarized in Table 5. The soil test for zinc was 1.2 ppm (DTPA extraction). A yield increase from applied zinc was not expected and none was measured. Likewise, in the absence of a significant effect on emergence, a reduction in yield was not expected and none was measured.

The observations gathered from this study in 2006 are in general agreement with the measurements of 2005. It appears that mixing zinc sources with 10-34-0 and placement of this mixture near corn seed at planting would be a good alternative to broadcast applications that would involve the use of higher rates of zinc.

Table 1. Influence of rate of applied zinc on corn yield and uptake of zinc by young corn plants.

Zinc Applied	Yield	Zinc Uptake
lb. /acre	bu./acre	micrograms/plant
0	62.1	120
0.1	130.7	180
0.3	136.6	223
1.0	139.6	258
3.0	142.0	392

Table 2. Zinc uptake by young corn plants as affected by zinc source.

Source	Uptake
	micrograms per plant
EDTA	388
Nulex	220
zinc oxide	218
zinc sulfate	225

Table 3. Influence of manganese applied in the row on yield of soybeans.[1]

Rate Applied	Yield
lb./acre	bu./acre
0	45
10	61
20	62
40	63

[*] applied as manganese sulfate

[1] soil test for manganese was low

Table 4. Emergence of corn grown on a silty clay loam as affected by rate and placement of three sources of zinc. 2005.

	Zn Rate (lb./acre) and Placement			
	0.1		0.5	
Source	With Seed	Top of Seed	With Seed	Top of Seed
	- - - - - - - - - - % of control - - - - - - - - - -			
Nulex	89.1	100.6	95.5	96.8
Tra-Fix	93.0	98.7	94.2	88.5
Origin	98.7	97.4	93.0	94.2

emerged population of control (no zinc) = 33,977 plants/acre

A Place for Foliar Applications

Foliar application of plant nutrients has always been of interest to researchers in the discipline of soil fertility and plant nutrition. Although the concept always seems to have merit, this practice is not widely used for the application of the macronutrients. Since requirements for micronutrients are much smaller, there have been questions about the use of this method of application.

Except for the inconsistent effect of foliar application of iron to the soybean crop when Iron Deficiency Chlorosis is a problem, foliar application of micronutrients has not been a common practice for either corn or soybean production. Yet, in recent years, there had been several reports of the positive benefits of micronutrients applied for small grain production. These reports had come from ag professionals working with a variety of growers.

Since these reports appeared to be valid, trials were conducted with hard red spring wheat in northwestern Minnesota to compare the effect of foliar applied micronutrients to soil applied micronutrients. Rather than focus on one micronutrient, the trial involved the application of various combinations of Fe, Cu, Mn, and Zn.

The micronutrients were applied as the sulfate salts when broadcast and incorporated before planting. With this method of application, the rate of each micronutrient was 10 lb. per acre. The chelate sources were used for the foliar application. For this method, each micronutrient was applied at a rate of 1.0 lb. per acre. Adequate N, P_2O_5, and K_2O were used for all treatments. The foliar application was made when the spring wheat was at the tiller stage of development.

The study was conducted at three locations and the results were consistent across locations. The data from the Northwest Research and Outreach Center will be used for this report.

Analysis of soil samples for micronutrients (DTPA procedure) showed concentrations of 5.5 ppm for Fe, 1.1 ppm for Cu, 13.4 for Mn, and 0.4 ppm for Zn. Because of very limited research with micronutrients for spring wheat production, the relative level for each of these values is not known.

Grain yields from this trial are provided in Table 6. When averaged over all treatments, yield was slightly lower from the foliar applied treatments: 51.5 bu/acre (foliar) vs. 55.3 bu./acre (soil applied). This reduction in average yield is attributed to the low yield of treatment #5 in the foliar treatments.

Considering the soil applied micronutrients, there was no significant difference among treatments. If yield was not reduced when a micronutrient is not included in the fertilizer program, this micronutrient is not required for optimum yield.

With foliar application, there was a significant yield reduction when Zn was not included (treatment #5). Yet, this reduction was not recorded when none of the micronutrients were applied (treatment #6). There was substantial leaf burn in treatment #5; but not in the other treatments. The leaf burn probably is responsible for the yield reduction. However, the cause of this burn is not known.

Seed Coating Is Another Concept

The need to apply small amounts of a needed micronutrient in a manner so that it is accessible to all plants grown on any given area is a dilemma in fertilizer management. This need might be difficult to achieve if dry materials containing the needed micronutrient are broadcast and incorporated before planting. The problem may diminish if the micronutrient is mixed with a fluid fertilizer, 10-34-0 for example, and applied in a band near the seed at planting. Another approach if economical, would be to coat the seed with the needed micronutrient. This approach has been used in recent years to address two problems. One is Iron Deficiency Chlorosis in soybeans. The second is zinc deficiency in corn.

The coating of soybean seed with iron has been evaluated in recent years. Chelated iron materials are chosen because of ease of handling in the coating process and relatively high solubility in most soils. A summary of one study is provided in Table 7. Planting of this study in 2004 was delayed because of excessive rainfall in late May and June. Planting was complete on June 21 followed by a killing frost on August 25. This set of circumstances eliminated yield measurement; but, iron uptake was measured. The first whole plant samples were collected at the 4th trifoliate stage of development. The second whole plant samples were collected at early bloom.

In this study, either EDDHA-Fe or DTPA-Fe was coated on soybean seed to supply 0.25, 0.50, 0.75, and 1.00 lb. Fe per acre if the seeding rate was 200,000 seeds per acre. The experimented site was in a field where Iron Deficiency Chlorosis had been a persistent problem.

The increase in uptake with an increase in the rate of application is evidence that the iron from both sources coated on the seed was taken up by the soybean plant. Comparing sources, uptake was generally higher when the EDDHA-Fe was used. Based on the results of this and other trials, the coating of seed appears to be an effective way to supply iron when Iron Deficiency Chlorosis is a problem. The challenge is to make this practice cost effective.

The concept of coating seed with a micronutrient has also been evaluated for corn production at one location in 2005. For this study, a zinc product from Agriliance was coated on corn seed at rates of 4 and 8 ounces per 100 lb. seed. The effect of the coating was evaluated with and without the application of zinc in a band placed with the seed at planting. For a system where dry materials were used, zinc sulfate was mixed with 18-46-0. For a system using fluid materials, Origin-Zn was applied with 10-34-0 in contact with the seed. When applied in a band at planting, the rate of zinc was 0.5 lb. per acre for all zinc sources.

At this site, application of zinc either on the seed or in a band at planting increased corn yield.

Results, however, were not conclusive when a single application either on the seed or in a band are compared. It appears that a combination of seed treatment and banded application was not needed for optimum yield. The results of this study show that the practice of coating the corn seed with zinc shows promise. This technology may be especially important for growers who need zinc in a fertilizer program but are not equipped to apply banded zinc.

Table 5. Yield of corn grown on a silty clay loam as affected by rate and placement of three sources of zinc. 2005.

	Zn Rate (lb./acre) and Placement			
	0.1		0.5	
Source	With Seed	Top of Seed	With Seed	Top of Seed
	- - - - - - - - - - bu./acre - - - - - - - - - -			
Nulex	218	211	213	204
Tra-Fix	201	207	213	200
Origin	210	205	201	217

Yield of control (no zinc) = 209 bu./acre

Table 6. Influence of soil and foliar application of micronutrients on the yield of hard red spring wheat.

Micronutrient Applied				Soil Application[1]	Foliar Application[2]
Fe	Cu	Mn	Zn		
				bu./acre	
yes	yes	yes	yes	54.7a*	59.8a
yes	no	yes	yes	54.7a	48.8b
no	yes	yes	yes	56.9a	52.7a
yes	yes	no	yes	56.2a	52.4a
yes	yes	yes	no	56.6a	41.4c
no	no	no	no	52.9a	53.9a

* Treatment means in each column followed by the same letter are not significantly different at the .05 confidence level.

[1] Rate of each micronutrient was 10.0 lb./acre

[2] Rate of each micronutrient was 1.0 lb./acre

Table 7. Effect of chelated iron source on uptake of iron by soybean plants.

	Iron Source and Sampling			
	4th trifoliate		early bloom	
Rate of Iron Applied	EDDHA	DTPA	EDDHA	DTPA
lb./acre	- - - - - - microgram Fe/plant - - - - - -			
	- 240 -		- 563 -	
0.25	262	271	527	462
0.50	274	319	600	440
0.75	334	291	582	599
1.00	455	291	842	481

Changes In Soil Test Interpretation

Application of zinc, copper, and manganese for crops, when needed, has generally been based on results of soil tests. In the North Central region, the DTPA extractant is commonly used. In recent years, there has been no noted change in either the definition of relative levels or suggested rates of application. The definition of relative level varies with state. The guidelines for 3 states in the region illustrate this variability (Table 9).

Herbicide Interactions

Until recently, the possibility that micronutrients may interact with herbicide application – especially the application of Roundup was not considered. Results of recent trials conducted in Kansas suggest that glyphosate-resistant soybeans respond differently to applied manganese than conventional soybeans (Table 10).

In this study, a glyphosate-resistant variety (KS4202 RR) was grown with the conventional isoline (KS4242) and manganese sulfate was broadcast and incorporated to supply 0, 2.5, 5.0, and 7.5 lb. Mn/acre. There was an interaction between variety and rate of manganese. For the glyphosate-resistant variety, yields increased with Mn addition up to the 5.0 lb. per acre rate. Yield of the conventional variety declined with increasing Mn rate. Concentration of Mn in the upper most expanded trifoliate at full bloom in the resistant variety was less than half of the conventional variety when no Mn was applied. The results of this study raise questions about the possible interaction of glyphosate with Iron Deficiency Chlorosis. Studies are currently in progress to evaluate this potential interaction.

Summary

Considering research activity in recent years, there have not been substantial changes in micronutrient management. Application methods essentially remain as they were in past years. There have not been substantive changes in either the definition of relative levels or suggested rates of application.

There has been, however more interest in mixing with fluid fertilizer for banded application. The ability to coat seed with a micronutrient is a new concept that deserves further investigation. There are challenges ahead for the management of micronutrients. These challenges offer an excellent opportunity to conduct research with this important group of nutrients.

Table 8. Corn grain yield as affected by zinc coated on the seed with and without zinc applied in a band.

Seed Coating Rate	Banded Zinc Source	Yield
oz/100 lb. seed		bu./acre
0	0	143
0	Origin	149
0	Zinc Sulfate	150
4	0	162
4	Origin	153
4	Zinc Sulfate	150
8	none	146
8	Origin	165
8	Zinc Sulfate	157

Soil Zn extracted by DTPA = 1.1 ppm

Table 9. Relative levels for zinc soil tests and corresponding guidelines for zinc application for three states in the North-Central region.

State	Relative Level[1]	Zinc to Apply for Corn	
		Band	Broadcast
	ppm	----- lb. zinc/ -----acre	
Illinois	< 1.0 (low)	--	--
	> 1.0 (adequate)	--	--
Iowa	0.0 to 0.4 (low)	2	10
	0.5 to 0.8 (marginal)	1	5
	0.9+ (adequate)	0	0
Minnesota	0.0 to 0.25 (very low)	2	10
	0.26 to 0.50 (low)	2	10
	0.51 to 0.75 (medium)	1	5
	0.76 to 1.00 (high)	0	0
	1.01+ (very high)	0	0

Table 10. Interaction between soybean variety and manganese application as indicated by yield and manganese concentration in the trifoliate tissue.

	Variety			
	KS4202		KS4202 RR	
Mn Applied	**yield**	**concentration**	**yield**	**concentration**
lb./acre	bu./acre	ppm	bu./acre	ppm
0	76.9	75	64.9	32
2.5	76.1	80	72.8	72
5.0	74.9	92	77.6	87
7.5	72.6	105	77.6	95