Super SOD

Superoxide Plant Dismutase

& Plant Stress

NOFA/Mass Winter Conference

January 13, 2024

Worcester, MA

Super SOD – Superoxide Dismutase

Got stressed plants? Wondering how to respond to drought, heat, floods?

Derek Christianson of Brix Bounty Farm will lead a discussion on the role Superoxide Dismutase (SOD) plays in managing plant cellular stress.

We'll cover the basic function of the three primary SODs in plants, then dive deep into fertility management strategies aimed to ensure our crops have an adequate supply of copper, iron, manganese, and zinc through the growing season.

Who is in the Room?

Scale of Operations

Experience Level

Science Spectrum

Snapshop Takeaways … Hoped For

Define Your Goal(s) : ROW (Return on Work)

At Brix > to produce an income growing vegetables to support my family,

while also improving the resource base for future generations

Awareness > we farm a "constructed" ecosystem >

monoculture on micro scale

tillage

maximizing yields and efficiency

production needed every year…

… maybe at odds with Natural Systems

Sources of Plant Stress

A List

What about

_____?

Strategies to Alleviate Plant Stress

Common

Crazy

An Alternative Approach at Brix

Oxidative Stress in Plants

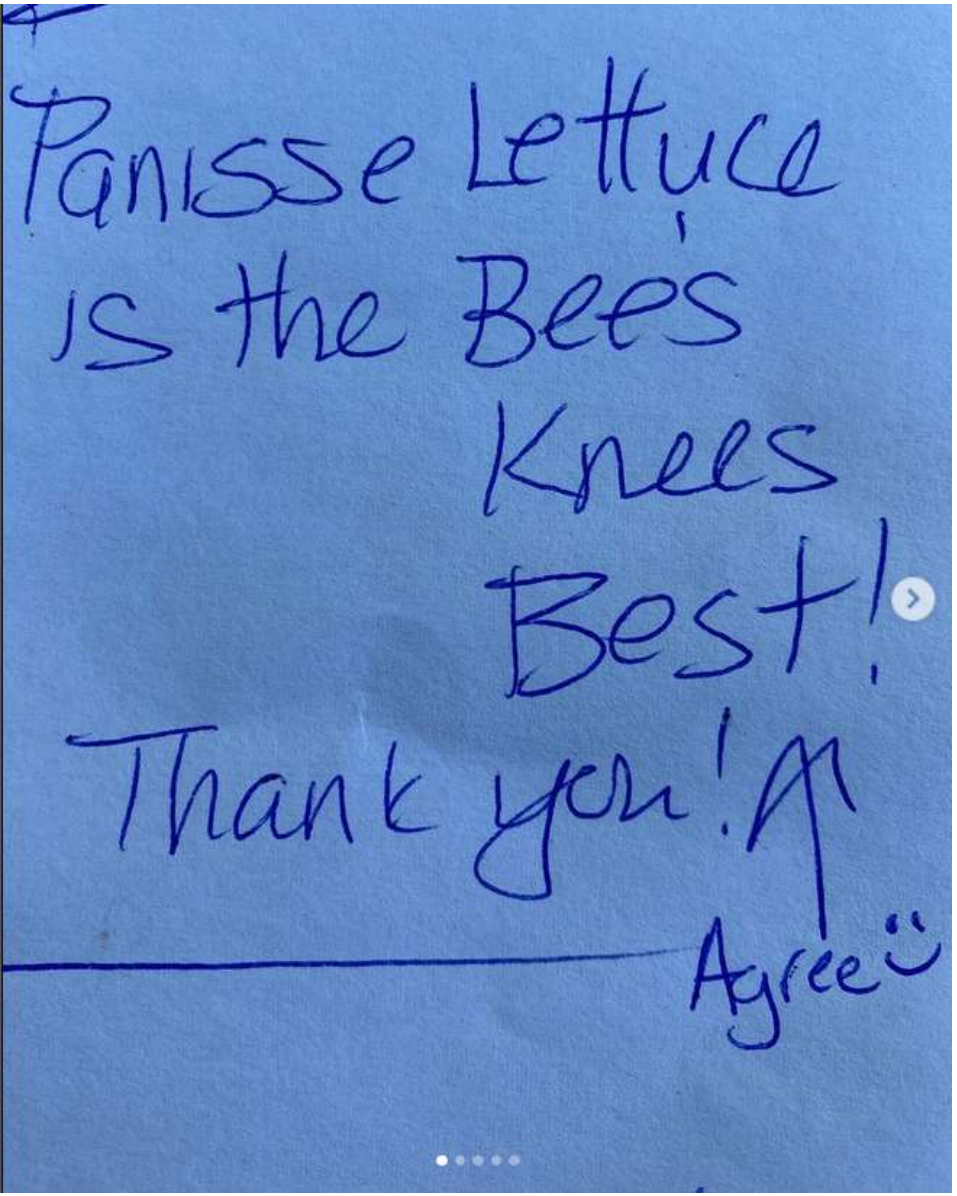
Reactive Oxygen Species (ROS)

Superoxide O^{2-}

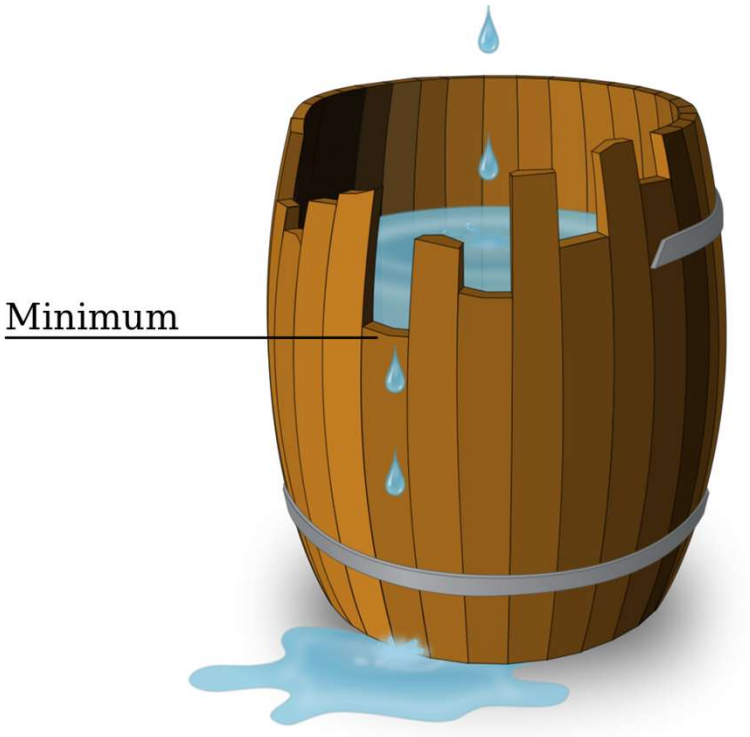
Hydrogen Peroxide - H_20_2

Singlet Oxygen $^10_2$

OH



Justus von Liebig Revisited
Mineral Balance? Quality?



Minerals Required for Plant Growth (BOLD)

*Often overlooked

Calcium

NPK – Nitrogen, Phosphorous, Potassium

Sulfur*

Magnesium

Carbon, Hydrogen, Oxygen

Silicon, Sodium

Boron*, Chlorine, Copper*, Iron, Manganese*, Zinc

Cobalt, **Molybdenum*, Nickel***, Selenium

Riding the Wave – Optimizing for June

Sunshine

So Much Sunshine

Biological Activity and Soil Warmth

Management – Opportunity for Impact > Outcomes

June 28, 2023 - Omero Cabbage

Reactive Oxygen Species in Plants: From Source to Sink
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8868209/

Table 1

Different types of plants and their associated stresses and defense mechanisms.

Plant	Type of Stress	Defense System	Reference
Triticum aestivum	Drought	CAT and SOD activity increased	[73]
Brassica napus	Drought	Increased POD and CAT activity	[74]
Vigna radiata	Drought	Decreased ascorbate and increased DHA while decrease in their ratio	[75]
Vigna radiata	Salinity	Enhanced ascorbate and DHA activity	[76]
Orysa sativa L.	Salinity	Enhanced GSH and GB content, enhanced SOD activity	[66]
Portulaca oleracea L.	Elevated temperature	Increased SOD and POD activity	[77]
Gossypium hirsutum	Elevated temperature	Increased FeSOD and Cu/ZnSOD activity	[78]
Triticum spp.	Freezing temperature	Increased GST and APX activity	[79]
Camellia sinensis L.	Freezing temperature	Increased tea polyphenol to amino acid ratio	[80]
Prunus persica L. *Batsch*	Flooding	Increased CAT, POD and SOD activity	[81]

Superoxide Dismutase - SOD

$O_2^- + O_2^- + 2H^+ > SOD > H_2O_2 + O_2$

Hydrogen peroxide > water and oxygen

Superoxide Dismutase: A Stable Biochemical Marker for Abiotic Stress Tolerance in Higher Plants – Dec 07 2018

https://www.intechopen.com/chapters/64689

Superoxide Dismutase: A Stable Biochemical Marker for Abiotic Stress Tolerance in Higher Plants

Dec 07 2018

Abstract

Superoxide dismutases (SODs) are ubiquitous metalloenzymes that constitute the first line of defense against reactive oxygen species (ROS). It constitutes one of the major enzymatic components of detoxification of superoxide radicals generated in biological system by catalyzing its dismutation to H2O2 and finally to H2O and O2 by catalase and peroxidase. Most plant species contain numerous SOD isoforms differing in their active site metal ions, namely Cu/Zn-SOD, Mn-SOD, and Fe-SOD. Many studies also reported that the tolerance level of plants is positively correlated with SOD activity as well as with the number of SOD isoforms, and established the fact that “More the SOD Activity, More the Stress Tolerance.” Therefore, the SOD isozyme profile of any plant can be used as stable marker for stress tolerance in plant. In this chapter, we have discussed the role of SOD in abiotic stress tolerance, type of SODs, and correlation of its activity and its isoforms with stress tolerance level.

3 Types of Superoxide Dismutase on Plants

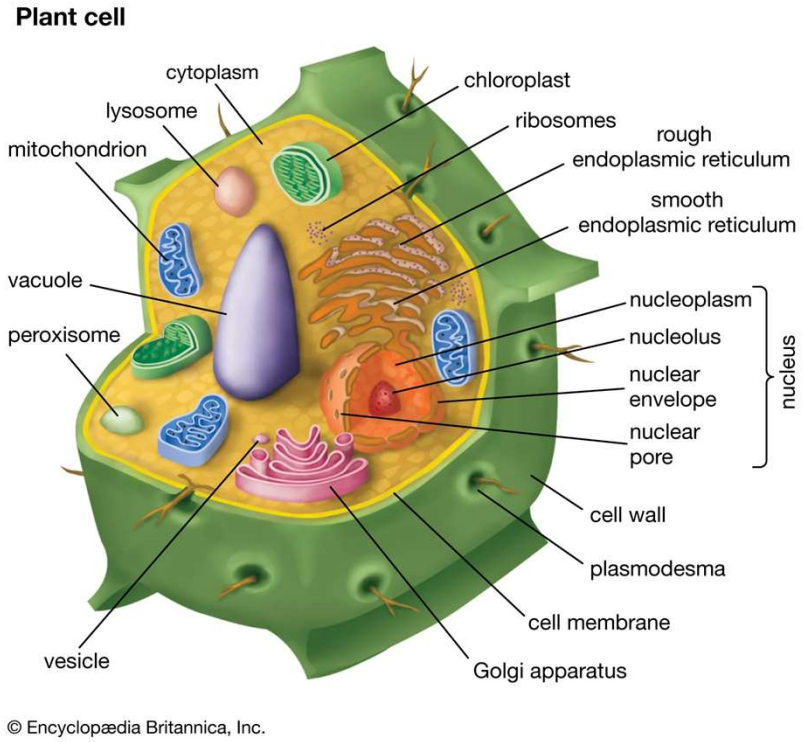
Copper/Zinc SOD (CuZnSOD) – Cu is catalytic and Zn is structural (Marschner) - chloroplasts, cytoplasm, peroxisomes,

Iron SOD (FeSOD) – chloroplasts primarily and peroxisomes

Manganese SOD (MnSOD)- mitochondria primarily and peroxisomes

Plant Cell

https://cdn.britannica.com/04/114904-050-722C9D96/Cutaway-drawing-plant-cell-organelles-wall.jpg

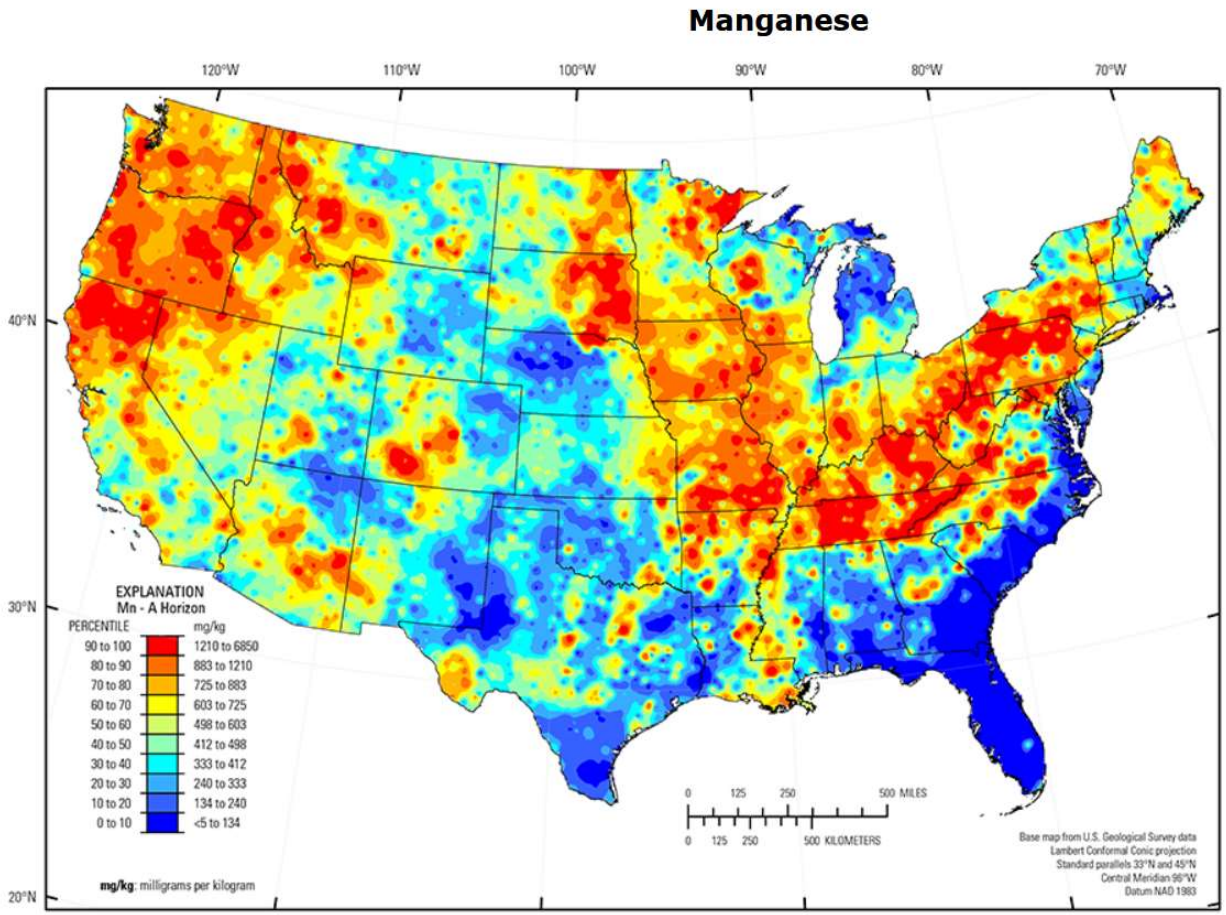


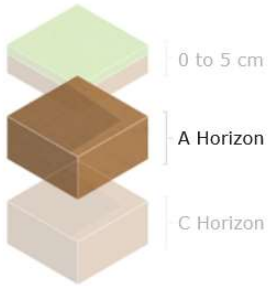
Manganese

Geochemical and Mineralogical Maps, with Interpretation, for Soils of the Conterminous United States

By David B. Smith, Federico Solano, Laurel G. Woodruff, William F. Cannon, and Karl. J. Ellefsen

https://pubs.usgs.gov/sir/2017/5118/sir20175118_element.php?el=25





INTERPRETATION

STATISTICS

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Copper

Copper > It's a "biocide" for a short period of time…

High OM can "tie up" Copper

Lignin Formation

Cell Elasticity – Prevent Radial Cracking in Tomatoes etc.

Copper Sources

Copper Sulfate (25% Cu)

Recommended Soil Application Rates >
Correct Deficiency – 2 years in a row

10# per acre Copper Sulfate
4 oz. per 1,000 sq. ft.
11.2 grams per 100 sq. ft.

Copper - Cu

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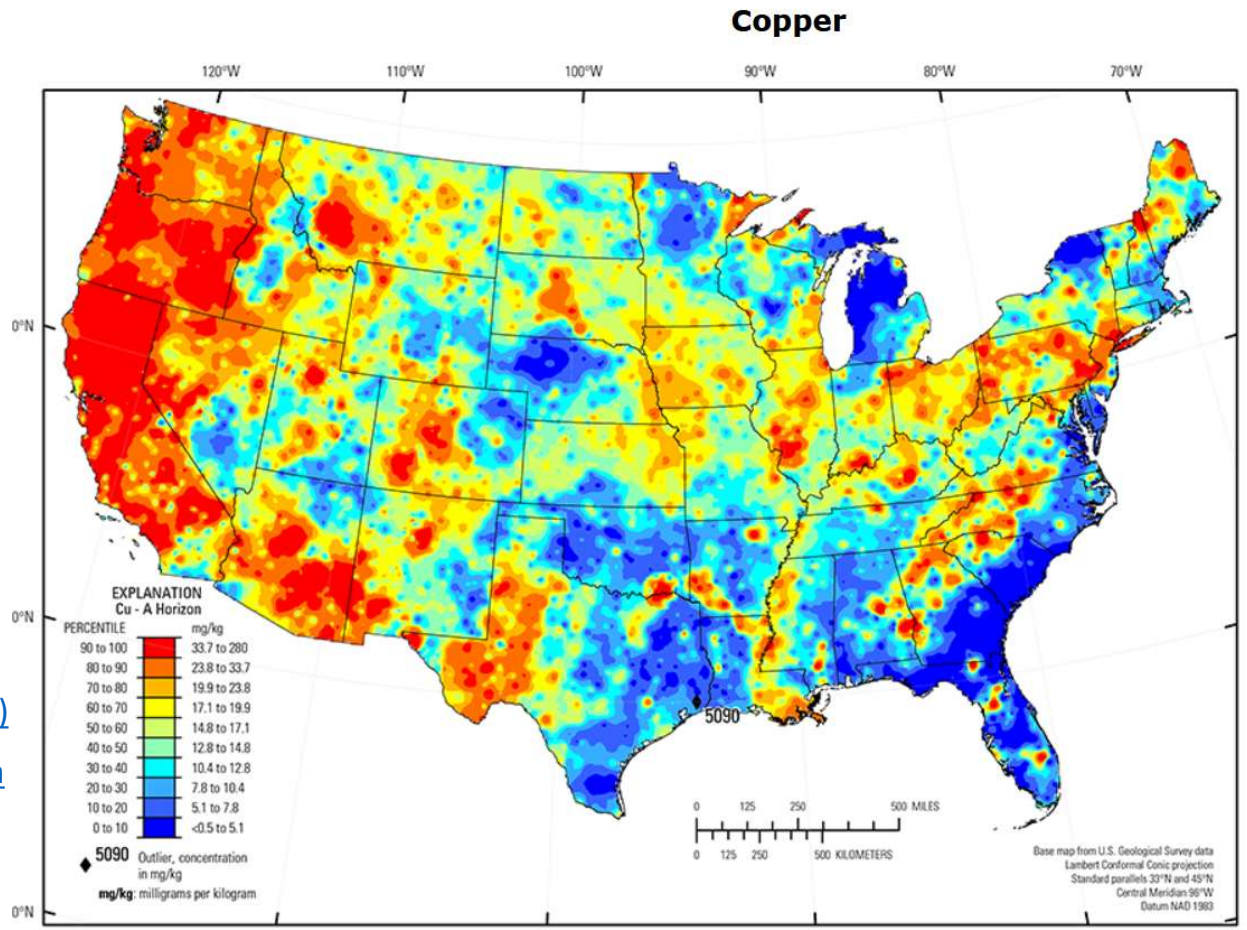
Copper in Counties (Nat Geochemical Survey)

https://mrdata.usgs.gov/geochem/doc/averages/cu/usa.html

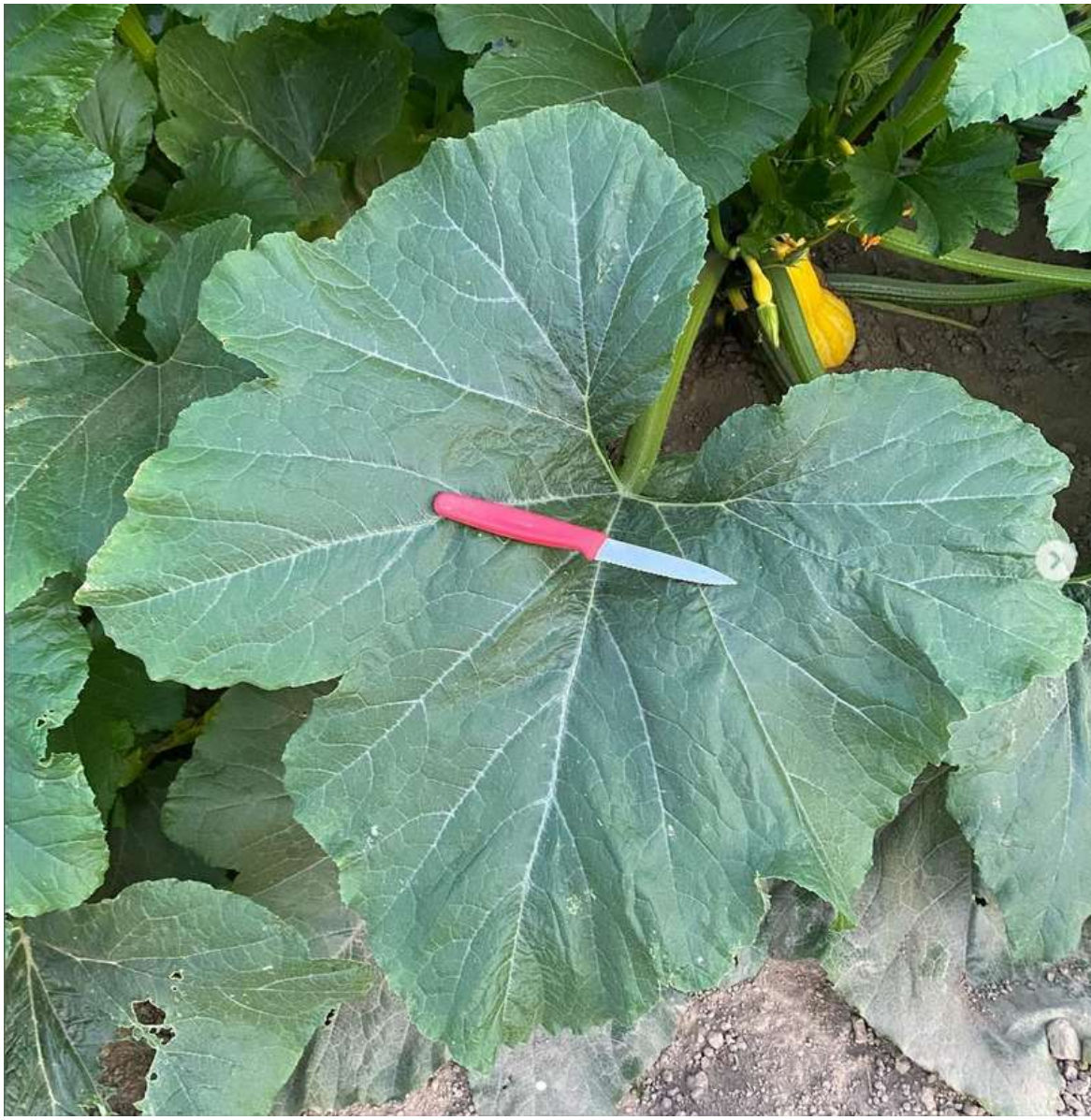


Zinc

Leaf Size

Water Use Efficiency (after Potassium)

Enzymes a plenty – Structure and/or “Activator”



July 17, 2022

brixbountyfarm Trialing Tempest summer squash from @johnnys_seeds this year. Mammoth solar collector genetics, we just started harvesting these beds on Thursday night (714). Plants were seeded 528 and transplanted 612. They were ready for first harvest on 712. Sustained a bit of early cucumber beetle pressure - though the beetles preferred the neighboring Goldy zucchini.

Not sure yet if Tempest will provide a nice compliment to Multipik. The fruit are fast growing and a bit less forgiving for wider harvest intervals - if we skip a day and go 72 hours between picking.

Plants are taking on the dry conditions like a champ.... We received ~ 1/2 inch of rain a few weeks back. Haven't caught a drop in the last ~ 3 weeks. Should be set to produce good yields through the end of August. We'll see how they hold up to powdery mildew pressure.

Zinc Sources

Biology – mycorhizzal fungi

Zinc Sulfate Monohydrate– 35.5% Zinc
Standard Application Rate – 20 pounds per acre Zinc Sulfate
(this delivers ~7 pounds of elemental zinc per acre or 3.5PPM)

Gardens > 8 oz per 1,000 sq ft or 22.4 grams per 100 sq ft

Grain Fed Manure or Composts
Krehers < 1 lb. Zinc per ton
https://www.krehereggs.com/compost-fertilizer

Leaf Composts/Woodchips/Etc.

Zinc

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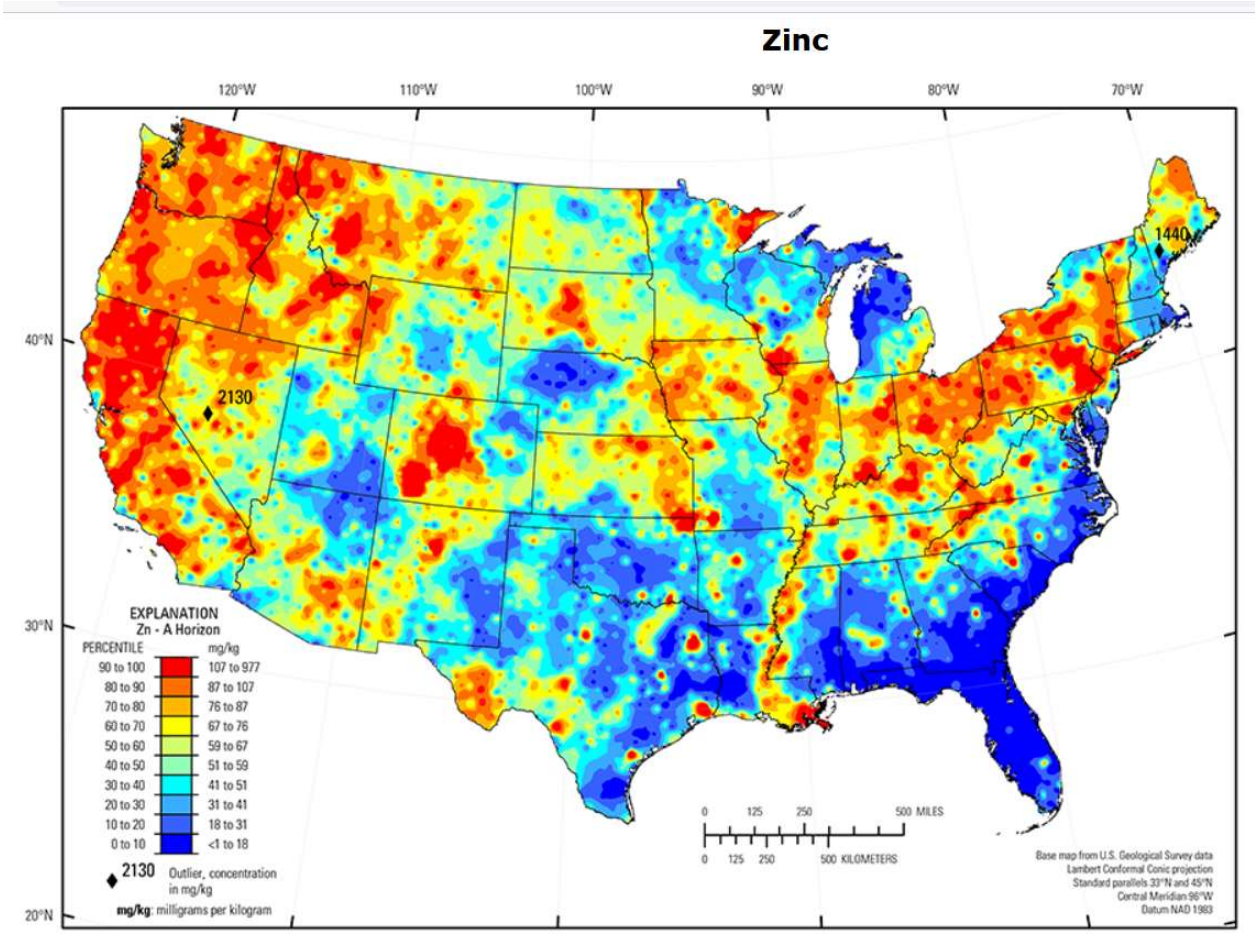

John Kempf (AEA)Webinar >July 20, 2022
https://www.youtube.com/watch?v=tqhechUWm_o

Farmers need to release manganese and other metals from soil reserves. Here's how. | Regenerative Ag

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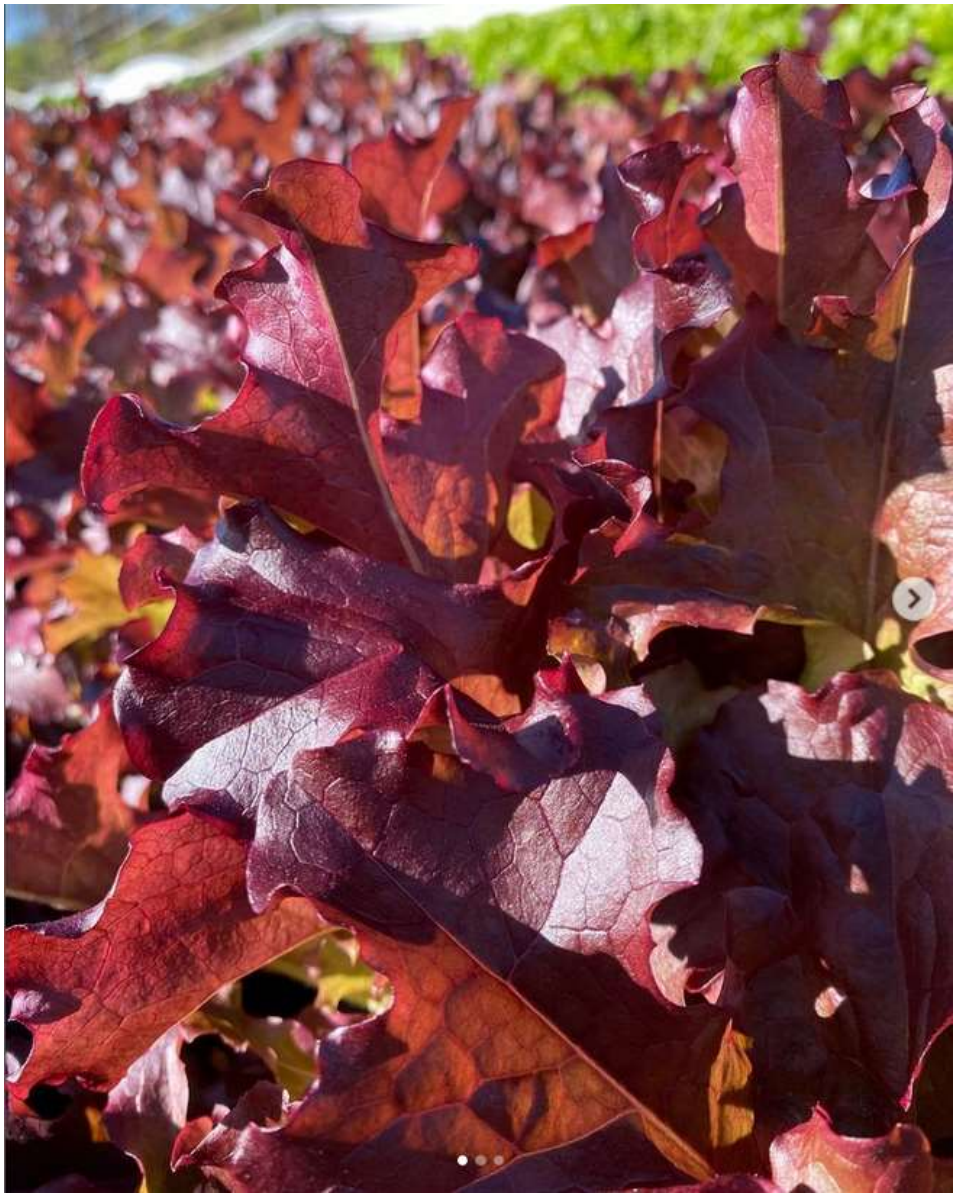


Iron – 5.6.2023

Chlorophyll Synthesis > Color

Leaf Thickness

Iron Superoxide Dismutase
FeSOD

Iron Availability

There is a lot of iron in soils,
yet very small quantities of Iron are available for plant uptake

Applications to the soil are typically not recommended
(though we've done them at Brix and seen a response)

We definitely include iron applications when putting on a heavy calcium application

Iron Sources and Availability

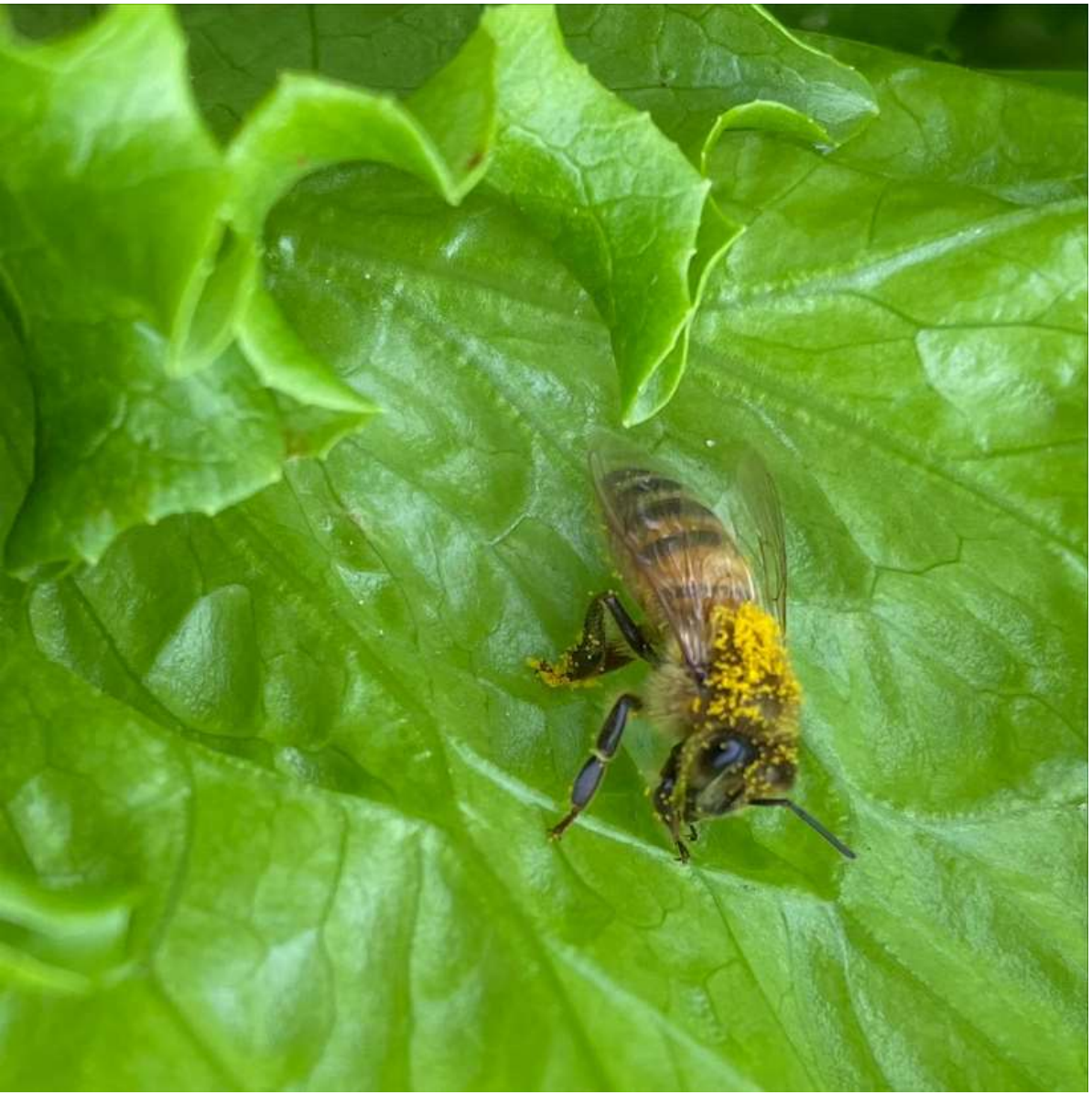
Iron Sulfate – Soluble 20% Fe
Blood Meal -

Humic Acid Applications – Soil

Foliar Iron > Many Sources – AEA, Biomin Iron,

May be Tied up with Calcium Applications, May be Tied up by bicarbonates
Generally less available with higher soil pH

Plant Uptake in the Reduced State –> Fe++
Iron Nutrition in Plants - https://edis.ifas.ufl.edu/publication/SS555



Manganese

Plant Uptake and availability requires Manganese to be in the reduced state > MN++

Enzymes of Note !!!
Photosynthesis >
water splitting enzyme

Reproductive Energy

Note on Balance with Iron
Always want higher Fe:Mn

Manganese

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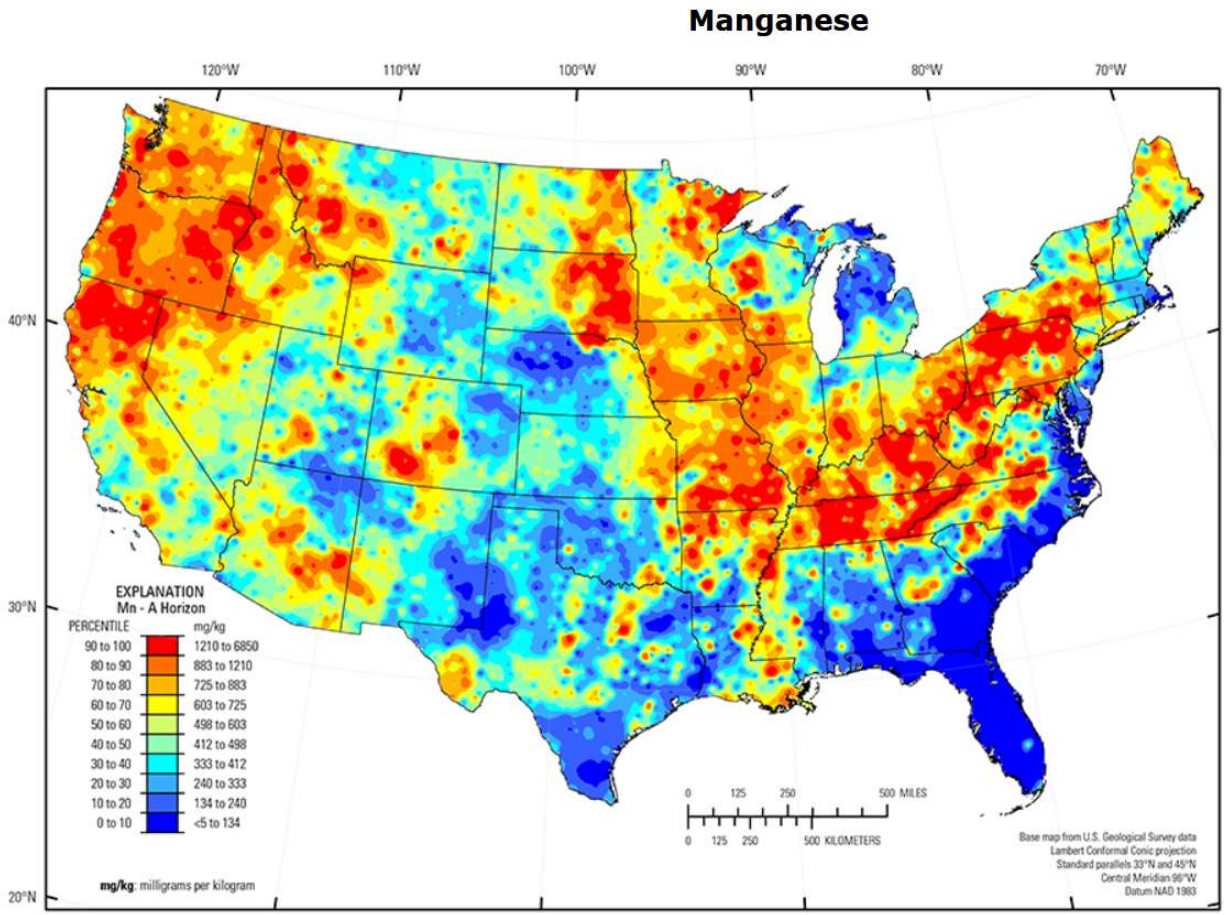

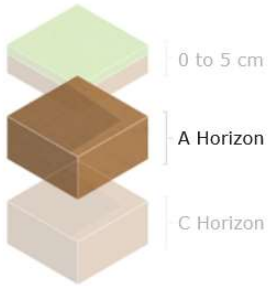

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Multipik – July 17. 2022

brixbountyfarm The (reproductive) power of Manganese... fertility info posted below. Here's a shot of the Multipik from the same bed as the Tempest photo shared earlier tonight.

Our soils on the coastal plain are typically low in Manganese, one of the minerals which brings reproductive energy to our plants. On a Mehlich-3 soil test we might see single digit PPM of Mn. Furthermore Mn becomes more available in a reduced soil environment, which we don't experience in dry aerated soils.

Foliar applications may be the best option for boosting plant available Mn quickly, it's also nice because you can target specific crops. Mn sulfate works in our experience when bonded with a fulvic acid, @advancingecoag also markets a Mn foliar product which many growers like.

Alas it's the busy season, and we haven't found the right moment for foliar sprays in this field.

No worries this is a field where we have been adding Mn to the soils over the last decade... recently at 5-20lbs per acre, always with a bit of iron sulfate to ensure we don't imbalance the Fe:Mn ratio.

Crop observation is a time tested method to determine mineral sufficiency or deficiency. If your fruiting crops aren't cranking out flowers or fruit you may want to consider Mn levels... just be careful on leafy crops.

Manganese Sources

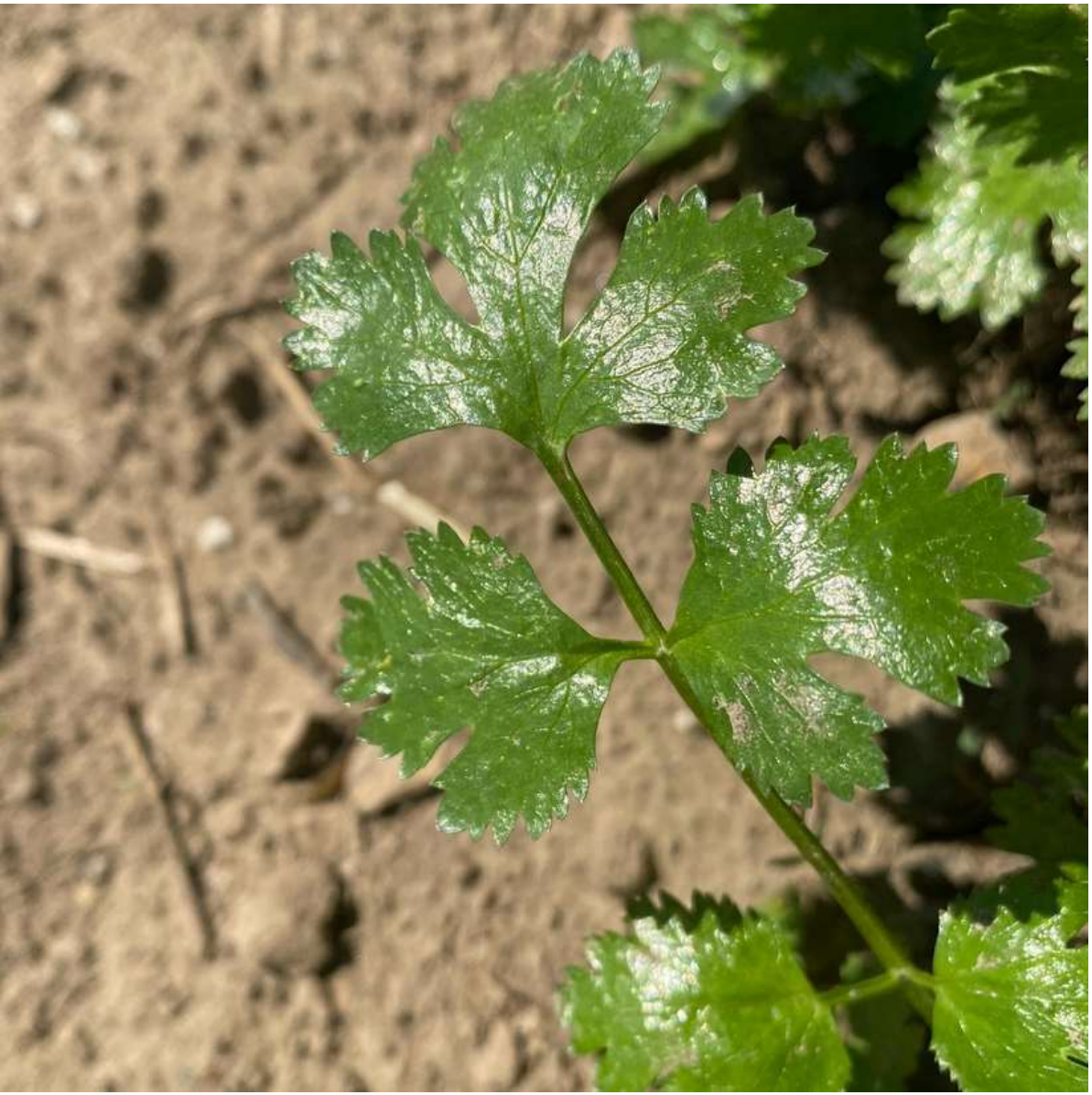
Manganese Sulfate – $MnSO_4$

Rebound Manganese (AEA) – for foliar applications

Biomin Manganese (SaferGro)

$17.10 per qt, $39.25 per gal (or less for 2 x 2.5 gal- JH Biotech)

https://safergro.com/products/biomin-manganese?variant=37877359345854



Minerals Required for Plant Growth (BOLD)

Calcium

NPK – Nitrogen, Phosphorous, Potassium

Sulfur*

Magnesium

Carbon, Hydrogen, Oxygen

Silicon, Sodium

Boron*, Chlorine, Copper*, Iron, Manganese*, Zinc

Cobalt, **Molybdenum*, Nickel***, Selenium

*Often Overlooked

Super SOD Takeaways

Do I have the necessary minerals available required to reduce oxidative plant stress?

If not, how can I increase their availability?

Observation, Observation, Observation

R.O.W.

Thanks

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