

Manganese Requirements of Crops Vibrantz

Manganese in Crops | Agenda

- What plant functions does manganese have?
- How common is manganese deficiency?
- What conditions make for a deficiency of available manganese, and why?
- What crops are most susceptible to Mn deficiency?
- What does Mn deficiency look like?
- When to apply manganese?
- How to best apply manganese – soil or foliar?
- What manganese sources are available and which is best?

Manganese is in the News

Yellowing in peanuts is due to manganese deficiency

Ag Professional
August 19, 2014 10:54 AM

Several peanut fields in Holmes County are demonstrating observed from a passing vehicle. There are several possible including nitrogen problems due to wet soils or poor nodulation conditions like white mold, or a nutrient deficiency or toxicity.

The fields (we visited) were experiencing a manganese (Mn) deficiency, which results in an interveinal chlorosis that typically shows on young leaves or new growth, but in severe deficiency in pe... soil pH tested...

A broadcast sp... growing season... manganese s... water per acre... most cases, r...

Purdue News

December 2000

'Hidden hunger' threatens many crops, researcher says

"Manganese, from a disease standpoint, plays a critical role," Huber says. "It's not only directly involved in plant photosynthesis but also in defense to..." Soybeans, wheat, oats and barley are... vulnerable to manganese shortages.

... and corn also need adequate amounts of zinc,...

... is sensitive to imbalances of manganese and nitrogen, which work in concert within the plant. In extreme cases the imbalance can set off a chain of events resulting in the plant feeding off the nutrient reserves in its own cell walls to ensure kernel development, Huber says. The cannibalization weakens the plant, inviting disease.

... on its own tissue,

Manganese: The "Silver Bullet" For High Yielding Corn?

By Darren Hefty

What's the "silver bullet" for achieving higher yields? That's a question I get all the time. Usually I would just say there isn't a silver bullet. This year for one farmer I know manganese was the single answer for a large yield gain. Let me explain.

A farmer who applies a good amount of hog manure as a majority of his fertility program attended an Ag PhD Soils Clinic in 2015. It inspired him to take a new look at his soil. With a complete soil analysis he learned that the only nutrient he was short in (in other words, his yield-limiting factor) was manganese. So for 2015's corn crop, he applied only manganese and left two check strips. He saw yield gains of 31 bushels per acre and 38 bushels per acre where he applied the manganese. It was his "silver bullet" this year.

We target a soil test level of 20 to 40 ppm on a Midwest Labs 6-inch soil test...

Crop removal on corn, soybeans, wheat, and most other crops... the critical level so it won't hurt your yield...

CROP TALK

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BA Deere
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Posts: 14,944
Registered: 05-13-2010

MANGANESE, 2017 NUTRIENT OF THE YEAR
01-12-2017 07:38 AM

Every year a hot new plant food or soil amendment is plugged, this year it's Manganese. Brian Hefty was in Rochester talking about their yield plot on their test plot in Baltic. They have top yield growers from around the country and give them their own little plot to manage however they want (sounds very interesting). Well the top plot yielders Brian H and Randy Dowdy applied 10-15lbs of Manganese Sulfate.

The Manganese improves crop emergence, if a corn plant is late coming up, it becomes kind of a "weed", ideally corn will spike uniformly within 24 to 48hrs. One of my heroes, Neal Kinsey visited the Hefty farm and walked 3 paces into one of the plots and right away remarked "This plot must have a Manganese deficiency" Darrin (the other Hefty brother) says "yes, our tissue samples showed that, but how do you know just walking 3 steps out here?????" Neal says "look at the uneven height of ear placement on the stalks, they didn't emerge at the same time". Neal is nothing short of a genius.

The four R's, our guiding Principal



**Right
Source**



**Right
Rate**



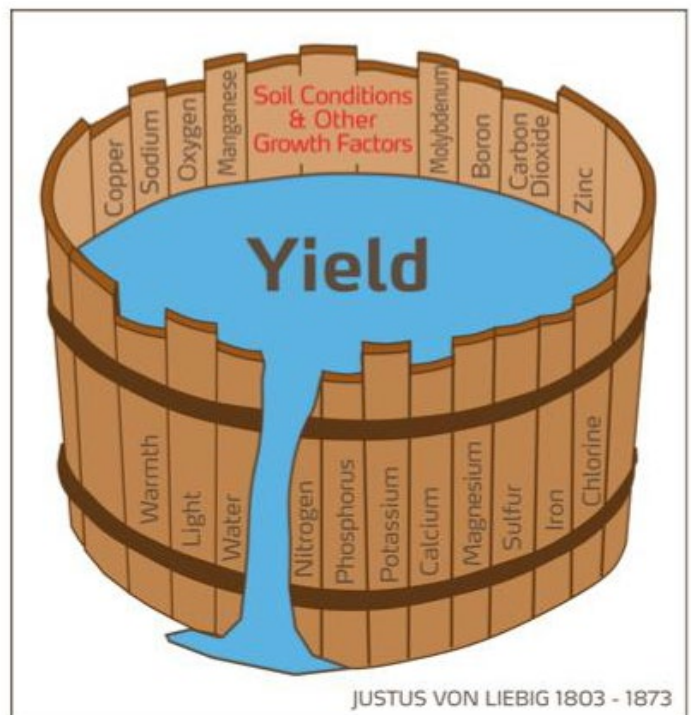
**Right
Time**



**Right
Place**

Liebig's Law of the Minimum

Justus von Liebig's "Law of the Minimum"
published in 1873: "If one growth factor/
nutrient is deficient, plant growth is limited,
even if all other vital factors/nutrients
are adequate... plant growth is improved
by increasing the supply of the deficient
factor/nutrient"



Mulder's Graph – Nutrient Interaction

Mn Availability Antagonized By Excess:

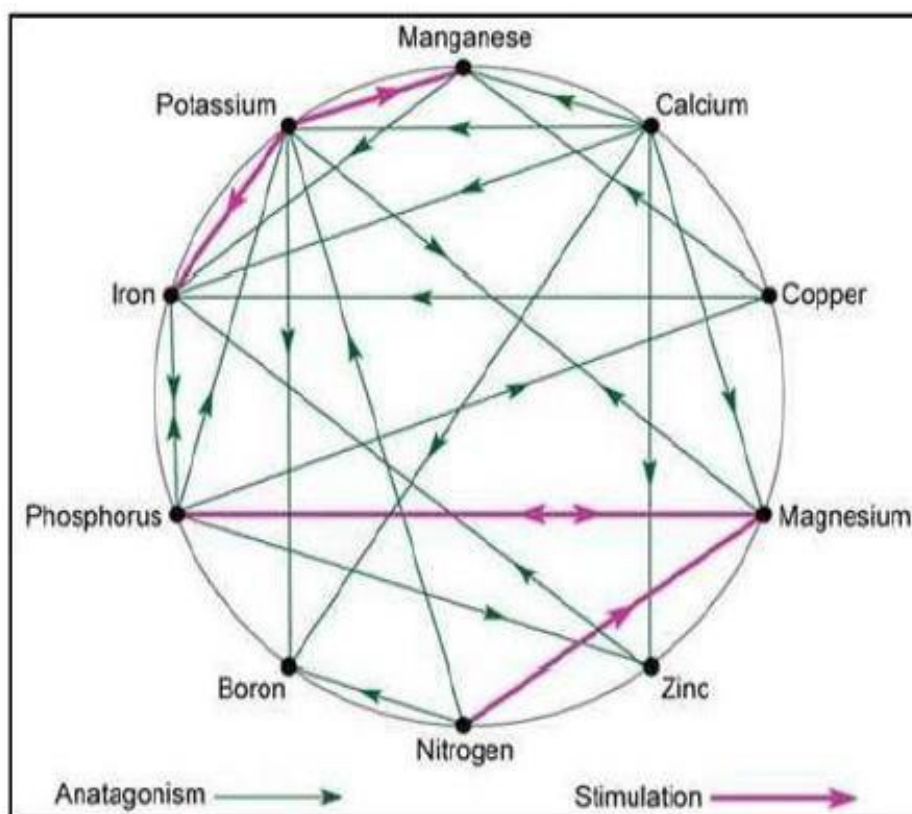
- Calcium
- Copper

Mn Surplus Antagonizes:

- Iron

Mn Demand Stimulated By:

- Excess Potassium

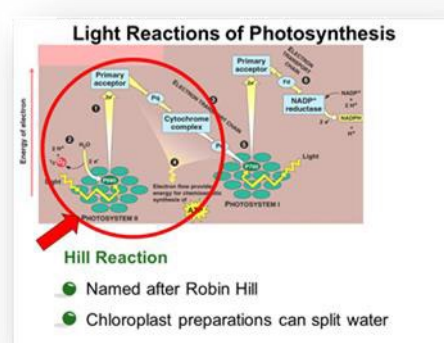
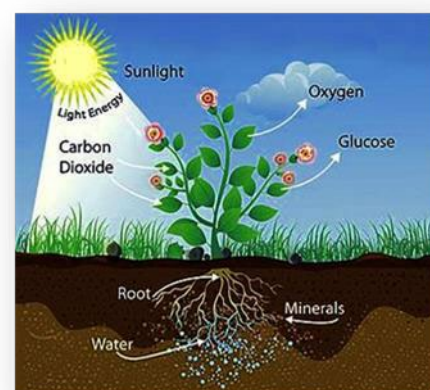


Antagonism: Decreased availability of a nutrient to a plant due to the action of another nutrient.

Stimulation: High level of a nutrient increases the demand of the plant for another nutrient.

Optimal Mn Nutrition by Fertilization can:

- Improve **photosynthetic efficiency** and dry matter production
- Provide **resistance to biotic stress** (pathogens) by optimizing the plant's ability to combat various diseases and reducing fungicide reliance
- Contribute to **abiotic stress tolerance**, particularly drought and heat
- Result in significant **crop yield improvement**.



How common is Mn Deficiency?

USA Study By the Trace Element Committee of the Council
On Fertilizer Application Studied all 50 States

Micronutrient Deficiency	Number of States
Boron	41
Zinc	30
Manganese	25
Iron	25
Molybdenum	21
Copper	13

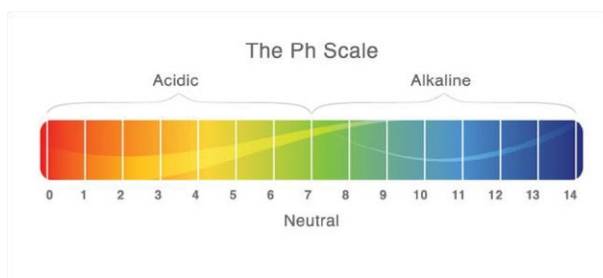
Mn Deficiency Crops	In Number of States
Bean	13
Corn	5
Fruit Trees	9
Small Grains	10
Spinach	8

<http://pubs.acs.org/doi/pdf/10.1021/jf60121a005>

Soil Predictors of Mn Deficiency

Soil pH:

- Ideal 5 to 6.5
- >6.5 Likely deficiency
- <5 Potential for Mn toxicity



Soil Organic Matter

- Organic (muck) soils with pH >5.8
- Soil Mn often chelated by organic molecules and often available

Soil Moisture and Temperature:

- Dry soil conditions reduce Mn availability
- Cold and wet conditions cause reduced Mn uptake



Mineral Interference:

- Excessive amounts of reduces Mn uptake:

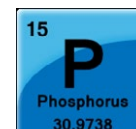
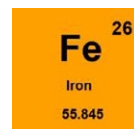
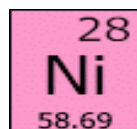
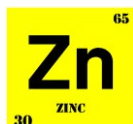
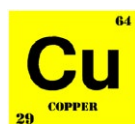
Copper

Iron

Nickel

Zinc

Phosphorous



Mn Supplementation Lesser Factors

- **Mn:Mo Balance:** One researcher observed that Mn concentrations were reduced in half by molybdenum (Mo) fertilization. This limited evidence should not be used to make Mo recommendations due to the possible toxic reactions of high Mo contents that could occur in animals grazing or eating the crops grown on high Mo soils.
- **Mn:Si Balance:** Research has shown that silicon (Si) applications can alter the Mn distribution in leaf tissue in such a way as to reduce the possibility of Mn toxicity from excess Mn uptake.
- **N STRESS:** Low N availability decreases the vigor of plants to an extent that it may fail to take up adequate amounts of many other nutrients. Manganese uptake can be affected in this way.
- **Mn:S Balance:** The Sulfur interaction is primarily one-way, as the Sulfur content of the plant is diminished so also is the Manganese content.
- **Mn:Anion Balance:** Heavy fertilization with materials containing Cl^- , NO_3^- , SO_4^- , can also enhance Mn uptake (termed the anion effect).

http://spectrumanalytic.com/doc/library/articles/mn_basics

Mn Supplication Predictor

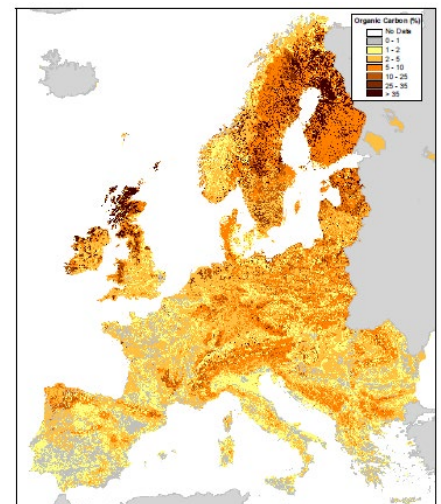
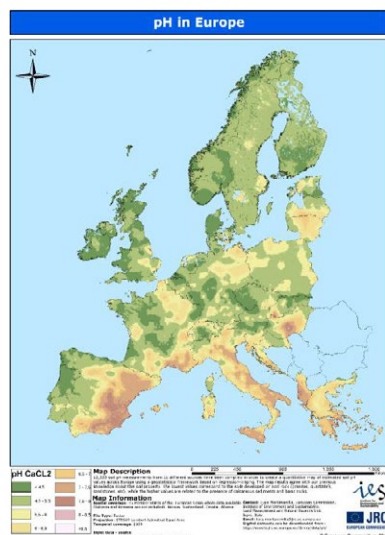
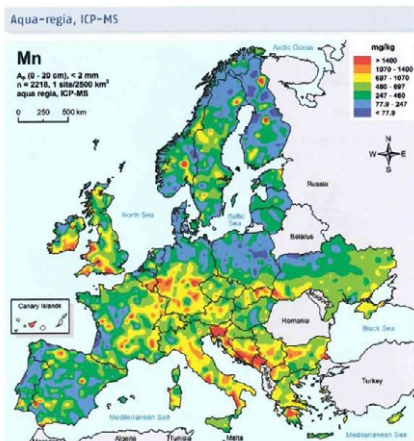
Low Soil Mn

+

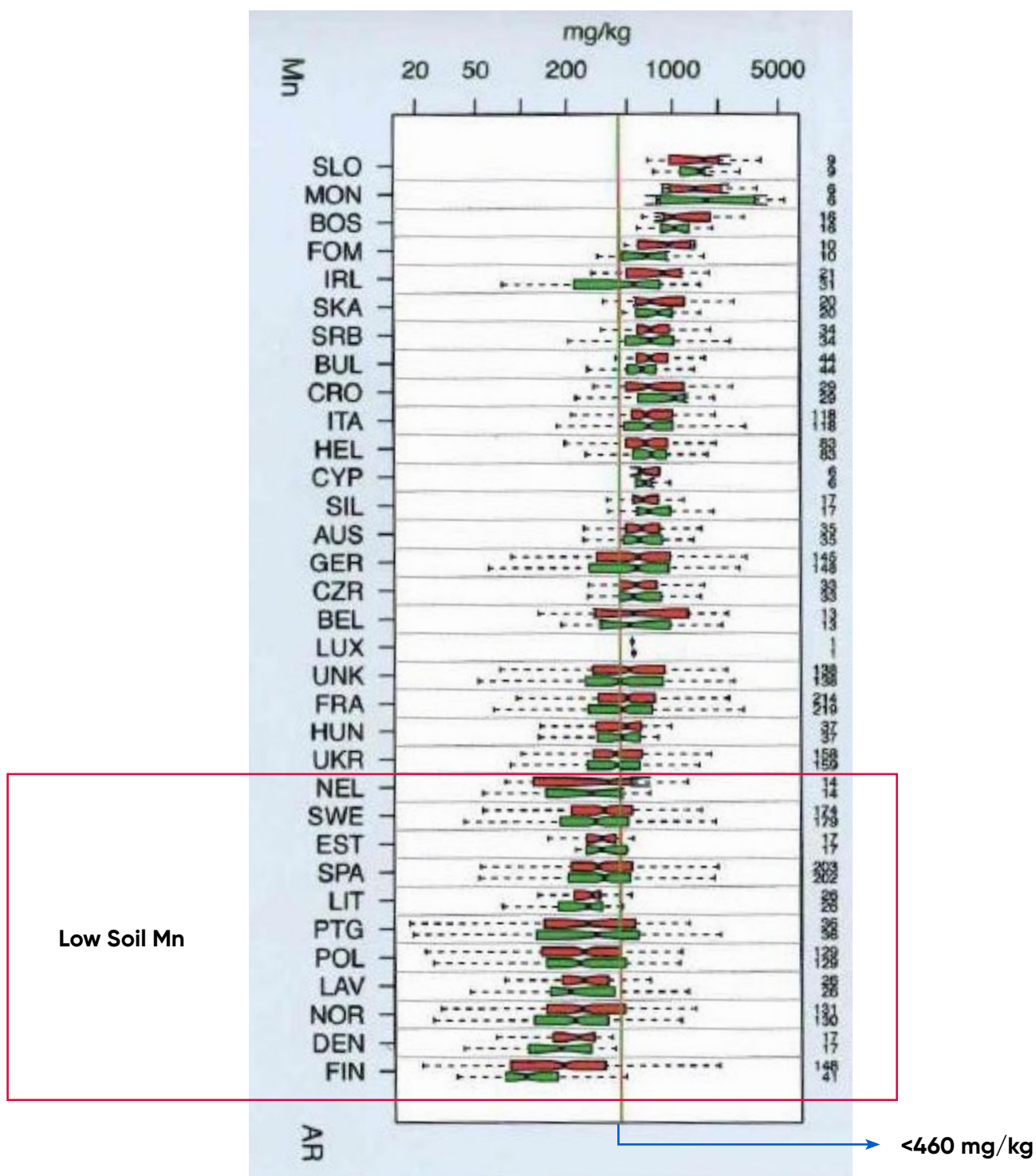
High pH

+

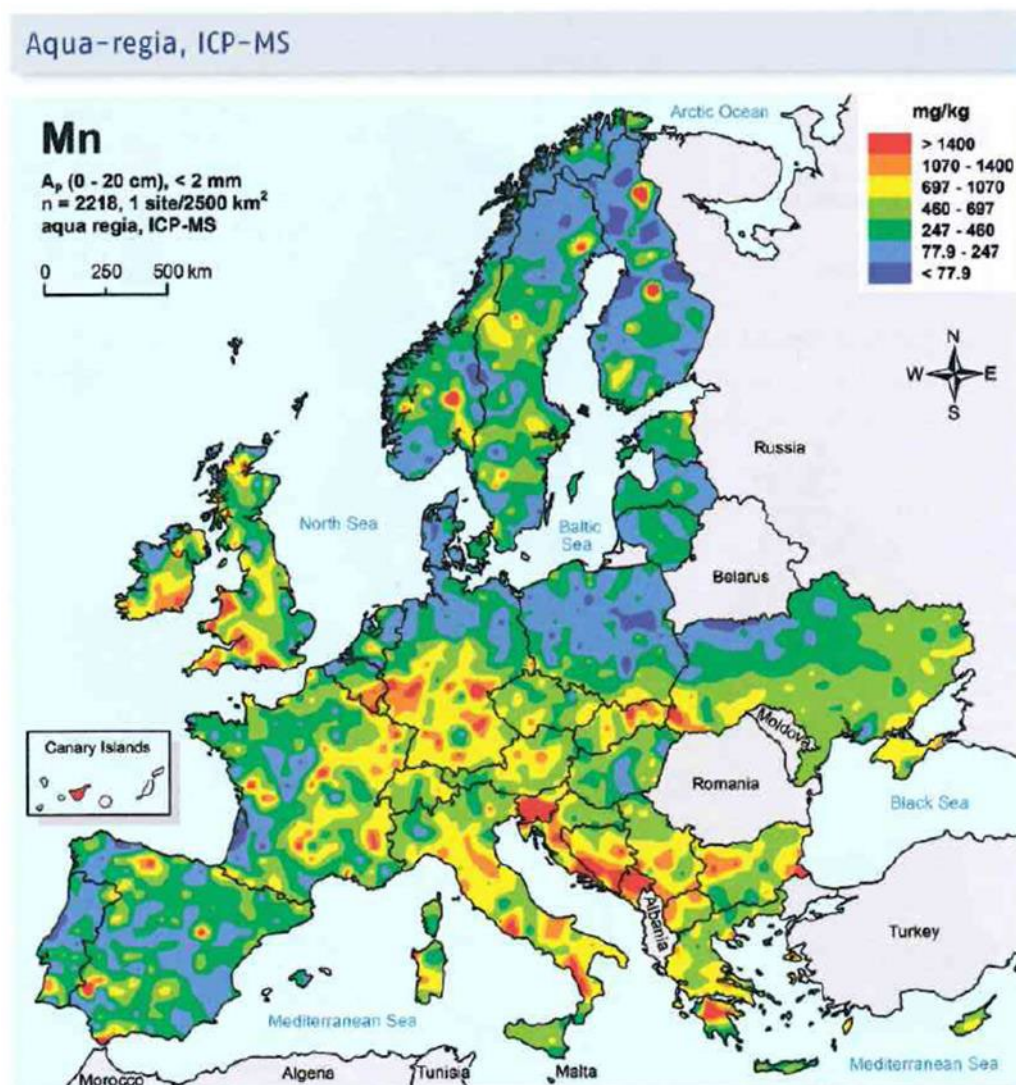
High Organic Content



Aqua Regia Extraction of Mn From Soil



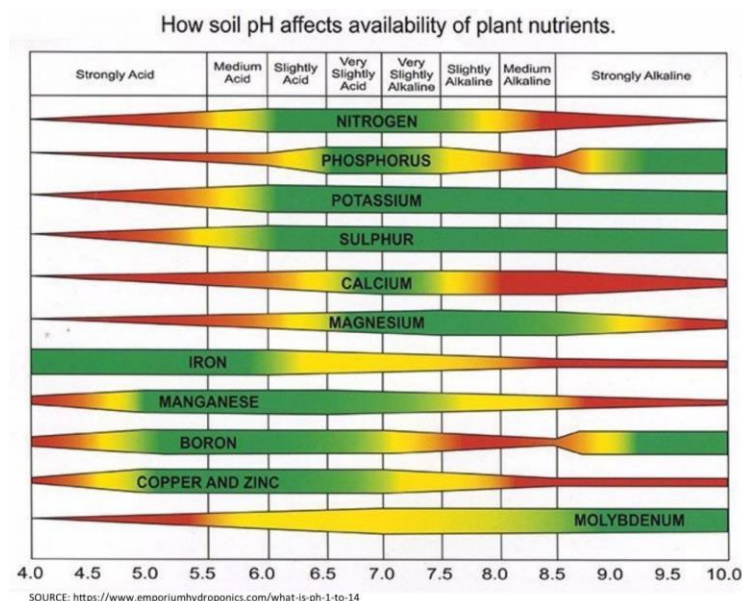
European Agricultural Production Land Mn Levels



- Manganese deficiency is the most widespread trace element problem in arable crops in the UK
- Most commonly seen in cereals, with an estimated 15-20% of the crop area being treated with Mn annually
- Increased incidence of Mn deficiency in cereal crops in the **Schleswig-Holstein area of Germany**, associated with higher yielding crops Finck (1987)
- Some deficiency also common in cereal crops grown in clay-loam soils with a soil pH of over 7.0
- Leached sand and podzolic soils especially deficient in Mn

Soil Analysis – the Baseline

- Manganese treatment is recommended if the soil tests less than 10 PPM.
- When soil organic matter exceeds 6%, the availability of manganese is based on soil pH.
- Manganese is recommended if the pH is above 7.0

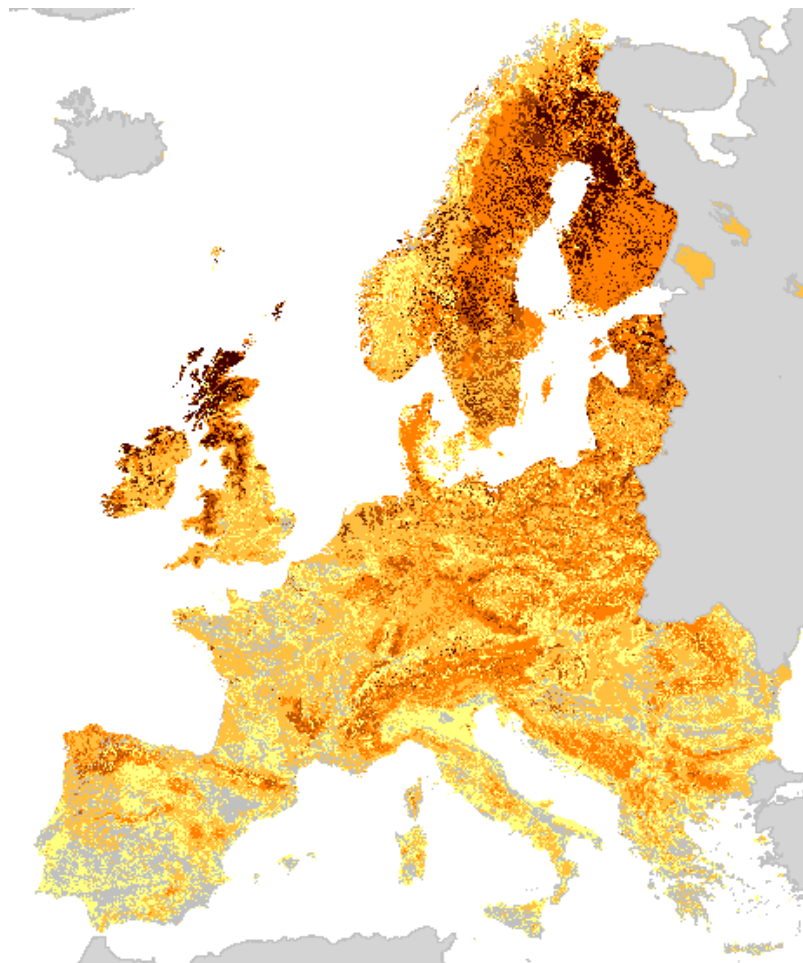


<http://www.soils.wisc.edu/extension/pubs/A2526.pdf>

https://richmond.ces.ncsu.edu/wp-content/uploads/2016/01/How_Soil_pH_affects_availability_of_plant_nutrients.jpg

European Soil Organic Matter

Country	Soil Organic Matter peta grams [Pg]
Sweden	13.8
Finland	12.5
United Kingdom	7.1
Germany	5.8
Norway	5.7
Poland	5.6
France	5
Spain	3.5
Romania	2.3
Italy	2
Latvia	1.8
Ireland	1.6
Estonia	1.5
Austria	1.2
Czech Republic	1.1
Lithuania	1.1
Bulgaria	1
Hungary	1
Serbia	1
Netherlands	0.8
Switzerland	0.7
Denmark	0.6
Greece	0.6
Slovakia	0.6
Portugal	0.5
Croatia	0.5
Bosnia and Herzegovina	0.5
Belgium	0.3
Slovenia	0.2
Albania	0.2
Macedonia	0.2
Cyprus	<0.1
Luxembourg	<0.1
Malta	<0.1



High Mn Response Crops

Many crop species show high susceptibility to Mn deficiency in soils, or a very positive response to Mn fertilization, including:

- Cereal crops (wheat, barley and oats)
- Legumes (common beans, peas and soybean)
- Stone fruits (apples, cherries and peaches)
- Palm crops
- Citrus
- Potatoes
- Sugar beets
- Canola

http://spectrumanalytic.com/doc/library/articles/mn_basics

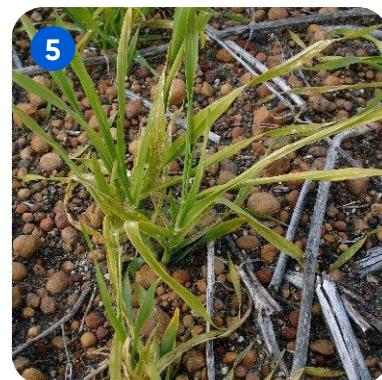
Deficiency Symptoms

The key is to know where your Mn levels are prior to having an issue.

- Mn is not translocated in the plant
- Deficiency symptoms appear first on younger leaves.
- The most common symptoms on most plants are **interveinal chlorosis**.
- Sometimes a series of brownish-black specks appear in the affected areas.
- In small grains, grayish areas appear near the base of younger leaves.

http://spectrumanalytic.com/doc/library/articles/mn_basics

Mn Deficiency Symptoms



- 1 Manganese deficient corn plants (right) compared with normal corn (left)
- 2 Typical interveinal chlorosis caused by manganese deficiency in corn, ...
- 3 ...in apples
- 4 ...in winter wheat
- 5 ...in barley
- 6 ...in oats
- 7 ...on potatoes.

Tissue Analysis for Mn Levels

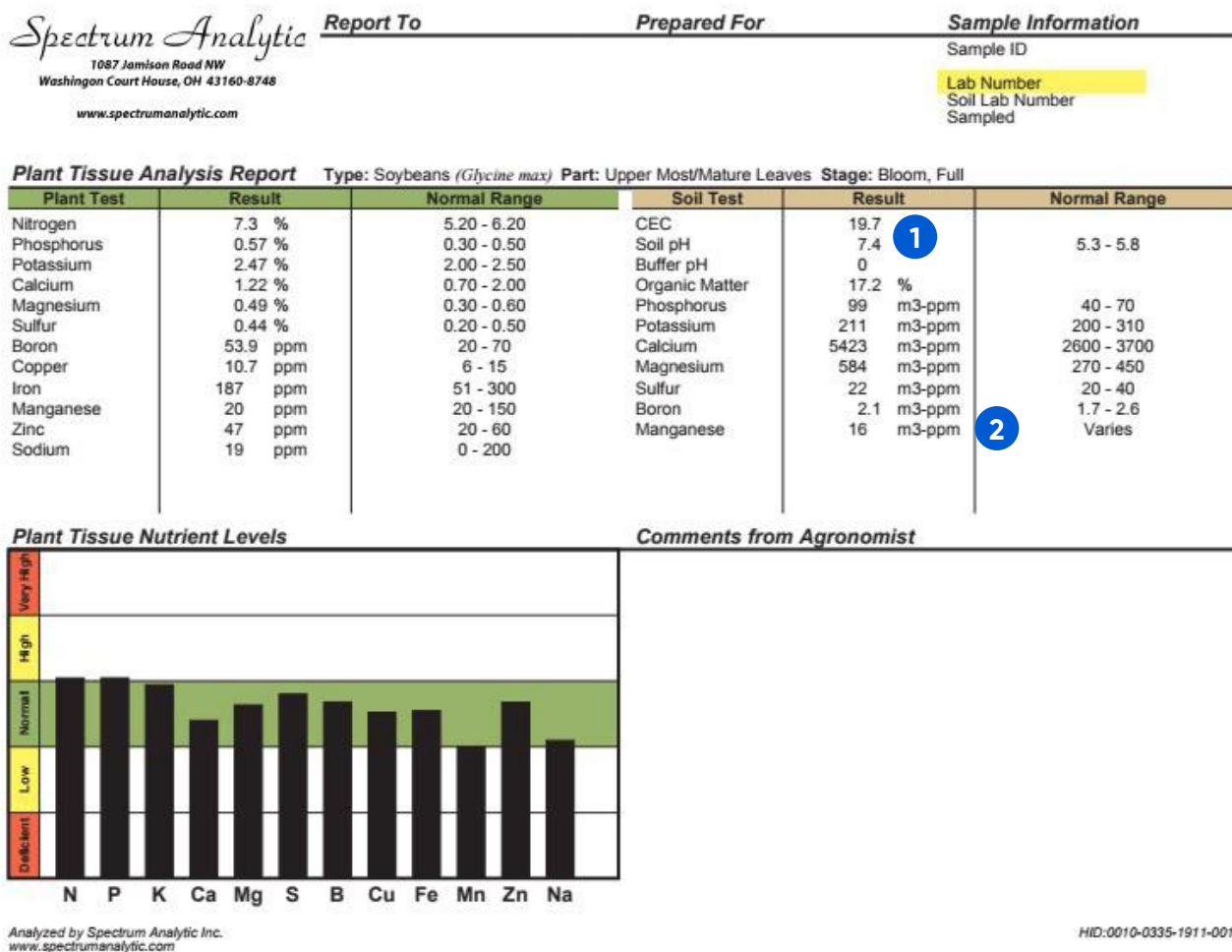
For timely remediation of Mn Deficiency

Table 4. Manganese plant-analysis interpretations for common Wisconsin crops.

CROP	PLANT PART SAMPLED	TIME OF SAMPLING	INTERPRETATION				
			DEFICIENT	LOW	SUFFICIENT	HIGH	EXCESSIVE
			ppm				
Alfalfa	Top 6 inches	Bud	<15	15–25	26–150	151–300	>300
Corn	Earleaf	Silking	<15	15–25	26–150	151–200	>200
Oat, wheat	Top leaves	Boot	<10	10–25	26–150	151–250	>250
Onion	Tops	Midseason	<10	10–20	21–150	151–300	>300
Potato	Top leaves	Flowering	<10	10–20	21–200	201–400	>400
Soybean	First Trifoliolate	Early flower	<15	15–20	21–100	101–250	>250

<http://corn.agronomy.wisc.edu/Management/pdfs/a2526.pdf>

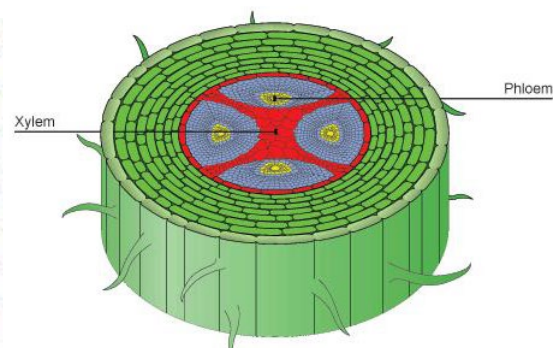
Tissue Tested Low, Soil Tested OK



- 1 When soil organic matter exceeds 6.0%, the availability of Mn is based on soil pH. Mn is recommended if the pH is above 7.0
- 2 In general, Mn treatment is recommended if the soil tests less than 10 PPM.

When to Apply & Mn Mobility

MOBILE & NON-MOBILE NUTRIENTS		
MOBILE	LIMITED MOBILITY	NON-MOBILE
Nitrogen (N)	Zinc (Zn) <small>poor mobility in permanent crops</small>	Calcium (Ca)
Phosphorus (P)	Boron (B) <small>only mobile in some fruit</small>	Silicon (Si)
Potassium (K)		Iron (Fe)
Magnesium (Mg)		Manganese (Mn)
Sodium (Na)		Copper (Cu)
Chlorine (Cl)		Molybdenum (Mo)
Sulfur (S)		Nickel (Ni)



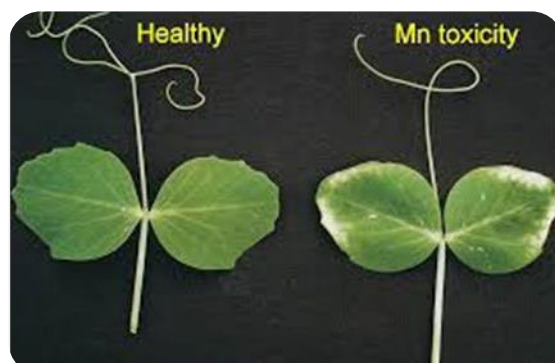
Plants have two different types of transport tissue. Xylem transports water and solutes from the roots to the leaves, phloem translocate food substances from the stems to growing tissues and storage tissues.

- Due to Mn's low phloem mobility in plants, Mn deficiency first develops in younger leaves.
- The critical concentration for Mn deficiency is generally below 20 ppm dry weight in fully expanded, young leaves.
- Feed in installments: Spoon feed the non-mobile nutrients at the right time and place. One time high rates for these nutrients is not efficient. It is best to keep feeding via the foliage or soil in small amounts on an as-needed basis.
- Apply to meet key demand periods, when these nutrients are most needed and most likely to come up short due to problems in the soil. Timely strategic fertigation or foliar feeding at critical times provides the best benefit.

http://www.fbsadvantage.com/micronutrients/#product_line_category-16084

Manganese Toxicity in Plants

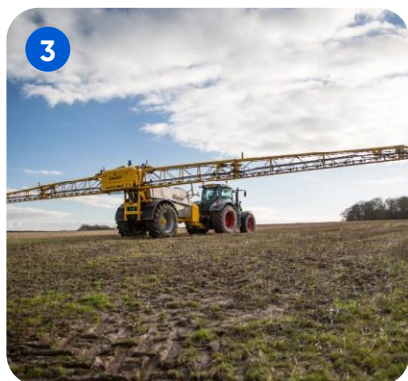
- Associated with acidic and poorly drained soils of pH 5.5 or lower, but can occur whenever the soil pH is below 6.0.
- Symptoms include chlorosis and necrotic lesions on old leaves, dark-brown or red necrotic spots.
- May alleviate by using Iron chelates applied to either the soil or preferably the foliage.



Applying Mn



- 1 Fertigation
- 2 Surface Spreading
- 3 Foliar
- 4 Seed Coating
- 5 Banding (In Furrow)



How To Best Apply – Soil & Foliar

Applying Mn to deficient soils or crops needs to be thought out.

- Mn can be easily tied up or converted into unavailable forms when applied directly to the soil.
- Banded applications, not broadcast applications, of Mn are best when applying directly to the soil for these reasons.
- It is not recommended to add EDTA chelated forms to the soil because they can actually increase the Mn deficiency due to its affinity to iron, and substitution ensues.
- If deficiency symptoms are observed in the crop, there are several options for foliar applied Mn solutions.

<http://www.lgseeds.com/blog/agronomy-blog/2017/02/03/importance-of-manganese-in-crop-production>

Application Rates, Univ. of Wisconsin

Table 3. Manganese fertilizer recommendations.

CROP	— MnO or MnSO ₄ —		— Mn CHELATE —	
	SOIL	FOLIAR	SOIL	FOLIAR
	———— lb/a of elemental manganese ————			
Beans (dry, lima, snap), lettuce, oat, onion, radish, raspberry, soybean, spinach, sorghum-sudan, wheat	5.0	1.0	0.8	0.15 ^a
Barley, beet, broccoli, brussels sprout, cabbage, canola, carrot, cauliflower, celery, corn, cucumber, pea, potato, tobacco, tomato, triticale	3.0	0.75	0.5	0.10
Other crops (not listed above)	0	0	0	0

^aPhytotoxicity may occur if Mn chelate is applied at a rate greater than 0.25 lb/a of Mn.

<http://corn.agronomy.wisc.edu/Management/pdfs/a2526.pdf>

Three Main Classes of Micronutrients

1. Inorganic

1. Sulfates
2. Chlorides
3. Nitrates
4. Oxides
5. Carbonates

2. Organics (Synthetic chelates) – protect the associated metal from reaction with other ingredients, such as herbicides, fungicides and insecticides

1. EDTA
2. EDDHA
3. NTA
4. DTPA

3. Natural organic complexes

1. Glucoheptonates, sugars e.g. sugar cane by-products
2. Lignosulfonates – Paper industry by-product
3. Citric Acids

<https://fluidfertilizer.org/wp-content/uploads/2016/09/Alan-Robinett-Micronutrient-Compatibility.pdf>

Fertilizer Sources of Manganese

Mn Source	Formula	% Mn	Water Solubility	Format	Advantages	Disadvantages
Mn Sulfate	MnSO_4	28 to 32	Soluble	Powder or Granule	Includes sulfur, good for chelate production	Renders glyphosates ineffective if mixed together
Mn Chelate	MnEDTA	5 to 12	Soluble	Powder	Very good foliar effectiveness	Cost, and some not good for soil app.
Mn Nitrate	$\text{Mn}(\text{NO}_3)_2$	15	Soluble	Solution	Most bioavailable Mn	No dry form available
Mn Chloride	MnCl_2	17	Soluble	Dry prill or flake	Compatible with calcium tank mixes	Can burn plants, care in use required
Mn Carbonate	MnCO_3	44	Negligible	Powder	Provides slow release, and good for chelate production	Not water soluble
Mn Oxide	MnO	60	Insoluble	Powder	High Mn %	Not water soluble

Global Presence, to Serve Local Ag Customers



Vibrantz Mn Sources

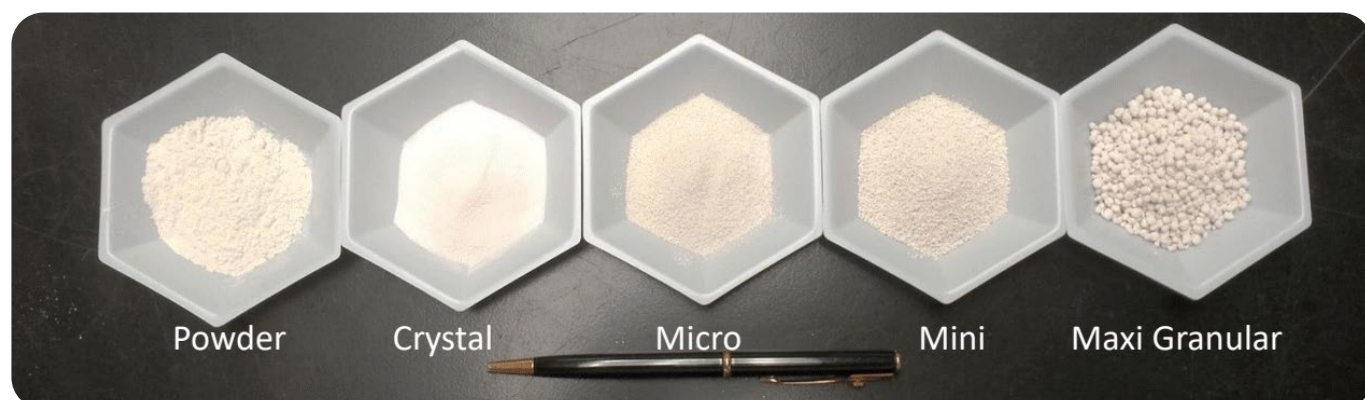


Tecmangam® – Versatile Crop Nutrition

Fully Water Soluble Manganese Sulfate

- 31 to 32% Mn
- 19% Sulfur
- Fast & thorough dissolution
- Low calcium and Mg
- Five Particle Sizes

Powder Crystal Micro Mini Maxi Granular



MnO HP – High Purity

Popular for Producing Crop Chelates

- Highest level of Mn at 77%
- Very pure
- Fast dissolution with no residue



Manganese Carbonate

- Popular with Organic Trace Mineral producers for its high reactivity
- Popular addition to foliar fertilizers for a time release manganese

Guaranteed Specifications:

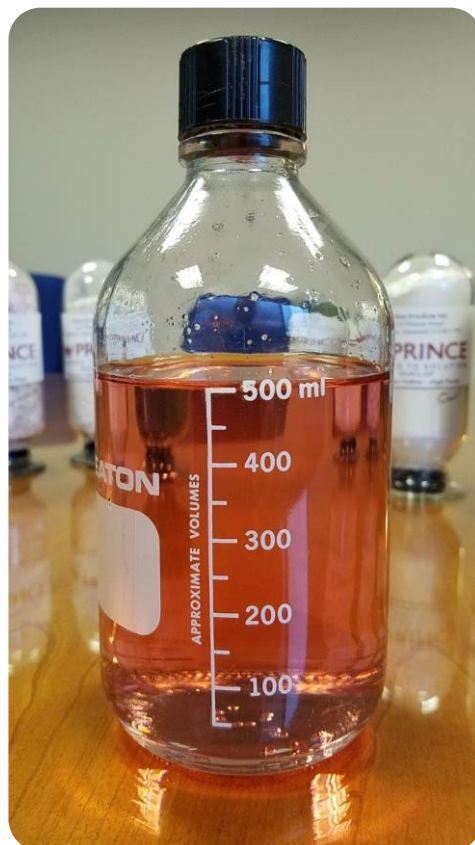
Mn	44% min.
H ₂ O (105° C)	2.5% max.
S	0.1% max.
<75 µm	90% min.



Manganese Nitrate Solution

Manganese in an extremely soluble form

- Has 15% Mn and 7% N
- Has twice the solubility on a metal basis as MnSO_4



ALMA®

60% Manganese in small particle form

- No more than 2% MnO_2
- In soil, under right pH conditions, has been shown to be a slow release nutrient

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