

Growing Profit & Health

**CATIONIC TRACE MINERALS &
VEGETABLE PRODUCTION**

(COPPER, IRON, MANGANESE, & ZINC)

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2015 NOFAMASS WINTER CONFERENCE
 SATURDAY JANUARY 10, 2015 - WORCESTER, MASS

Definitions

- Cations
- Lbs/Acre
- PPM
- Trace Minerals

Approaching Agriculture - Our Philosophy

Brix Bounty Farm
Growing Food with Respect for the Earth & Future Generations

Minerals & Biological Activity - Keys to Healthy Crops

- 1) By addressing mineral deficiencies in our soils,
- 2) Increasing biological activities to ensure these minerals are available and biologically complexed,
- 3) And ensuring adequate moisture and air in our soils...

We can achieve healthy crops

**Yields and Farm Viability (\$) are
Connected with Soil Health and Fertility Investments**

Honoring Complexity

Humility & Awe

Major & Secondary minerals are important.



Trace Minerals are also important, we & plants need them

Whole Farm Organism

Biodynamics

“Closed Loop”

Each Farm is Unique

Our Relationship with Our Community

Energy Returned on Energy Invested (ERoEI)

Fixed Costs & Labor



Field Tomatoes, June 19, 2014

July 19, July 25, July 30, & Sept 22

The Case for Considering Trace Minerals

Considering Complexity

High Value Crops Deserve Attention
 We aren't conventional growers
 We aren't row crop producers
 We aren't wholesale producers

We are community members supplying nourishment.

(And consider safety in handling...)

Minerals in the Soil

- An average acre furrow slice weighs 2,000,000 pounds.
- Targets for major cations may be:
 - ~3,000 lbs/acre Ca
 - ~200 lbs/acre K (200 lbs/acre = 100 PPM) minimum
 - ~200 lbs/acre Mg minimum
- For folks following mineral balancing protocol
 - 65-70% CA, 10-12%Mg, 3-5% K

Trace mineral targets are much, much lower...

Trace Mineral Targets

- Trace Mineral Targets – using Mehlich-3 extraction (LL)
 - Copper (Cu) – 2-4-6 PPM
 - Iron – 75-150 PPM
 - Manganese (Mn) – (25-55)-90 PPM
 - Zinc (Zn) - 4-8-12 PPM

Considering these amounts in practical terms

2,000,000 pounds

If 4PPM Copper = 8 pounds Copper

A 4'x8' bed = 1500 pounds, 2.6 g of Copper (~2Tbsp CuS)

“Just Right”: Enough, Deficiencies & Balance

Capturing Energy, Mobilizing Nutrients Through Fruit

Sun Cherry, August 2012	Yellow Mini, August 2012

Copper – Cation Cu Trace Mineral

• Function

- Photosynthesis, Respiration, Nitrogen utilization
- Lignin formation

• Availability

- Copper may “lock-up” with OM reducing availability
- Molybdenum (Mo) reduces Cu availability within livestock

• Mobility

- Copper is not very mobile in soils, it ties up with OM rather quickly...

• Application Rates and Notes

- Copper Sulfate (25% Cu), Max 10 lbs. Copper Sulfate per acre per year
- Chelated Copper – Biomin Copper (4% Cu) too pricey for farm scale, but suitable for gardens

• Economics – of soil applications

- Once soil copper levels are raised, they often stay adequate for long periods.
- at 5 - 10 lbs/acre of Copper Sulfate (@\$2/lb.) = \$10 - \$20 per acre... ~4-5 years to achieve target
- Garden: 2 - 4 oz. (10-20 tsp.) Copper Sulfate per 1,000 sq. ft. = \$.50 - \$1 per 1,000 sq. ft.
- Garden: 1-4 oz. Biomin Copper per 1,000 sq. ft. = \$1 - \$4 per 1,000 sq. ft. depending on price

Target Level
(Mehlich 3)
2-6-10 PPM
½ Zn level (Aster)

Copper Considerations

• Copper Mining (in perspective)

- Examination of Costs & Justification

• Soil Test – Copper Levels & Organic Matter

• Fungicidal & Algacidal Properties

• Sheep Nutrition (Copper vs. Molybdenum concentrations)

Copper in the Soil & in Plants

- Photosynthesis (enzymes): may impact chlorophyll production
- Respiration (enzymes)
- Lignin formation enzymes - polyphenol oxidase, diamine oxidase

- Needed for fruit & seed development
 - Increase in flower formation

• Nitrogen utilization (protein synthesis)

- Stalk Strength
- Flavor
- Color (onions)
- Prevents Cracking (grapes) ... (tomatoes??)



www.haifa-group.com, 1/9/15
Epstein and Bloom 2004

Copper Availability

- Organic Matter – high OM soils
- Very Sandy Soils w/low OM – low Cu holding capacity
- pH (above 7 reduction in Cu availability)
- Nitrogen: Higher N additions require higher Cu levels
- High P may limit Cu uptake
- Molybdenum
- Zinc

Mycorrhizal Fungi

(Banni & Fattori 2013 Study re: Cu toxicity <http://www.idosi.org/mejsr/mejsr17%281%2913/15.pdf>)

Addressing Copper Deficiencies

Soil Applications (need determined by soil test/crop)

1,000 lbs of Krehers (5-4-3) at .005% Cu = ~22 grams Cu

- Copper Sulfate – 5 – 10 pounds Copper Sulfate/acre
- Biomin Chelated Copper – 1 qt – 1 gal per acre

Foliar Sprays

- Copper Sulfate – ¼ tsp = 1.5 g ... 1 oz = 6 tsp
 - .5 – 1 # Copper Sulfate per acre – addressing deficiency action
 - Maintenance – we may add ¼ tsp/gal for foliars (a chelated source “better”)
- Biomin Chelated Copper – (1-0-0,4% Cu)
 - 1-4 pints/acre “2-4 weeks after emergence or when deficiency... repeat in 1-3 weeks if necessary...”

<http://fbitech.com/plant-products/biomin-copper/>

Copper – Practically Speaking

Critical Periods

early in growth cycle (true for any enzymatic traces)
anytime N intake is high
flower & fruit formation

Consistent use of OMRI listed Copper Fungicides require consideration into fertility plan,

Considering Copper in relation to Nitrogen

In 2015 at Brix Bounty

- Soil applications, following our fertility plan (added to “Min-mix”)
- Trial chelated copper in our seed starting mix/early foliar application

Iron - Cation

Fe Trace Mineral

- **Function**
 - Assist in the function of enzymes in chlorophyll production
 - Leaf Thickness – Cary Reams
- **Availability**
 - Decreases as soil pH goes up ... (esp. above 7.4)
 - Carbon dioxide & water > form bicarbonates ... tie up Fe in plants
 - "Overly"-aerated soils reduce availability
 - Soil applied Fe often mixed with Sulfur...to improve avail...
- **Mobility**
 - Rapidly tied up into less available forms
 - High P can tie up Fe, high Fe can tie up P (Iron Phosphate)
- **Application Rates and Notes – Iron deficiency is "rarely a problem in the NE"**
 - Lower pH > improve Fe availability
 - Irrigation (well) Water
 - Compost/Manure – Fe levels vary: Kreher's ~1# Fe per 1000# lbs.
 - Greensand
 - Iron (Ferrous) Sulfate (20% Fe)
 - Foliar applications – Iron Sulfate, Chelated Iron
- **Economics – of soil applications**

Target Level
(Mehlich 3)
150 PPM
(1/3 – 1/2 ideal K) – Astera
Canadian Network

Iron Considerations

- Rarely deficient in soils, though short-term availability may be limited and create deficiency periods...
- Legumes – need for iron ...
- Color & Chlorophyll ... Photosynthesis
- Sluggo – Iron Phosphate for slug & snail control

Iron in the Soil & in Plants

- Role in Chlorophyll Production
- Nitrate & Sulfate Reduction
- Lignin Formation



Haifa-Group.com, 1/9/15

Iron Availability

- Cool Soils may limit Iron availability...
- High pH
- High Ca or High P
- High Cu, Mn, Zn can inhibit Fe
- "Over-Liming"

Addressing Iron Deficiencies

Soil Applications

- 50-100# in row Iron Sulfate... for row crops in "Nebraska"
- 100# Iron Sulfate broadcast for general Iron deficiency (pH < 7)
- Turf – 2oz Iron Sulfate in 3-5 gal water per 1,000 feet – green up
- Turf – 2 cups Iron Sulfate in 5 gal water per 1,000 feet corrective action
- Reams – 40# Iron Sulfate per acre

Foliar Sprays

- Iron Sulfate (Ferrous Sulfate) can burn leaves...careful
- Solution of 1-2% Iron Sulfate (8-16 lbs/100gal or 1-2.5 oz/ gal)
- Multiple applications may be necessary
- Chelated Iron commonly used, especially in high pH conditions

Iron – Practically Speaking

- Consider reduction in Fe availability when liming.
- Foliars are most practical to assess if deficiency is real.
- Always in relationship with Manganese
- At Brix Bounty in 2015 – we'll trial some beds with broadcast Iron Sulfate a la Reams ... 1# FeS/1,000 sq ft.

Manganese – Cation Mn Trace Mineral

- **Function**
 - Catalyst in photosynthetic process
 - Role in fat forming enzymes
 - Important reproductive energy
- **Availability**
 - Decreases as soil pH goes up...
 - "Overly"-Aerated soils reduce availability
 - Use of acid-creating fertilizer increases availability
- **Mobility**
 - Immobile in the plants, moves up in the xylem (like Calcium) – dry soils = reduced avail.
- **Application Rates and Notes**
 - Manganese Sulfate - **Max 20 lbs. Manganese Sulfate per acre/per year**
 - Foliar Applications – often recommended for financial reason and "soil availability"
- **Economics**
 - Manganese Sulfate @ \$1-1.50 per pound = \$20-30 per acre for corrective action

Target Level
(Mehlich 3)
25-50-90 PPM
1-3 - ½ Fe (Aster)

Manganese Considerations

- "Fruiting" Energy (Cary Reams)

Mn and Fe (always consider Fe levels when looking at Mn)

- At a higher pH less Mn is available...
- Fluffy soils (aeration) reduce Mn availability
- Water logged soils can create excess Mn availability (Mn reduction) followed by leaching of Mn...

Manganese in the Soil & in Plants

- Chlorophyll Production
- Protein Synthesis
- Lignin Formation
- Lipid Forming Enzymes
- Germ Formation & Fruiting Energy

Manganese Availability

- pH – higher PH reduces availability
- toxicity usually only an issue on very acidic soils
- Aerated Soils
- Waterlogged Soils



• "These leaves show a light interveinal chlorosis developed under a limited supply of Mn. The early stages of the chlorosis induced by manganese deficiency are somewhat similar to iron deficiency. They begin with a light chlorosis of the young leaves and netted veins of the mature leaves especially when they are viewed through transmitted light. As the stress increases, the leaves take on a gray metallic sheen and develop dark freckled and necrotic areas along the veins. A purplish luster may also develop on the upper surface of the leaves." Haifa-group.com, 1/9/15

Addressing Manganese Deficiencies

- **Soil Applications**
 - Timing is "critical" – right before planting for best availability...
 - Manganese Sulfate: 10-20-40 pounds/acre broadcast
 - Manganese Sulfate: 5-10 pounds/acre banded
 - Biomin Manganese (2-0-0, 5%Mn)
Note: differing opinions regarding efficacy of soil applied Mn chelates.
 - Cornell > application of acid forming fertilizers to reduce pH...
- **Foliar Sprays**
 - Manganese Sulfate – 1.5-3# per acre Manganese Sulfate/ 30 gal water
 - May require a 2nd application ...
 - Chelated Manganese

Understanding & Applying Chelated Fertilizers Effectively Based on Soil pH
<http://edis.ifas.ufl.edu/hs1208> (published Nov 2012)

Manganese – Practically Speaking

- Critical Period – Early in growth for most plants
- Fruiting Energy! Watch out with Greens
- Onions (Yara) <http://www.yara.com.au/crop-nutrition/crops/onion-and-garlic/key-facts/role-of-manganese/>
- Manganese – Extension "Advice"
 - Cornell - <http://nmsp.cals.cornell.edu/publications/factsheets/factsheet49.pdf>
- Manganese – Foliar Sprays most economical...

Zinc – Cation Zn Trace Mineral

- **Function**
 - Auxin Production (leaf size)
- **Availability**
 - Decreases as soil pH goes up
 - Timing is critical – cool wet soils, limit Zn uptake
- **Mobility**
 - Not very mobile in soils
 - Not very mobile in plants
- **Application Rates and Notes**
 - Zinc Sulfate - **Max 25 lbs. Zinc Sulfate per acre/per year, rec start 5-10#/acre**
 - Foliar – Zinc Sulfate - .75-1.5# per acre Zinc Sulfate in 30 gallons water min.
- **Economics**
 - 5 lbs. Zinc Sulfate = \$5, 10 lbs. Zinc Sulfate = \$10, 20 lbs. = \$20
 - Garden: 2-8 oz. per 1000 sq. ft. = \$.20 – \$.2.00

Target Level
(Mehlich 3)
4-8-12 PPM
1/10th Soil P (Astera)

Zinc Considerations

- Zinc from ...
- P & Zinc – high applications of P fertilizers may necessitate Zn applications (for conventional P)
- Soil Test – Zinc Levels and
- Compost and Zinc Levels
- Zinc – Needed Early in Growth Cycle

Zinc in the Soil & in the Plant

- Auxin Production (leaf size)
- Chloroplast Production (photosynthesis)
- Cell Division & Protein Synthesis
- Water Utilization (gas exchange & stomata)

Zinc Availability

Zinc availability may be limited in cool season

> Zinc is often added to starter fertilizers

- Consider Zn if adding heavy levels of P
- U Maine – Zinc and corn/potatoes...
 - http://anlab.umesci.maine.edu/soillab_files/under/commpan.pdf
- This leaf (Fig. 22) shows an advanced case of interveinal necrosis. In the early stages of zinc deficiency the younger leaves become yellow and pitting develops in the interveinal upper surfaces of the mature leaves. As the deficiency progresses these symptoms develop into an intense interveinal necrosis but the main veins remain green, as in the symptoms of recovering iron deficiency. (Haifa-group.com, 1/9/2015)



Addressing Zinc Deficiencies

What is your long-term whole farm fertility plan?

Soil Applications

- Zinc Sulfate (36% Zn)
 - 5#-10#-20# per acre Zinc Sulfate
 - Maximum 20# Zinc Sulfate per acre (though I've applied 35#...)
 - Banded at rate of 3-6# Zinc Sulfate (U Maine recommendation for ...)
- Compost
- Manure

Foliar Sprays

- Zinc Sulfate – Foliar .75-1.5# of Zinc Sulfate per acre for corrective action
- Foliar - Maintenance Rate – ½ tsp. per gallon
- Chelated Zinc – follow label directions

Zinc – Practically Speaking

- Zinc & Moisture Management – include Zinc in any dry land farming fertility management...
- Zinc in a “Starter Fertilizer”
- Zinc needs are greater in cool & wet springs
- Zinc levels in seed may impact Zn needs in crop... corn research
- If heavy dosing P, add some Zn broadcast or to starter...

Takeaways ...

Trace Minerals Deserve Attention in your Fertility Plan
Needed early in growth for healthy crop production

Copper – consider availability esp. w/ N additions, can build up long term soil reserves (it doesn't stay mobile)

Iron – typically available, foliar for short term results

Manganese – fruiting energy, broadcasting mixed results

Zinc – critical early in the season & with heavy P...

Foliar Application Rates - Reference

To enhance uptake, we typically add a spreader sticker & a carbon/sugar to our foliar mix - fructose (J. Frank), molasses, FulvaGrow (fulvic acid) + N,P (organic gem)...

- Copper Sulfate (.1-.25# Cu/acre = .4-1# CuS/acre)
 - Copper Chelate – follow label directions
 - Iron Sulfate(1-2# Fe/acre = 5-10# FeS/acre)
 - Manganese Sulfate (.5-1# Mn/acre = 1.5-3# MnS/acre)
 - Zinc Sulfate (.25-.5# Zn/acre = .75-1.5# ZnS/acre)
- Rates above are a 1x boost, maintenance rates are lower

Sourcing Materials

- Lancaster Ag Products
- NOFA Bulk Order (North Country Organics)
- Nutrient Density Supply Company
- Peaceful Valley
- Online for OMRI chelated minerals – JH Biotech - Biomin
 - (shipping can be expensive) – Amazon, Unbeatable Deals, LeafTek

Upcoming Educational Events

Winter Study Session (Mondays in Mar.) *Teaming with Nutrients*, Lowenfels

Soil & Health Conference 2015 - Feb 10,11 in Northampton, MA

- Early Season Production - Fertility Considerations
- Dry Season Production – Strategies for Bounty

SEMAP Ag & Food Conference – March 1st, Bristol Agricultural HS

- Trace Minerals in the Garden

NOFA Workshop Series – Growing Vegetables for Health, Quality, & Profit (a season long series) Mar 22, June 14, Sept 13 at Brix Bounty

NOFA/RI Winter Conference – March 29 – Jeff Lowenfels

Thank You

Handouts & Presentation
Available at www.brixbounty.com

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