Modern Micronutrient Use Considerations

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Essential Micronutrients

**Formulae**
- Those that solve the problem
- Shotgun vs. rifle
- Raw material vs. formulated vs. actual sale

**Elements**
- Zinc
- Boron
- Iron
- Manganese
- Copper
- Molybdenum
- Ni, Se, Si, Co, Cl?
Industry Overview
Total market for agricultural inputs, ~$150 billion
North America

- 21% world market
  - ~$600 million
  - 4% of total fertilizer market
U.S. Market Ranking – reality?

- Zinc – 45%
- Iron – 25%
- Boron – 20%
- Manganese – 8%
- Copper – 2%
Market Realities?

- Fertilizer distribution channels comfort zone is commodity trading and logistics
- Ag chem distribution used to jugs and “specialty” markets
- Neither model perhaps understands the nuances of “non-agricultural” commodities, raw materials, real life agronomics, metal markets etc.....
- As a result, any guesstimate of the market is meaningless
  - Raw materials
  - Sales to distribution – double / triple count
  - Adjuvants / biologicals / others
Secondary nutrients (e.g. Ca, Mg) often dumped to “micros” – i.e. afterthought

Agronomic “research”
- Solution culture vs. soil
- Curative (loser) vs. Preventative (there’s a novelty)
- Yield as the Holy Grail?
- Nutritional / Quality – poor NPK practices?
  - Constitutive
  - Chemical
  - B, Mn, Ni classics
- Genetics – you generally need a seed to grow a crop – *ignore at your peril*
Genetics ahead

- Drought tolerance
- Nutritional
  - Constitution (Se)
  - Taste
  - Quality
- Nutrient use efficiency
- Non-conventional use e.g. B/N, Zn/Ca, Ni/Zn
It is somewhat of a play-pen but there are rules.....

Unattended Children will be given an espresso and a free puppy.
Here’s the playpen

Inorganic

- Water Soluble
  - Nitrates
  - Chlorides
  - Sulfates
  - Sodium Salts
  - Potassium Salts
  - Ammonium Salts
- Not Water Soluble
  - Carbonates
  - Phosphates
  - Silicates
  - Hydroxides
  - Oxides

Organic

- Complexing Agents
- Sugar Alcohols
- Low Molecular Weight Acids
  - Citric
  - Oxalic
  - Tartaric
- Na Glucoheptonate
- Lignin Compounds
- Fulvic Acids
- Humic Acid
- Amino Acids
- EDTA
- DTPA
- HEEDTA
- HEDTA
- Citric Acid
- NTA

- Chelating Agents
- High Molecular Weight

Low Molecular Weight
Solutions

- Inorganic vs. Organic
- Complexes vs. Chelates vs. Salts
- Stability constant
- Role of pH and soil type
- Organic matter
- Solubility and plant availability
Considerations

- Molecular weight, size, dimension
- Soil or foliar? Both?
- In plant mobility?
- Biodegradable / environmental compatibility
- Chemical compatibility
- Phytotoxicity
- Stability constant
Agronomic considerations – try not to forget the plant...

- Micronutrients usually applied in amounts of less than 10 lb metal /ac
- Problems?
  - Uniformity of soil application – surface activity
  - Liquid vs. dry
  - Are the combinations plant available?
    - Biological / chemical - glyphosate
  - Can you get it out of the spray tank?
  - Crop safety issues – timing (pollenation)
  - Predicting the problem
Soil applications

- Strong chelate
- Compatible with fertilizer
- Plant mobility not an issue, chemical stability is....
- Local market / custom usually dictates
  - Liquid / dry
  - Chelate vs. salt (starter vs. fall blend)
  - Cost per lb / vs. cost per acre
% Zn remaining after 4 minutes mixing with a 1-2-0 ortho P

- ZnEDTA 100
- ZnPhenolic 11
- ZnCitrate 8
- ZnSO4-NH3 complex 8
- ZnSO4 4
Foliar applications

- Much maligned in “conventional” circles
  - Cure all vs. agronomic proven supplement
  - Muck and mystery vs. proven solutions
  - Ignorance at “research” level is a hurdle (disparate disciplines)
- Multiple ride opportunities?
  - Glyphosate / herbicide
  - Fungicide
  - Corrective / compensatory / additive aspects
Foliar needs

- Weak complex
- Low molecular weight
- High water solubility
- Low phytotoxicity
- Plant analog
- In-plant mobility
Foliar Applied Ingredients
2 Pathways

- Lipophilic Pathway
  - Stomata’s
- Hydrophilic Pathway
  - Hydrophilic Pores
  - Imperfections of cuticle

Most Fertilizers and Micronutrients
(Any active ingredient that is water soluble)
Leaf Penetration (Cuticle)

- Lipophylic
  - Non-electrolytes – organic molecules
    - Agrochemicals
- Hydrophylic
  - Polar / Aqueous pathways
  - Hydrated ionic compounds (sugars, inorganic ions)
  - Pores – 0.45 – 1.18 nm
Factors influencing permeability of inorganic ions and charged molecules across plant cuticles

- E.g. – Ca$^{2+}$, glyphosate, precipitation at pore (Fe)
  - Humidity
    - 2-3 x greater as RH approaches 100%
    - Sorption of water to polar domains
    - = swelling of cutin polymer
    - = increased penetration of ionic compounds
  - Temperature
    - No effect (except humidity)
- Light
  - Rates of salt penetration 2-fold lower in dark
- Molecular weight
  - Reduced 3-10x as Ca salt increases from 100 – 500 gmol
In summary – the crop or end-user that counts?

- In 2015 Zn will still be Zinc but gene expression, traits etc might have shifted...
- Operational vs. agronomic service
  - Just another SKU or a business necessity?
- Prescription vs. insurance
  - Re-birth of real agronomists
- Chemistry vs. price
  - Sophisticated products in a singularly unsophisticated market
- Soil vs. foliar
- Yield vs. quality
- Nutritional value of the crop
Sometimes it helps to stay quiet and look inconspicuous……