Economics of Micronutrients

Dave Franzen PhD
NDSU Extension Soil Specialist
There are 118 elements known on earth.

17 elements are essential for plants to grow, develop and reproduce.

A few others are needed for specific plants.
Of the 17,

3 (CHO) come from water (H\textsubscript{2}O) and air (CO\textsubscript{2})

The remaining 14 are mineral elements that are extracted by plants from the soil-
Nitrogen
Phosphorus
Potassium
Sulfur
Calcium
Magnesium
Chlorine
Zinc
Manganese
Iron
Copper
Boron
Molybdenum
Nickel
Nitrogen
Phosphorus
Potassium
Sulfur
Calcium
Magnesium
Chlorine
Zinc
Manganese
Iron
Copper
Boron
Molybdenum
Nickel

MACRONUTRIENTS
Nitrogen
Phosphorus
Potassium
Sulfur
Calcium
Magnesium
Chlorine
Zinc
Manganese
Iron
Copper
Boron
Molybdenum
Nickel

SECONDARY NUTRIENTS
Nitrogen
Phosphorus
Potassium
Sulfur
Calcium
Magnesium
Chlorine
Zinc
Manganese
Iron
Copper
Boron
Molybdenum
Nickel

MICRONUTRIENTS
Deficiencies of micronutrients occur around the world.

What is needed in one part of the world is not needed in another part due to-

- Parent material  
  (what elements are in the soil minerals)
- How long the soil has been farmed  
  (100 years in North Dakota compared with 5,000+ years in central Turkey)
What micronutrients might we expect to see in North Dakota?

What crops are susceptible?

Share micronutrient data on various crops.
Zinc-

Research has identified four ND crops with zinc deficiencies -

Potato

Corn

Dry edible beans

Flax
Potato-


Deficiency symptoms and correction by Zn fertilizer was also recorded by Grunes et al., 1961, Agron. J. 53:68-71 on a shaped Gardena loam near Upham.
Zinc deficiency first recorded on corn in ND by Grunes et al, 1961 (AJ 53:68-71). Unlike potato in the same study, corn symptoms were much more severe and occurred even in undisturbed soil.

Zn fertilizer improved corn yields by 24 bu/acre
Corn-

Low zinc soil (Hamar lfs) in Richland Co., 1966-
No zinc 123 bu/acre
2 lb/acre Zn as zinc sulfate broadcast- 131 bu/acre

Similar soil, different experiment, 1966
no zinc 127 bu/acre
1 lb/acre banded zinc (Zn EDTA) 140 bu/acre
Corn-

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1 lb/acre banded zinc (Zn EDTA) 140 bu/acre

Reported by Wagner and Bauer, 1970 NDAA fertilizer conference, Fargo.
Corn-

Bauer, 1968 Farm Research, showed yield increases in 3 of 6 field experiments in SE North Dakota with the application of zinc.
Corn and Zinc-

There are differences in varietal response and susceptibility.

A warmer spring would be expected to show less deficiency.

Banded materials are more efficient than broadcast and foliar treatments are a last resort application.
Typical corn responses to low zinc (less than 1 ppm) would be about 10%.

Without zinc example - 140 bu/acre
With zinc example – 154 bu/acre
$ benefit@ $6/bu corn - $84/acre

Cost of zinc banded - 1 qt/acre - ~ $5/acre/yr
30 lb 36% zinc broadcast @$1/lb ~ $30/acre would last about 10 years.
Dry Bean-

There is a lack of hard local data on dry bean yield response to zinc, although Moraghan and Grafton, 1999, said that the varieties that they used in their experiment showed zinc deficiencies in North Dakota.

Nearly every major dry bean producing state has reported zinc deficiency and improvements in yield with zinc application- WY, MT, CO, MI, MN
Dry Bean-

One five-site study by Dahnke (1982 CPG)
no zinc- 1588 lb/acre
with zinc- 1688 lb/acre
Flax-

Zubriski has the first recorded data on zinc response by flax in ND.

Casselton, ND, 1963-
No zinc- 22 bu/acre
With zinc- 23 bu/acre
Flax-

Moraghan generated most of the flax/zinc data in ND, but little field yield data was produced.

Deficiency is “chlorotic dieback”- a yellowing or whitening of the growing point.

H.H. Flor, NDSU plant pathologist, described chlorotic dieback as common in the RRV, but was unable to diagnose the cause (AJ 1943).
Several Australian papers related growth problems of flax similar to those described by Flor as zinc related.

Moraghan (AJ, 1970) confirmed that the cause of our flax growth problems was zinc.

Further work by JTM in the greenhouse validated earlier studies. These were not followed up with field studies.
Zinc on other crops?

Soybeans- Moraghan found little response in ND Minnesota and South Dakota have seen no response.

Sugarbeet- Studies showed small response a small pct of time. Recent studies near Fargo on lighter soils showed no response.

Wheat- several studies showed no response


Canola- Canadians have not seen a problem.
Zinc sources?

Dry- Water solubility is important as is granule distribution. Zinc sulfate is a good broadcast product, but rates should be about 30 lb/acre of product for good distribution. In a band, proportionally less can be used.

Liquids-
Ammoniated zinc complexes or chelates are effective as seed-banded options. Dilute soluble zinc sulfate or chelates can be used foliar if on the label.
Manganese?

Most recent Mn research comes out of Michigan, northern Indiana and Ohio, where Mn problems have been seen for decades.

Goos has explored Mn problems in this state and has not crossed one yet.

Zubriski found no response in sunflower at four locations in 1981.
Economics of manganese in North Dakota

Response - 0

Cost - $5-20/acre
Iron?

Iron chlorosis can be seen in most crops if the soil conditions are high in carbonates and the environmental conditions are cold, wet, possibly with salts.

In most crops, the areas affected are small and the environment or soils would not support good yields even if the chlorosis were gone.
Iron?

Rating crops on iron susceptibility,

Soybean most susceptible
Sugarbeet responses to Fe seen
Dry bean symptoms in high carbonate/salt
Flax symptoms in high carbonate (salt?) soils

The only crops worth considering are soybean and maybe sugarbeet
Iron?

EDDHA (Soygreen) has been shown effective in reducing IDC symptoms on soybean. A yield study was conducted near Crookston in 2009, but I have not seen the results. Strip-trials during the last 2 years have looked very positive and Goos has seen some of them.

Yield increases with 1 lb/acre Soygreen were reported in sugarbeet at multiple locations in 2007. (see sugarbeet report web pages, 2008)
Economics of iron ortho-ortho-EDDHA on soybeans-

Cost of 2 lb product- $20/acre

Average benefit used with tolerant soybean 10 bu/acre or $120/acre @ $12/bu beans
Profitable yield/sugar increases have also been recorded in sugarbeet several times in sandier soils in the Red River Valley area.
Boron?

NDSU has not seen B problems in alfalfa despite investigative studies.

Sunflower was investigated several years ago by Franzen when head deformation was seen. Endres found an inconsistent response at a Carrington location. Zubriski found no response at 4 locations in 1981.

Studies on sugarbeet in 2006/2007 found no responses to B application.
Copper?

Sunflower- Zubriski- 4 locations, no response, 1981

Spring wheat/durum- Franzen et al., 2008. Yield increased at 5 of 20 sites, and reduced at 2. Fusarium incidence and severity decreased at 4 sites.

Use of copper is at best site-specific on sandy, low organic matter soils, with low Cu.

Copper sulfate at 5 lb/acre is a good soil treatment.
Economics of copper in wheat-

Whole field- most fields only contain inclusions of deep low organic matter sandy soils, anywhere from 0-20%.

Example field, 10% susceptible soils. 160 acres total. Increased wheat yield 10 bu/acre on 16 acres- Wheat at $8/bushel. Field response- $128
Cost- 5 lb Cu/acre @ $2/lb CuSO4-20% $50. Profitable site-specific, not whole-field.
Summary-

Micronutrients have been studied in ND for over 60 years.

Zinc is most commonly seen, but only in corn, potato, flax and dry bean economically.

Copper on small grains

Iron on soybean and sugarbeet

Avoid mixes- use what the crop needs.
Sulfate ion wet deposition, 2005

Sites not pictured:
- AK03 1 kg/ha
- VI01 10 kg/ha

Sulfate as SO$_4^{2-}$ (kg/ha)
- ≤ 3
- 3 - 6
- 6 - 9
- 9 - 12
- 12 - 15
- 15 - 18
- 18 - 21
- 21 - 24
- 24 - 27
- > 27

National Atmospheric Deposition Program/National Trends Network
http://nadp.sws.uiuc.edu
Response of field pea to S application (Haderlein and Dowbenko, 2002).

<table>
<thead>
<tr>
<th>Source</th>
<th>Rate Lb/acre</th>
<th>Yield Lb/acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>0</td>
<td>630</td>
</tr>
<tr>
<td>Ammonium sulfate (AS)</td>
<td>20</td>
<td>2260</td>
</tr>
<tr>
<td>50/50 blend AS and ES</td>
<td>20</td>
<td>2180</td>
</tr>
<tr>
<td>Elemental sulfur (ES)</td>
<td>20</td>
<td>2060</td>
</tr>
</tbody>
</table>
Response of corn at six locations in Minnesota to sulfur (Rehm, 2005).
* Response is significant at P > 0.05

<table>
<thead>
<tr>
<th>Site/texture</th>
<th>S applied, lb/acre</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Yield, bu/acre</td>
<td></td>
</tr>
<tr>
<td>loamy fine sand</td>
<td>166</td>
</tr>
<tr>
<td>silty clay loam</td>
<td>184</td>
</tr>
<tr>
<td>loamy fine sand</td>
<td>99</td>
</tr>
<tr>
<td>Loam</td>
<td>150</td>
</tr>
<tr>
<td>sandy loam</td>
<td>140</td>
</tr>
<tr>
<td>silt loam</td>
<td>149</td>
</tr>
</tbody>
</table>
Before 2005, S deficiency in Iowa was virtually unknown. A series of experiments in 2005-2006 showed a consistent response to S in some soils.

In 2007 17 of 20 sites showed a significant response to S. In 2008, 11 of 25 sites showed a significant response to S. Average response to S was 13 bu/acre.

When grouped by texture within responsive sites, heavier soil increase was 15 bu/acre. Sandier soil increase was 28 bu/acre.

(Sawyer, 2009)
ANY crop is susceptible to S deficiency if soil and water conditions are favorable.

Most at risk-

- Sandy soils
  - Low organic matter
  - Significant rainfall in fall or spring
  - Higher landscape positions

Least at risk

- Clay soils
  - High organic matter
  - Dry conditions in fall/spring
  - Depressions
Yield of canola with S rate, source by landscape position, Rock Lake, ND, no-till system. Deibert et al., 1996.

<table>
<thead>
<tr>
<th>Sulfur rate lb/acre</th>
<th>Sulfur source</th>
<th>Soil Series/landscape position</th>
<th>Yield, lb/acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td>Buse-hilltop</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Barnes-slope</td>
<td>230</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Svea-footslope</td>
<td>1430</td>
</tr>
<tr>
<td>20</td>
<td>AS</td>
<td></td>
<td>1610</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1630</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td>1680</td>
</tr>
<tr>
<td>40</td>
<td>AS</td>
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<td>1820</td>
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<td></td>
<td></td>
<td></td>
<td>2120</td>
</tr>
<tr>
<td>40</td>
<td>ES</td>
<td></td>
<td>600</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1040</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1590</td>
</tr>
</tbody>
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S from Gypsum and ammonium sulfate compared to MAP and N only preplant on canola yield, 2008 on a Barnes soil (DeSutter and Lukach)

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<tr>
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<th>Canola yield, lb/acre</th>
</tr>
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<tbody>
<tr>
<td>Flue gas gypsum</td>
<td>20</td>
<td>2110 a</td>
</tr>
<tr>
<td>Ammonium Sulfate</td>
<td>20</td>
<td>2150 a</td>
</tr>
<tr>
<td>MAP only</td>
<td>0-1</td>
<td>1518 b</td>
</tr>
<tr>
<td>N only</td>
<td>0</td>
<td>1550 b</td>
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<td>3170 a</td>
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<tr>
<td>Ammonium Sulfate</td>
<td>20</td>
<td>3150 a</td>
</tr>
<tr>
<td>MAP only</td>
<td>0-1</td>
<td>770 b</td>
</tr>
<tr>
<td>N only</td>
<td>0</td>
<td>320 c</td>
</tr>
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<thead>
<tr>
<th>Site/Texture</th>
<th>Yield w/o S</th>
<th>Yield w/S</th>
</tr>
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<tbody>
<tr>
<td>1 / loamy fine sand</td>
<td>123</td>
<td>151</td>
</tr>
<tr>
<td>2 / loamy fine sand</td>
<td>154</td>
<td>198</td>
</tr>
<tr>
<td>3 / loamy fine sand</td>
<td>88</td>
<td>108</td>
</tr>
<tr>
<td>4 / loam</td>
<td>196</td>
<td>204 (NS)</td>
</tr>
<tr>
<td>5 / silt loam</td>
<td>118</td>
<td>171</td>
</tr>
<tr>
<td>6 / silt loam</td>
<td>129</td>
<td>167</td>
</tr>
<tr>
<td>Across all sites</td>
<td>129</td>
<td>167</td>
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Micronutrients, Roundup and Their Unhappy Marriage

Dr. Dave Franzen
NDSU Extension Soil Specialist
Once upon a time there were micronutrients.

They were needed to increase the happiness and prosperity of farmers in certain parts of the world.
Sometimes, the micronutrients were needed.
Sometimes, they were not. 😞
Farmers were sometimes confused about what they needed and what they didn’t need.

Friendly people would give steak dinners and encourage farmers to invite micronutrients onto their farms for only a little gold per acre.
The friendly people would provide “testimonials” from farmers who believed they had benefited from their micronutrients.

Sometimes these people came from the kingdom, but other times these people came from far away, where farm conditions and crops were different.
Farmers would try the micronutrients, and sometimes fields would be better off—but often they were not.

The unhappy farmers would try to find the friendly people and introduce them to their attorney, but the formerly friendly people were often hard to find and the farmers remembered that they forgot to leave “check strips” on their 10,000 acres of test fields.
The friendly people often had moved to Palm Springs after the steak dinner, and besides, even if they were found, the king had outlawed public burnings of traveling friendly people years ago.

And many farmers were sad because they hadn’t read the “Terms and Conditions of Sale”.
The farmers decided to go to an Extension meeting, where a soil fertility wizard would help them foretell what micronutrients might be important for which crops.

This is what they heard—

- Micronutrient needs are crop specific.

- Antagonism or non-performance is possible if metals are applied with glyphosate.
So the farmers came away from the Extension meeting knowing that only four crops benefited from Zinc, only a few crops benefited from Fe, and then more from seed-placed EDDHA than foliar, and there was no need at all for copper and manganese, or boron in the kingdom for corn, soybeans, canola or sunflower, but still, the friendly people tell them through the magic screen that micronutrient mixes are important.
And it came to pass that a young maiden-Miss Roundup came to the kingdom. The farmers were delighted to see her, because everywhere she went, evil weeds would die and fields made pure and clean.
Farmers courted Miss Roundup and eagerly sent gifts of Tech Fees to her guardians as thanks for her many blessings.
Miss Roundup performed her magic with a group of approved attendants, called adjuvants.

However, friendly people, seeing an opportunity, suggested to farmers that perhaps micronutrients could accompany her when she performed her magic within the fields, and therefore accomplish a weed and feed blessing.
Farmers were excited, because they could use the friendly people’s micronutrients without an extra trip into their fields.

Miss Roundup could accomplish the task with no increase in gratuity to her guardians.
However, one wise old farmer, a true Consultant in the kingdom, suggested that they go to an Extension meeting and ask the wizard for wisdom.
And it came to pass that the wizard arrived, and unable to bestow wisdom, offered to share data instead.

This is what he shared-
Application of FeHEDTA to soybeans, affected by iron chlorosis, along with application of Blazer, Raptor and Cobra, Walcott, ND, 2002.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>w/o Fe</th>
<th>w/Fe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blazer</td>
<td>40.3</td>
<td>36.3</td>
</tr>
<tr>
<td>Raptor</td>
<td>35.0</td>
<td>38.1</td>
</tr>
<tr>
<td>Cobra</td>
<td>31.9</td>
<td>26.8</td>
</tr>
</tbody>
</table>

LSD 5% 2.4

No differences at Arthur, ND or Rothsay, MN.
Bernard, MI, 2004-

Micronutrients and Roundup tank mixes-

Velvetleaf control reduced 50% with Fe$^{+3}$ (270 ppm), and Zn$^{+2}$.

Lambsquarter control reduced 50% by Fe$^{+3}$ (400 ppm).

Adding AMS, or increasing glyphosate rate increased weed control, but reductions persisted.
Also Bernard et al.,

Mn reduced Glyphosate absorption in ligno- and sulfate fertilizer.

Mn EDTA had no effect.

Mn-EAA reduced efficacy, but mechanism unknown.
Virginia, Weed Tech., Bailey et al.

Mn Ligno- and Mn chelate reduced control of lambsquarter, smooth pigweed, and large crabgrass.
A number of studies have shown that micronutrient additions to glyphosate can reduce weed control.

Even applications of micronutrients a few days before glyphosate application can reduce weed control.

Reductions in weed control may not always happen, and additions of AMS may help reduce the reductions, but farmers want clean fields, so the risk of unhappiness is there.
So the farmers left the wizard and considered the wisdom of marriage between Miss Roundup and micronutrients.

Some were still enchanted by the lure of magical riches promised by friendly people through visitations by micronutrients on their farm that could be carried by Miss Roundup.

Some weeds were not vanished by the blessing of Miss Roundup, the farmers lost their farms and became insurance salesmen.
Others took the Extension words to heart and refused to marry Miss Roundup with micronutrients, and lived

Happily Ever After

The End.