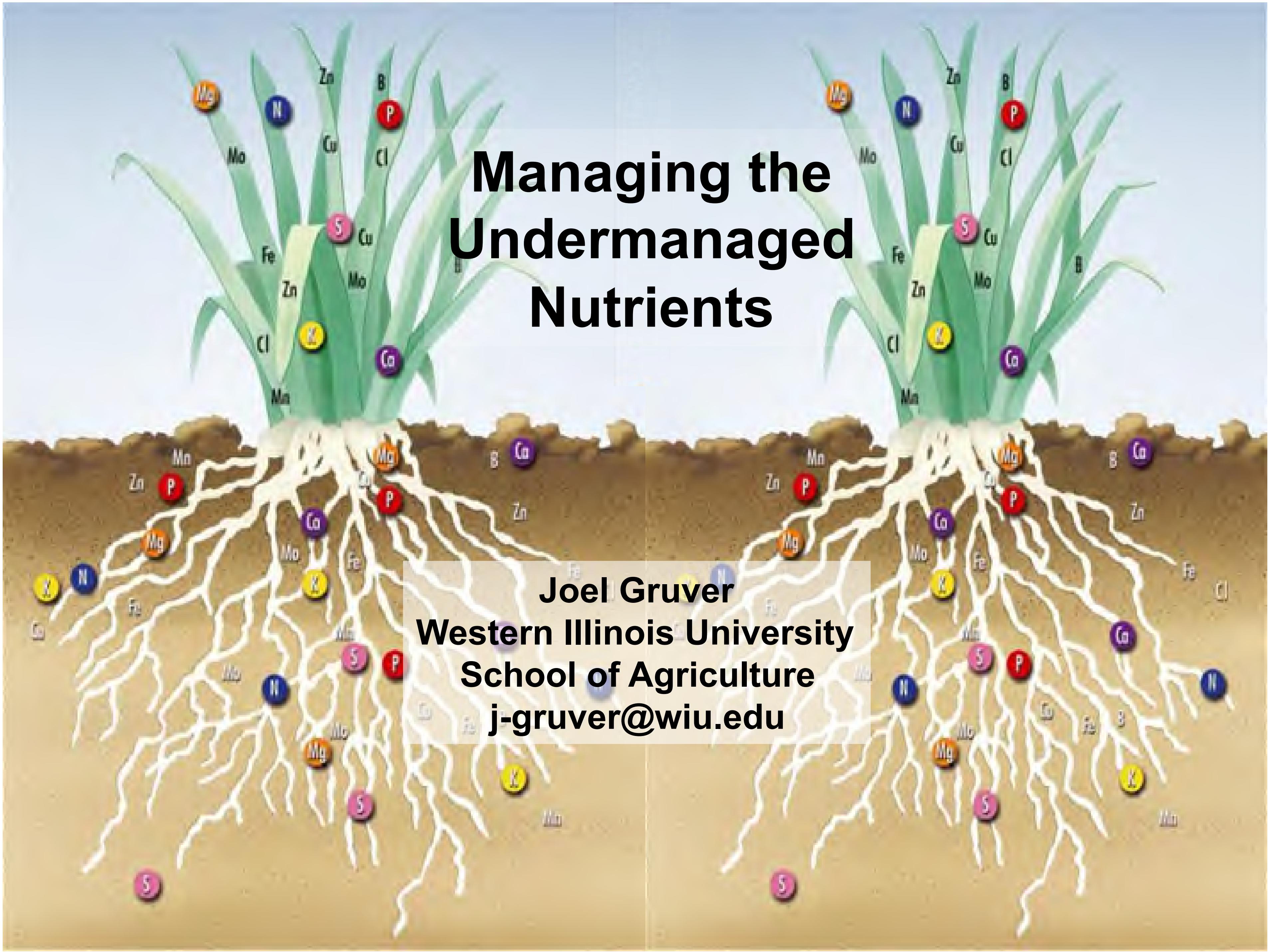
Alternative technologies for timely cover crop establishment

http://www.slideshare.net/jbgruver/alternative-cover-crop-seeding-technologies-6547533

Managing the Undermanaged Nutrients

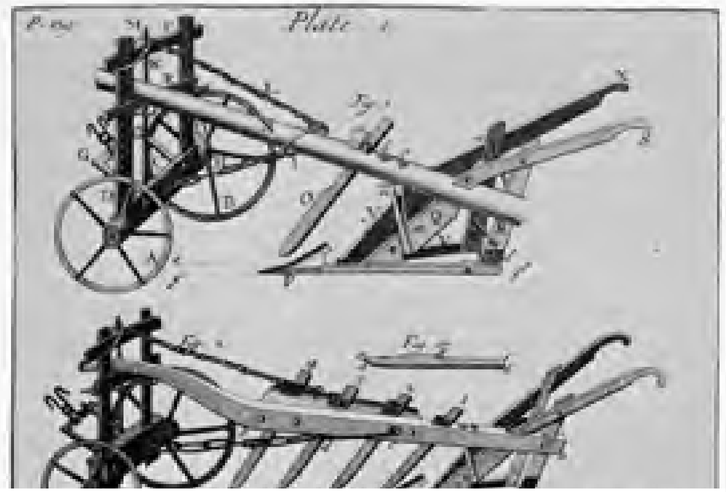
Joel Gruver
Western Illinois University
School of Agriculture
j-gruver@wiu.edu



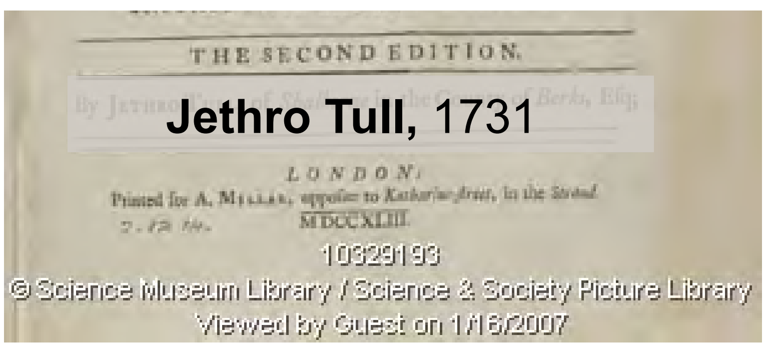
What is driving current interest in micro/secondary nutrients ?

1) High commodity prices, input costs and crop yields.
2) Higher retailer profit margins :->
3) Increased availability of precision nutrient application equipment allowing micronutrients to be applied accurately and uniformly at relatively low rates.
4) Ease and convenience of adding micronutrients to multiple-input tank mixes of herbicides, fungicides, etc. already destined for field application.
5) Increased understanding of soil/crop nutrient relationships by producers and their crop advisors.

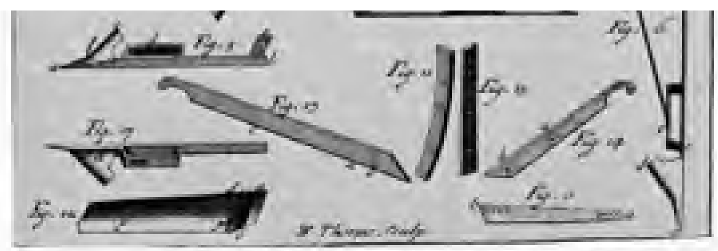

THE
Horse-Hoing Husbandry;
Compleat in Four Parts:
OR, AN
E S S A Y
ON THE
PRINCIPLES
OF
TILLAGE and VEGETATION.
WHEREIN



Jethro Tull invented the grain drill and many complementary technologies that resulted in large increases in grain yields during the 18th century.


THE SECOND EDITION.

LONDON:
Printed for A. Millar, opposite to Katharine-street, in the Strand.
MDCCXLIII.



Jethro Tull's *Horse-Hoing Husbandry*, London, 1733, influenced Washington's early attempts at scientific farming. (Beinecke Rare Book and Manuscript Library, Yale University)

[xxvii]

"**All sorts of dung and compost contain some matter, which, when mixt with the soil, ferments therein; and by such ferment dissolves, crumbles, and divides the earth very much; This is the chief, and almost only use of dung...** ***This proves, that its (manure) use is not to nourish, but to dissolve, i.e., divide the terrestrial matter, which affords nourishment to the mouths of vegetable roots***."

Jethro Tull, 1731

Adoption of Tull's tillage intensive row cropping system increased yields dramatically across Europe

"All sorts of dung and compost contain some matter, which, when mixt with the soil, ferments therein; and by such ferment dissolves, crumbles, and divides the earth very much; This is the chief, and almost only use of dung... *This proves, that its (manure) use is not to nourish, but to dissolve, i.e., divide the terrestrial matter, which affords nourishment to the mouths of vegetable roots*."

Jethro Tull, 1731

even though it was based on an incorrect theory of crop nutrition

~ 18 elements have been identified as essential for the growth of all plants

Soil

C O H N K Ca Mg P S Cl Fe Mn Zn B Cu Mo

air & water macronutrients micronutrients

0.1%
of plant dry matter

Many more elements are found in plants
some of which clearly have beneficial
(but not essential) effects on plant growth/health

V Ni
Si **Needed by some plants** Co
Na

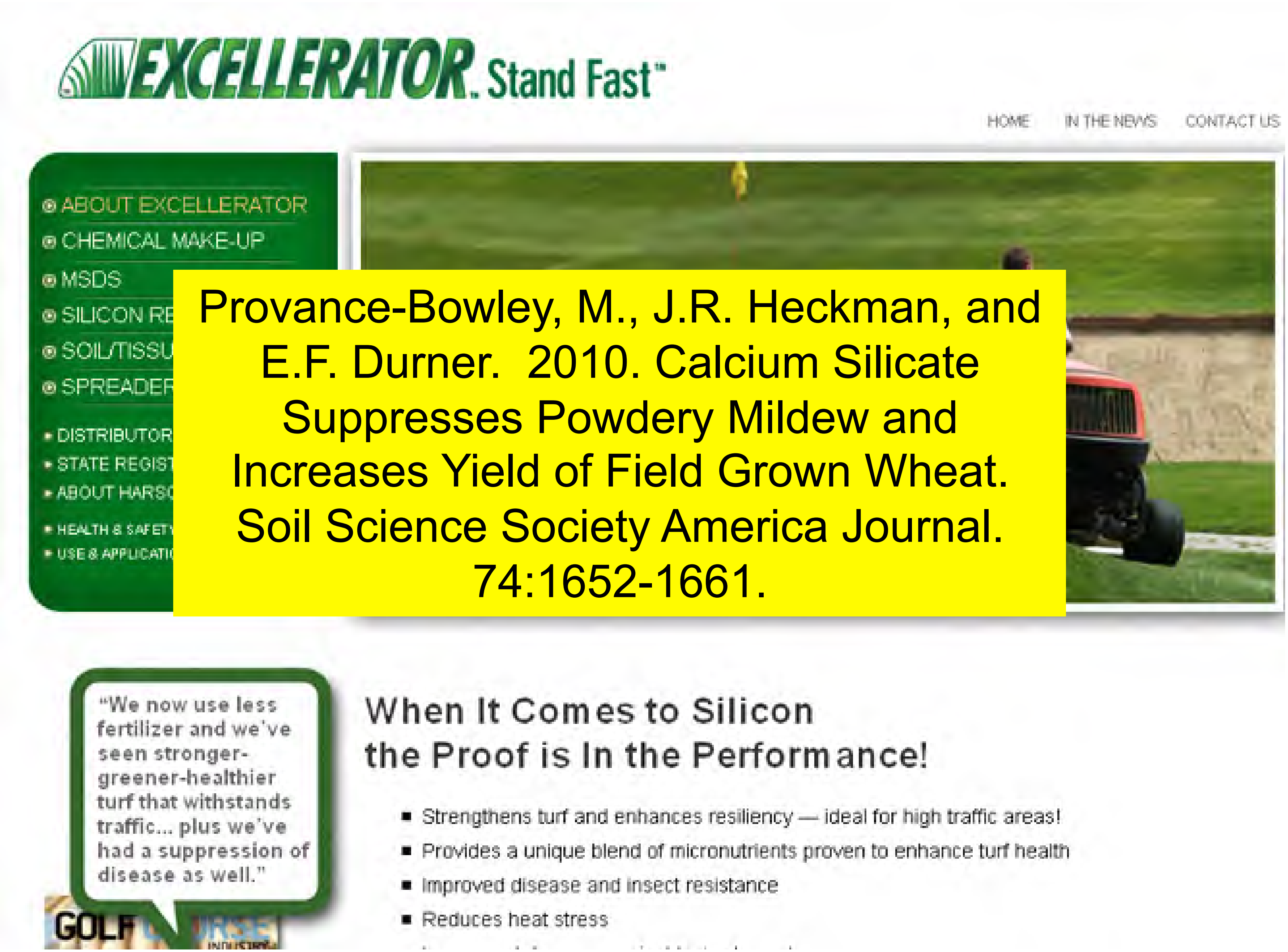
Current Opinions in Plant Biology. 2009 Jun;12(3):267-74

Physiological functions of beneficial elements.

Pilon-Smits EA, Quinn CF, Tapken W, Malagoli M, Schiavon M.
Biology Department, Colorado State University, Fort Collins, Colorado 80523, USA. epsmits@lamar.colostate.edu

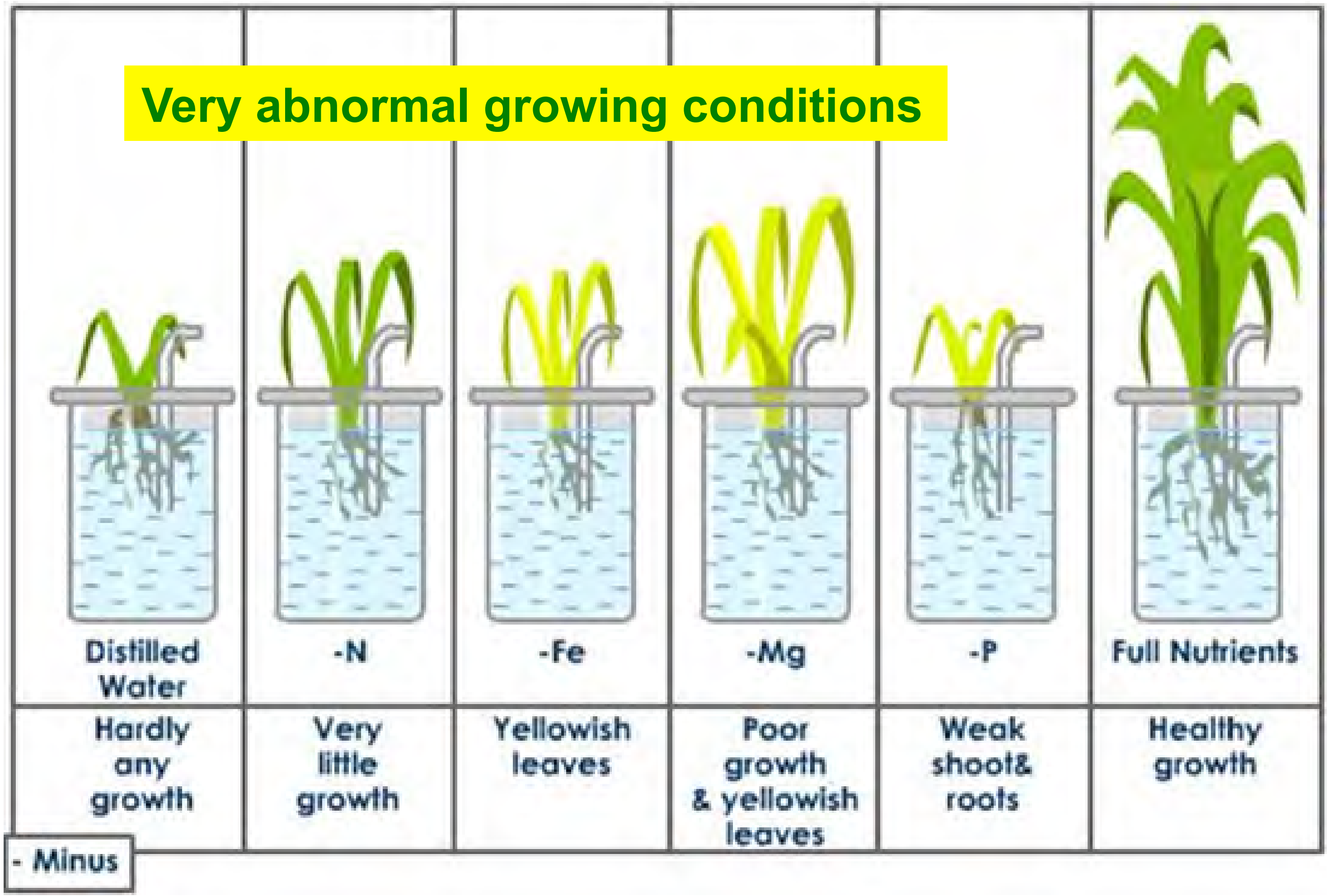
Abstract

Aluminum (Al), cobalt (Co), sodium (Na), selenium (Se), and silicon (Si) are considered beneficial elements for plants: they are not required by all plants but can promote plant growth and may be essential for particular taxa. These beneficial elements have been reported to enhance resistance to biotic stresses such as pathogens and herbivory, and to abiotic stresses such as drought, salinity, and nutrient toxicity or deficiency. The beneficial effects of low doses of Al, Co, Na and Se have received little attention compared to toxic effects that typically occur at higher concentrations. Better understanding of the effects of beneficial elements is important to improve crop productivity and enhance plant nutritional value for a growing world population.



Provance-Bowley, M., J.R. Heckman, and E.F. Durner. 2010. Calcium Silicate Suppresses Powdery Mildew and Increases Yield of Field Grown Wheat. Soil Science Society America Journal. 74:1652-1661.

Investigating the Essentiality of Elements




Some elements (e.g. Se, I, As, Cr)
have been identified as essential for
animals but *not* for plants.

Uptake of micronutrients is very small relative to N

Micronutrients	Chemical symbol	Relative % in plant	
Boron	B	0.2	
Chlorine	Cl	0.3	1/333 of N
Copper	Cu	0.01	
Iron	Fe	0.2	
Manganese	Mn	0.1	
Molybdenum	Mo	0.0001	1/1,000,000 of N
Nickel	Ni	0.001	
Zinc	Zn	0.03	

N = 100

http://web.missouri.edu/~umcsnrsoilwww/webpub05/micro1_2005rev.htm

Acre-plow layer stocks of trace elements

expressed as years of removal by corn, soybeans and alfalfa

element	Total lbs/ ac-pl	lbs removed by 150 bu corn	yrs	lbs removed by 60 bu soybeans	yrs	lbs removed by 6 ton alfalfa	yrs
B	90	0.16	563	0.1	900	0.3	300
Cu	48	0.1	480	0.1	480	0.06	800
Mn	960	0.3	3200	0.6	1600	0.6	1600
Mo	4	0.008	500	0.01	400	0.02	200
Zn	130	0.27	481	0.2	650	0.24	542

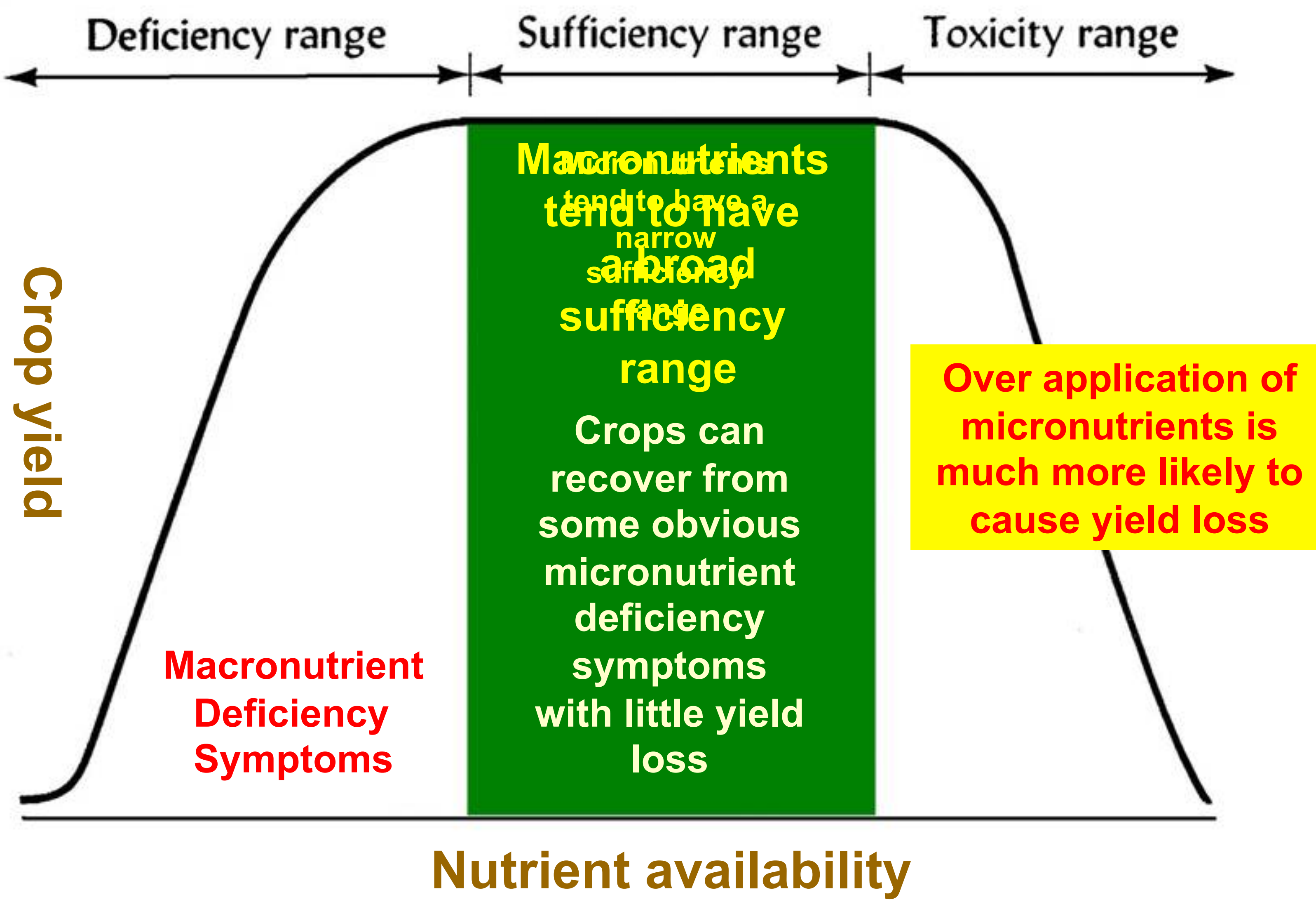
Total levels are for the plow layer of a typical Corn Belt soil

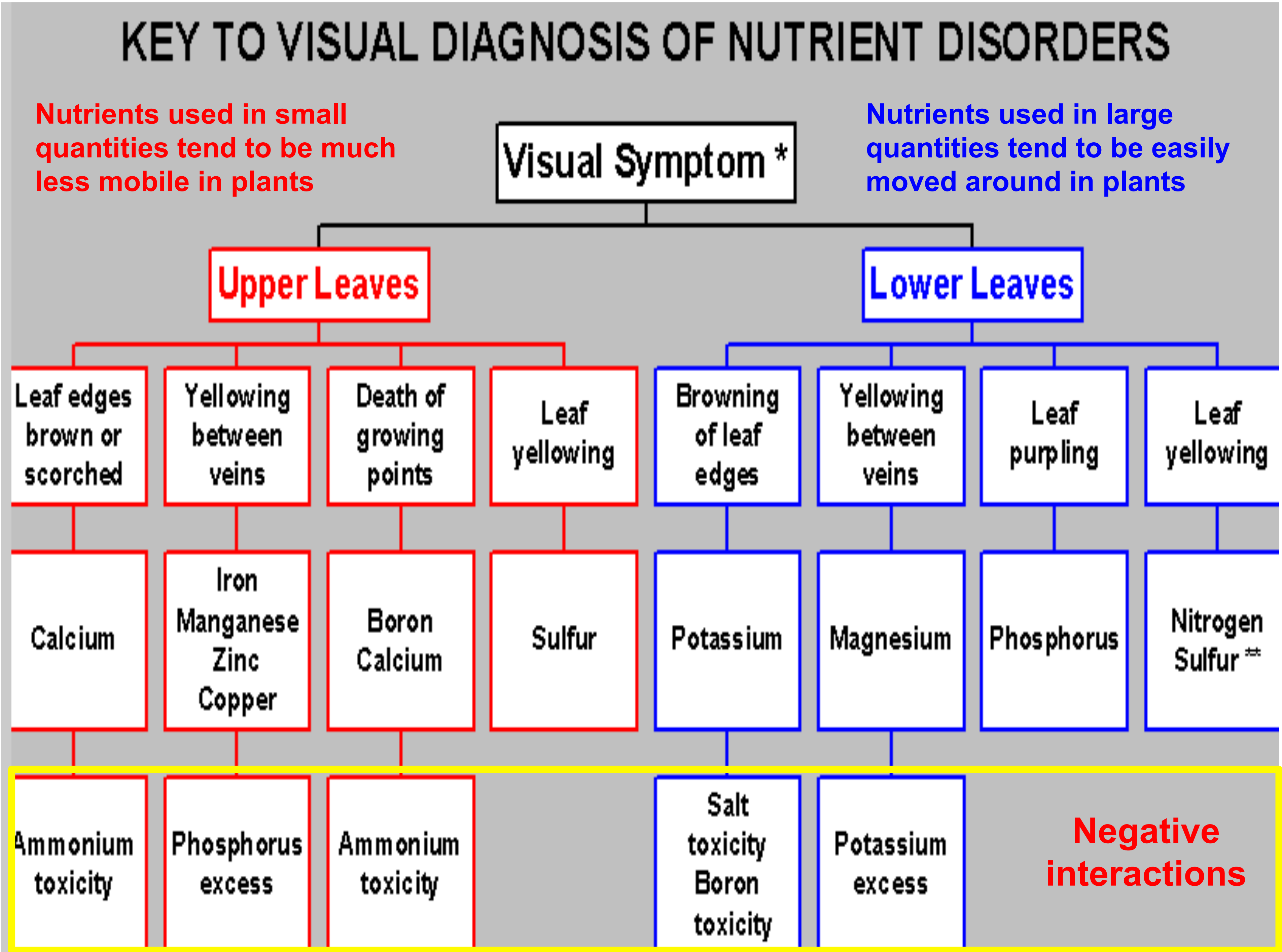
Variation in the Nutrient Content of Corn

Units	Nutrient	Min	Max	Mean	CV
parts per thousand	N	10.2	15	13	9.8
	P2O5	5	12.3	9.1	19.6
	K2O	[illegible]	[illegible]	[illegible]	13.9
	S	[illegible]	[illegible]	[illegible]	13.5
	Mg	[illegible]	[illegible]	[illegible]	23.6
	Ca	[illegible]	[illegible]	[illegible]	30
parts per million	Fe	9	89.5	35.5	52.6
	Zn	15	34.5	26.7	18.4
	B	2.3	10	5.9	36.3
	Mn	1	9.8	4.8	52.2
	Cu	1	5.8	3.2	49.6

Surprisingly little is known about the factors controlling this variation

Classic concept of yield response to nutrient availability

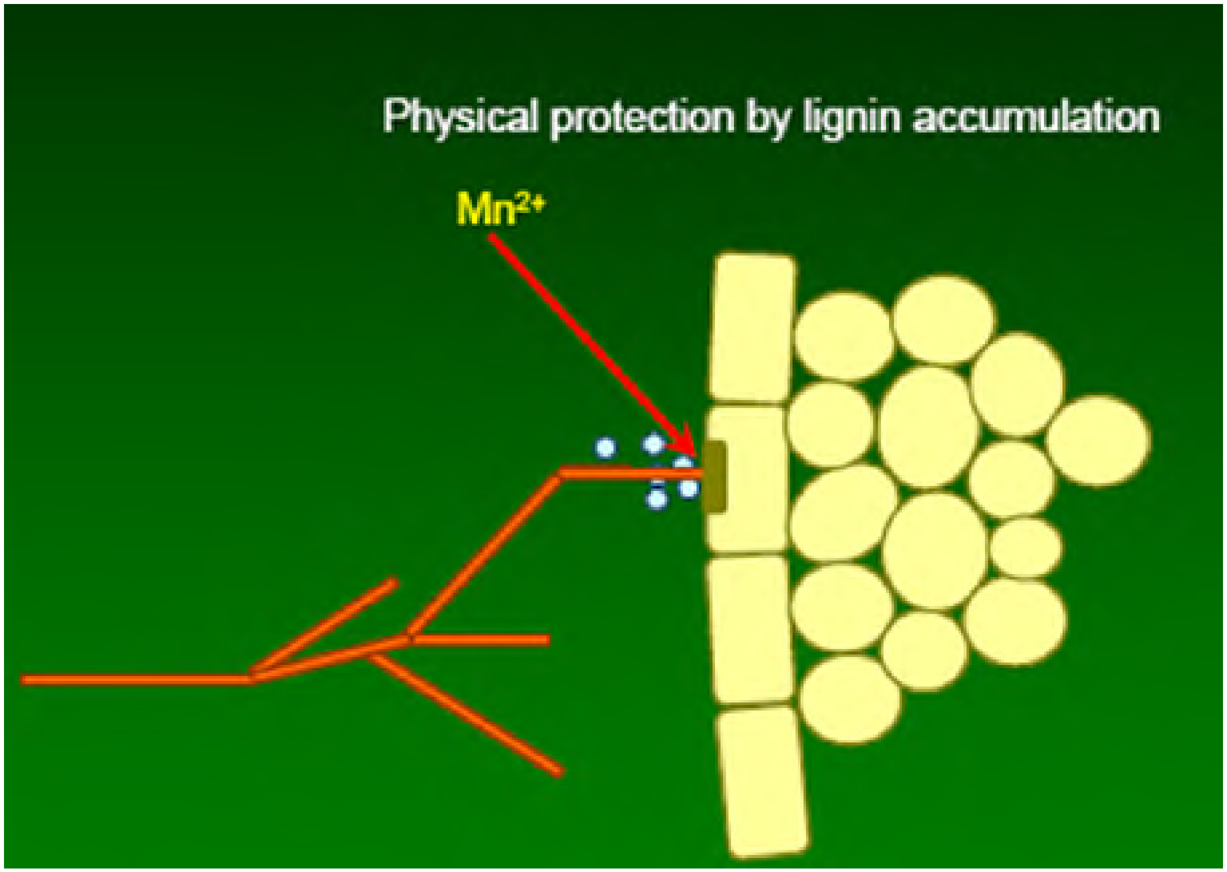


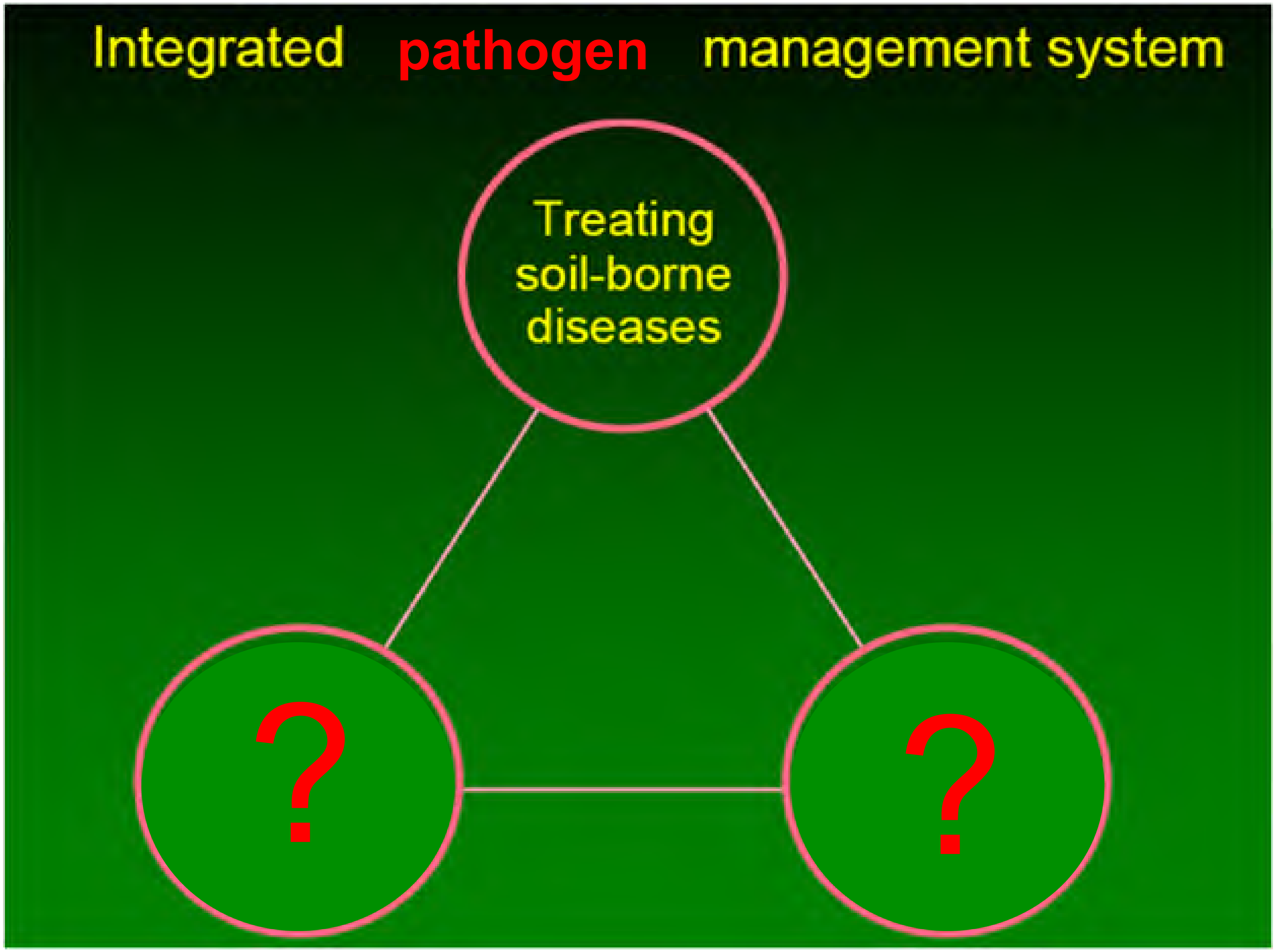

KEY TO VISUAL DIAGNOSIS OF NUTRIENT DISORDERS
Nutrients used in small quantities tend to be much less mobile in plants
Visual Symptom *
Nutrients used in large quantities tend to be easily moved around in plants
Upper Leaves
Lower Leaves
Leaf edges brown or scorched
Yellowing between veins
Death of growing points
Leaf yellowing
Browning of leaf edges
Yellowing between veins
Leaf purpling
Leaf yellowing
Calcium
Iron Manganese Zinc Copper
Boron Calcium
Sulfur
Potassium
Magnesium
Phosphorus
Nitrogen Sulfur **
Ammonium toxicity
Phosphorus excess
Ammonium toxicity
Salt toxicity Boron toxicity
Potassium excess
Negative interactions

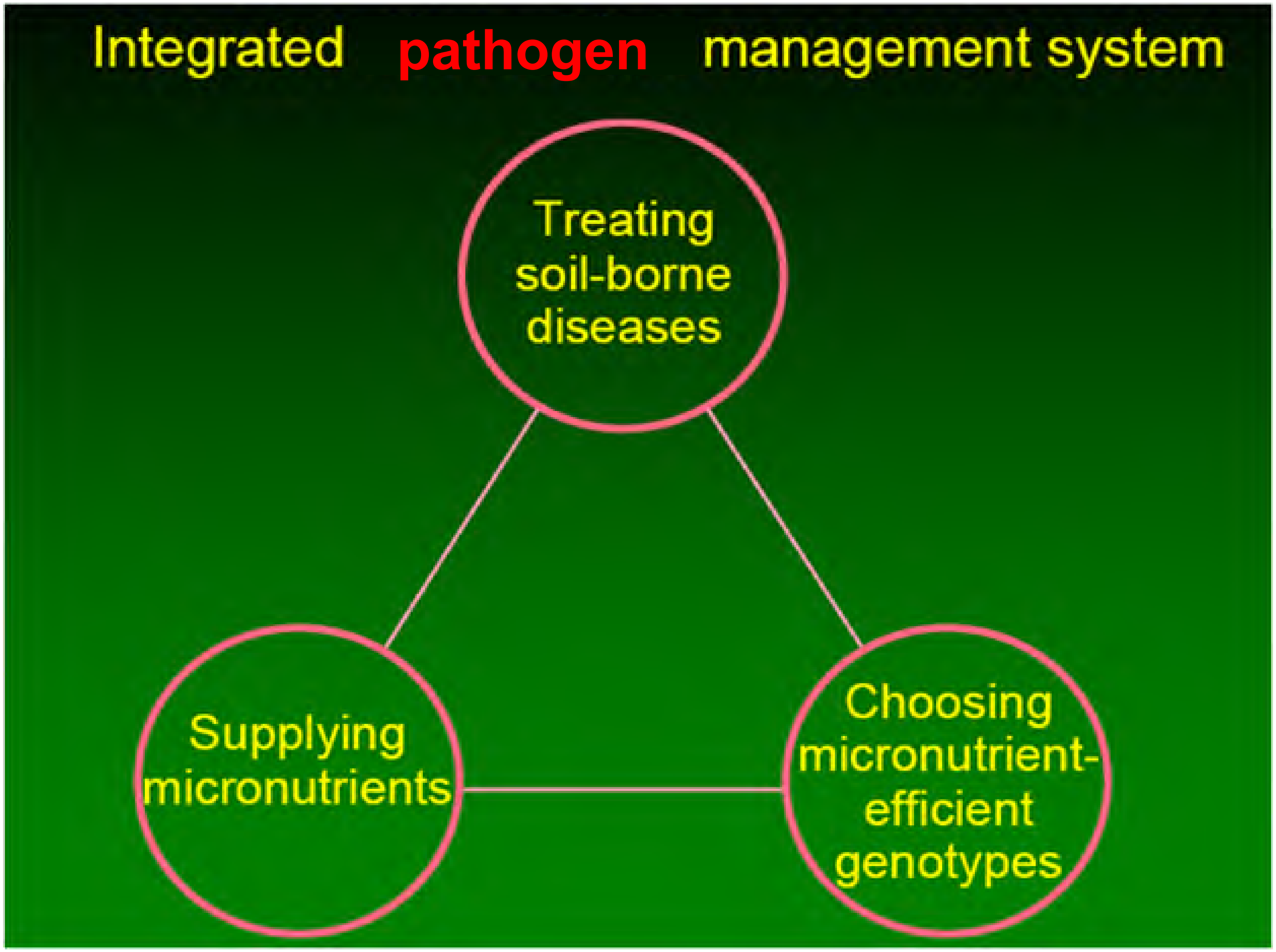
Micronutrients have very important roles in plant metabolism

Just a few atoms can make all the difference in the structure and function of enzymes

Metabolic proce					Mo	Zn
Photosynthesis						X
Carbohydrate s						X
Protein synthes						X
Fatty acid synth						
Enzyme activat					X	X
Cell wall format						
Tolerance to oxidative stress	X	X	X	X		X


Physical protection by lignin accumulation
Mn^{2+}


Integrated pathogen management system
Treating soil-borne diseases
?
?


Integrated pathogen management system
Treating soil-borne diseases
Supplying micronutrients
Choosing micronutrient-efficient genotypes

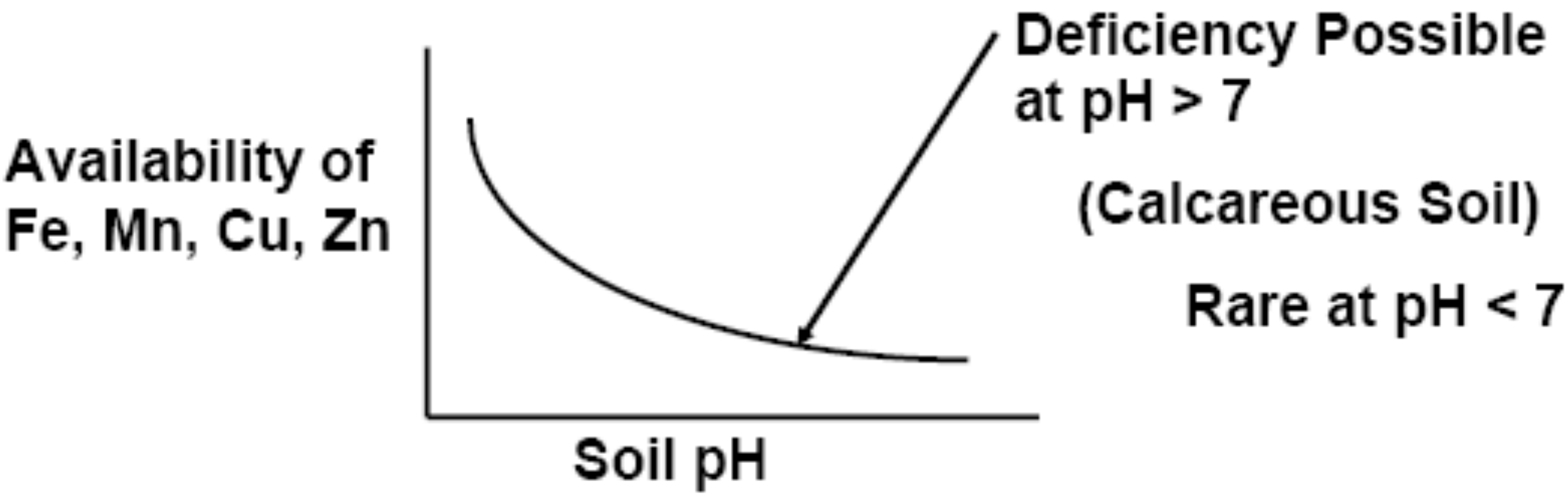
Inorganic nutrient forms taken up by plants

Cation(3+)	Cation(2+)	Cation(+)	Neutral(0)	Anion(-1)	Anion(-2)
Macronutrients:					
	Ca^{2+} Mg^{2+}	K^+ NH_4^+		NO_3^- $H_2PO_4^-$	HPO_4^{2-} SO_4^{2-}
Micronutrients:					
Fe^{3+} **All are more available in acid soils**	Fe^{2+} Mn^{2+} Zn^{2+} Cu^{2+} Ni^{2+}		$B(OH)_3$	Cl^-	MoO_4^{2-}

AVOID OVER LIMING!!

Metal Micronutrient Cations

Why is VRT lime more likely to pay than VRT P, K or N?



6.5 7.5

Suggested soil test levels for selected micronutrients in IL

	SOIL TEST LEVEL (LB/ACRE)		
MICRONUTRIENT AND PROCEDURE	**VERY LOW**	**LOW**	**ADEQUATE**
Boron (alfalfa only) hot water soluble	0.5	1.0	2.0
Iron (DTPA)	--	<4	>4
Manganese (DTPA)	--	<2	>2
Manganese (H_3PO_4)	--	<10	>10
Zinc (0.1N HCl)	--	<7	>7
Zinc (DTPA)	--	<1	>1

Unfortunately

soil tests for micronutrients have limited value

- sampling and soil test methods are less reliable
- calibration databases are inadequate
- subsoil supply may be sufficient

If soil test levels are high, deficiency is unlikely *but* low soil test levels are a weak predictor of deficiency!

Low plant tissue levels of micronutrients are a more reliable indication of likely response to fertilization than soil testing

Critical tissue nutrient levels for corn, soybeans and alfalfa

Crop	Plant part	N	P	K	Ca	Mg	S	Zn	Fe	Mn	Cu	B
		------------		*percent*		------------		----------		*ppm*		----------
Corn	Leaf opposite and below the ear at tasseling	2.9	0.25	1.90	0.40	0.15	0.15	15	25	15	5	10
Soy-beans	Fully developed leaf and petiole at early podding	. . .	0.25	2.00	0.40	0.25	0.15	15	30	20	5	25
Alfalfa	Upper 6 inches at early bloom	. . .	0.25	2.00	1.00	0.25	0.22	15	25	20	7	25

Why are these #s higher?

N = nitrogen, P = phosphorus, K = potassium, Ca = calcium, Mg = magnesium, S = sulfur, Zn = zinc, Fe = iron, Mn = manganese, Cu = copper, B = boron.

http://iah.aces.uiuc.edu/pdf/Agronomy_HB/11chapter.pdf

Nutrient concentrations below these critical levels (in designated plant parts) indicate that deficiency is likely.

Some consultants feel that higher tissue levels are needed for high performance

Micronutrients deficiencies are normally associated with one or more of the following five situations:

(1) highly weathered soils (natural pH < 5)
(2) coarse-textured soils
(3) high-pH soils
(4) Organic/muck soils ← **Why ??**
(5) soils that are low in organic matter because of severe erosion or land-shaping processes have removed the topsoil.

Specific crops are much more likely to experience specific deficiencies

Crop	Micronutrient				
	Boron	Manganese	Zinc	Molybdenum	Copper
Alfalfa	High	Medium	Low	Medium	Medium
Corn	Low	Medium	High	Low	Medium
Soybean	Low	High	Medium	Medium	Low
Wheat	Low	High	Low	Low	Medium
Oat	Low	High	Low	Low	Medium
Potato	Low	Medium	Medium	Low	Low
Beet	High	Medium	Medium	High	High
Cabbage	Medium	Medium	Low	Low	Low
Lettuce	Medium	High	Medium	High	High
Onion	Low	High	Low	High	High
Pasture (legume-grass)	High	Low	Low	High	Medium
Small grain silage	Low	High	Low	Low	Medium
Sorghum-sudan forage	Low	High	Medium	Low	Medium

Source: Laboski et al., 2006. Nutrient application guidelines for field, vegetable, and fruit crops in Wisconsin. UW-Extn pub. A2809.

Boron (B) deficiency is common for alfalfa.

Characteristic symptoms of the deficiency are yellowing of the upper leaves, eventually turning to a purpling color, along with stunting of the upper stems. Deficiency symptoms for B are similar to leaf hopper damage. Deficiency symptoms are most commonly observed during drought conditions. If B deficiency has previously been observed, it will likely occur whenever alfalfa is grown in that field unless B is applied on an annual basis.

Boron fertilization

On sandy soils, apply 1 lb of boron per acre after the first cutting of alfalfa each year. On heavier soils, 3-4 lb/acre after the first cutting (yr 1) is normally adequate for the life of the stand.

Boron is highly *toxic* to germinating seeds of *corn and soybeans*. *Boron* fertilizers should never be applied as a "starter fertilizer" in or near the row.


Foliar application of Boron
Adequate boron is critical for high quality vegetable crops
Crops with high demand for boron may benefit from foliar applications of boron (~ 0.2 lbs B/acre) at the following times: prior to heading of cole crops, prior to root swell in root crops, and at first bloom for tomatoes and okra.
NCDA recommendations for Boron:
peppers and tomatoes: 1 lb per acre
okra: 0.5 lbs per acre

Boron Mobility and Consequent Management in Different Crops

By Patrick H. Brown and Hening Hu

In corn, wheat and alfalfa , B is immobile and must be acquired at all stages of plant growth.

Foliar application can be used to correct deficiency in current tissues but will have minimal effect on later plant growth.

For some species, B mobility varies considerably between cultivars.

TABLE 2. Leaf B concentration (ppm dry wt.) along a shoot in various plant species.

Species	Basal	Middle	Apical	Remarks
Pecan	303	119	30	B-immobile
Tomato	721	318	94	B-immobile
Strawberry	512	176	68	B-immobile
Walnut	304	127	48	B-immobile
Apple	50	56	70	B-mobile
Apricot	45	60	81	B-mobile
Pear	42	57	62	B-mobile
Celery	32	49	104	B-mobile
Grape	74	55	88	B-mobile
Loquat	72	101	162	B-mobile
Olive	42	51	56	B-mobile
Peach	53	57	208	B-mobile
Pomegranate	21	20	111	B-mobile

Manganese deficiency symptoms

(stunted plants with green veins in yellow or whitish leaves) are common on high pH (alkaline) sandy soils, especially during dry soil conditions.

When should Mn be applied to soybeans?

Mn should be applied promptly when deficiency symptoms are observed

Manganese is relatively immobile so multiple applications may be necessary to optimize yield.

2x2 banding of Mn in Indiana has **NOT** been found to be effective

Are Roundup Ready™ Soybeans more likely to experience Mn deficiency ?

There is a growing body of evidence that RR soybeans are more likely to experience Mn deficiency than non-RR soybeans.

Researchers at Purdue University have attributed this to *less effective Mn utilization within RR beans* and *glyphosate interference with Mn uptake*.

THERE IS CONSIDERABLE VARIATION BETWEEN RR SOYBEAN VARIETIES

Why does this matter?

Impact of glyphosate on Mn transforming microorganisms

Manganese Oxidation

- In soybean rhizosphere soil (3 wks after glyphosate applied):

	Mn Reducing Organisms	Oxidizing Organisms
	Colonies per gram of soil	
Control (no glyphosate)	7,250	750
+ Glyphosate	740	13,250

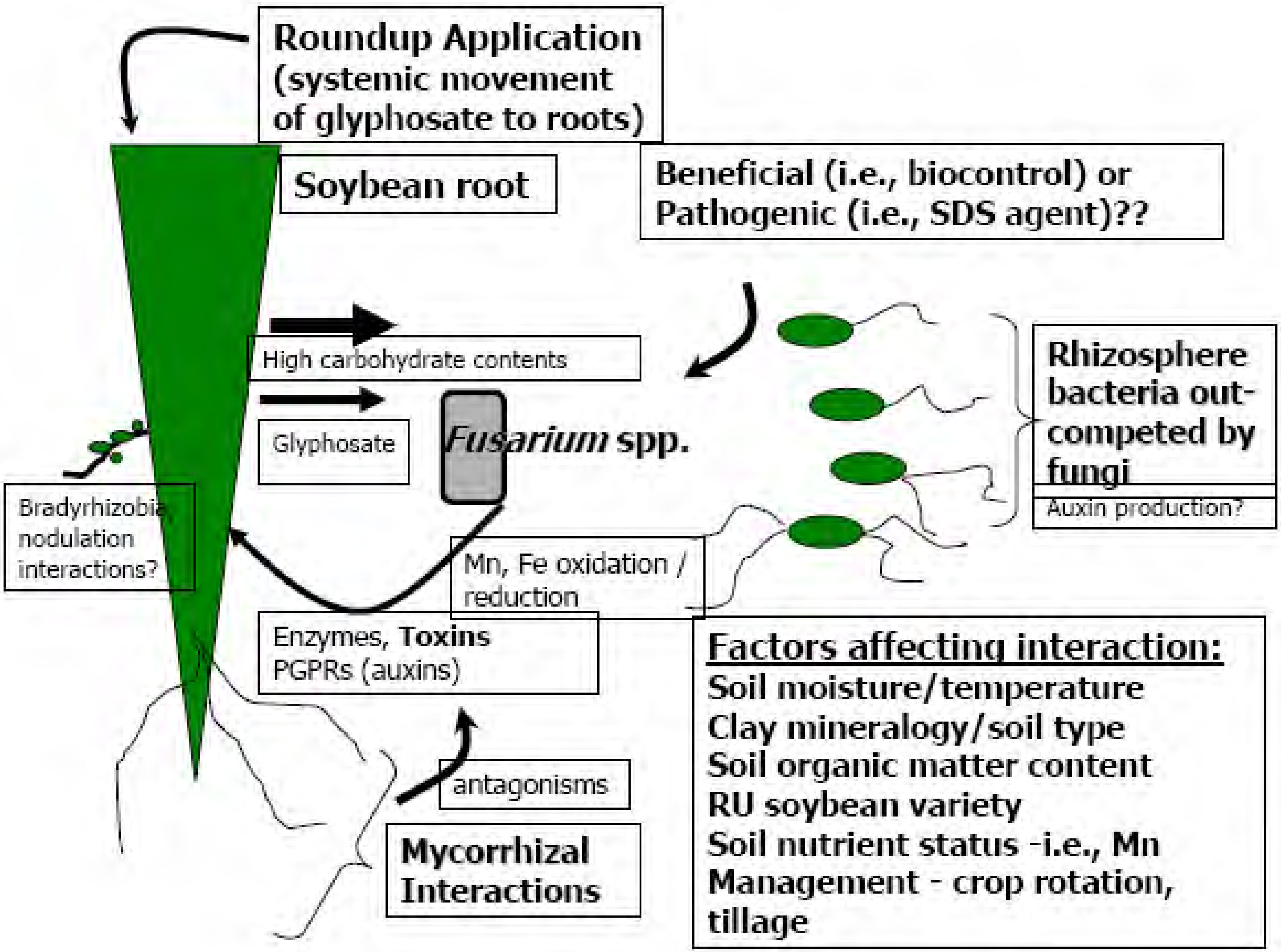
Don Huber

Interpretation

Glyphosate promotes Mn oxidizing microbes and inhibits Mn reducing microbes

Dry soil conditions → oxidization of Mn

Far reaching effects of glyphosate on soil chemistry and ecology



Don Huber

A recent study at the U of I found that the amount of "flash" following glyphosate application increased with glyphosate rate, but that foliar application of Mn had no impact on the amount of "flash", leaf Mn content, or crop yield.

It is likely that glyphosate effects on yield related to Mn only occur when Mn levels are approaching deficiency.

Caution should be taken when mixing Mn and other micronutrients with glyphosate.

Dry flowable products show the most antagonism, while chelates show the least. Antagonism may result in greatly reduced weed control.

Not all formulations of glyphosate are equally reactive.

Glyphosate can inhibit the mobility of Mn applied to plant foliage prior to, with, and for up to eight days after application.

PURDUE
UNIVERSITY

PURDUE EXTENSION
WEED SCIENCE
www.btny.purdue.edu/weedscience/

Jim Camberato

Kiersten Wise and

Bill Johnson

Purdue Extension

Glyphosate – Manganese Interactions and Impacts on Crop Production: The Controversy

We have been getting many phone calls concerning the recent No-Till Farmer article 'Are We Shooting Ourselves in the Foot with the Silver Bullet?' (http://fhrfarms1.com/notillglyphosate.pdf). In this article based on an interview with Dr. Don Huber (retired plant pathologist from Purdue University), it is alleged that the non-judicious use of glyphosate has induced micronutrient deficiencies which have led to more plant disease. In our opinion the doomsday scenario painted by this article is greatly exaggerated. A more balanced assessment of the non-target effects of glyphosate is available in the article 'Glyphosate Manganese Interactions in Roundup Ready Soybeans' (http://www.weeds.iastate.edu/mgmt/2010/glymn.pdf) written by Dr. Bob Hartzler (weed scientist at Iowa State University). The extent of glyphosate and glyphosate-resistant crops on the manganese (Mn) nutrition of soybeans is not agreed upon, nor fully understood. We are concerned that the article in No-Till Farmer encourages growers to make drastic changes to their fertility, weed, and disease management programs out of fear, not understanding.

DR. DON M. HUBER

What About Glyphosate-Induced Manganese Deficiency?

Take heart. There are strategies to get around the far-reaching non-target effects that this most extensively used herbicide in the history of agriculture can have on susceptible plants.

Glyphosate [N-(phosphonomethyl) glycine] is the most extensively used herbicide in the history of agriculture. Glyphosate weed management programs in field crops have provided highly effective weed control, reduced concern for residual chemicals in the environment, simplified management decisions, and resulted in cleaner harvested products. This relatively simple compound (modification of the essential amino acid glycine) is an economical and effective broad-spectrum systemic herbicide that can have extensive non-target effects on nutrient availability, soil environment, and agricultural sustainability. Through an active chelation of specific mineral elements, glyphosate

SUMMARY

Summary: Glyphosate weed management programs can influence all components of the "plant disease triangle" by reducing plant uptake and translocation efficiency, changing soil biology, and modifying nutrient form or availability in the environment. Crop cultivars highly efficient in nutrient uptake should be selected when possible. Remediation treatments for micronutrient deficiency (Fe, Mn, Zn) should be applied at least eight days after the glyphosate event, and glyphosate formulations least inhibitory to plant nutrient functions and the soil biota should be used where possible. Biological amendment with glyphosate-resistant organisms (Mn reducers and N fixers) needs further study, as well as more effective means of detoxifying glyphosate in the rhizosphere. Alternate weed control or the use of non-systemic herbicides should be considered to minimize impacts on soil organisms and predisposition to disease. Herbicide rotation may be as important as crop rotation in the future.

Glyphosate: The Micronutrient Minimizer?

Sep 1, 2008 12:00 PM, By Lynn Grooms

Manganese deficiency in soybeans appears to be a growing issue in areas with high-pH soils (6.5 and up) and/or higher organic matter content and where glyphosate-resistant soybean varieties have been planted. Deficiencies have been reported in Indiana, Michigan, Kansas and Wisconsin.

One of the most limiting factors to high yield in glyphosate-resistant soybeans is a suspected micronutrient deficiency resulting from applications of glyphosate to soil, weeds and to glyphosate-resistant soybeans, report Shawn Conley and Carrie Laboski, soil specialists, University of Wisconsin (UW). They are conducting a study after numerous inquires about the issue last year.

"It's important to know that their research applies most appropriately to soils that have borderline or deficient levels of manganese (Mn)," writes George Rehm, University of Minnesota nutrient specialist, retired. "This issue is not one we can paint with a broad brush. It's important to understand that soils differ greatly across the Corn Belt. It is difficult to take data from one state and transfer it to another.

"The response to Mn in Indiana might be expected because soils in the northwest and northeast part of that state have low Mn levels," Rehm says. "In Kansas, the responses were reported in production environments with yields of roughly 70 bu./acre."

POPULAR ARTICLES

- National Farm Machinery Show Highlights
- World's Largest Planter: John Deere's DB120
- Doc, Should I Fix It?
- Economic Study On How Cap & Trade Will Impact Farmers

LATEST AG JOBS

- Production Leader
Plymouth, IN

Do Your Beans Have GIMD?

Glyphosate Induced Manganese Deficiency

University research has determined Glyphosate Induced Manganese Deficiency occurs in glyphosate-tolerant soybeans in 2 ways. The first is caused by the glyphosate tolerant gene itself, interfering with the soil uptake of manganese into the plant. The second occurs after the application of glyphosate, and interferes with cation exchange, and the plant's ability to metabolize manganese that is already in the plant tissue.

Factors that determine the severity of GIMD in soybeans are:
- Soils that are known to be manganese deficient
- Soil pH values of 7.0 and higher
-"Yellow Flash" is seen after glyphosate application in severe cases.
- Yield drag has been found to occur even when visual symptoms are not present.

MAN-GRO DF CURES GIMD!

MAN-GRO DF is a highly concentrated water soluble manganese powder designed for foliar application. 3 pounds of MAN-GRO DF applied to soybeans in the R1 to R3 stage of growth, 8-14 days after glyphosate application will correct GIMD. The addition of an adjuvant/water conditioner will assist in mixing and maximize uptake of manganese. MAN-GRO DF is compatible with most insecticides and fungicides (see reverse).

TETRA MICRONUTRIENTS

Alan Robinett	Larry Grote	Stan Mickels	Sales Office
Product Manager, Southeastern U.S.	Midwest U.S. and Central Plains	North Central Plains and Western U.S.	Denver, CO
CELL: [illegible]	CELL: [illegible]	CELL: [illegible]	[illegible]

MAN-GRO DF COMPATIBILITY BULLETIN

MAN-GRO DF has shown to mix with the following:

Insecticides:

Ambush, Asana, Baythroid, Decis, Furadan, Cypermethrin, Karate (Z) Warrior, Lorsban, Orthene, Sevin

Fungicides:

Bravo, Dithane M-45, Folicur, Penncozeb, Quadris (Abound), Endura, Gold (2E) [illegible], Terraclor, Tilt EC, Stratego, Headline, Artisan, Quilt (1)

Herbicides:

Cyprol 4L, Canopy Pro, Cobra 4L, Meridian 4L, Dual II ED, Gramoxone, Pursuit EC, Staple, Treflan, Trilin, Harmony GT, Harmony Express, Harmony Extra, Classic **, Cadre

Glyphosate Herbicides:
* Do not apply tank mixes of MAN-GRO DF or DF + Boron with Glyphosate herbicides. The mixture will reduce significantly the weed control of Glyphosate herbicides.

(1) Quilt may require a compatibility agent.

**Classic is a soluble granule, slurry or dissolve first then add to MAN-GRO.

** 2-4D Ester (1-2 pts/AC). 2-4D Ester has mixed with MAN-GRO DF. A jar test determine compatibility with your brand of 2-4D Ester is recommended.

DO NOT MIX MAN-GRO DF WITH 2-4D AMINE, MCPA, 2-4DB OR OTHER PHENOXY AMINE HERBICIDES.

**NOTE: If your spray water source is hard, has a high pH>7 or contains low to high carbonates or bi-carbonates, we recommend that 0.5 to 1.0 of (ZMS) per 100 gal/water be added prior to mixing MAN-GRO DF. If you are unsure of your water quality, we suggest you have it tested or conduct a jar test for compatibility or add ZMS as a precautionary.*

Plant Regulators and Fertilizers:

Boron*	PGR IV	Megafol Plus (PGR)
Ascent RS	KWG-0-0-8	Pentra (PGR)
Megafol (Megafol Plus)	Tri Sert 20-0-20-1.5S	Ribonucleate (15-0-46-18)
Pro	N-Boron *	Boro Ram-L*

** When using Solubor TM chemistry always use ZMS at .5 - 1.0 pounds per 100 gallons of water to buffer water when mixing with MAN-GRO DF.*

**** Mixing Nitrogen Solutions including Urea***

Note: It is recommended that you add ZMS at 0.25 to 0.5 lbs. per 100 gal/water, then MAN-GRO DF and then add the nitrogen solution.

When mixing MAN-GRO DF with Nitrogen Solutions i.e., UAN 32%, 28-0-0-5, ATS 12-0-0-26 or AMS 8-0-0-9 the following sequence has worked best:

1. Water
2. MAN-GRO
3. ZMS for Citric Acid @ 0.25 to 0.50 lbs. per 100 gallons water
4. UAN 32% or Nitrogen Solution
5. 8-0-0-9

*** Use a jar test to determine the compatibility of nitrogen solutions containing sulfur.*

NOTE: DO NOT MIX MAN-GRO DF WITH 10-34-0 OR SIMILAR TYPES OF PHOSPHATE FERTILIZERS!

ADDITIONAL NOTE:

The above product mixing and compatibility information is for reference only and is not a TETRA Micronutrients or chemical manufacturers' product recommendation. Always read and follow label directions.

Zinc deficiency in corn is exhibited on the upper leaves as inter-veinal chlorosis. The veins, midrib and leaf margin remain green.

As the deficiency intensifies “feather like” bands develop on either side of the midrib and the leaves may turn almost white (hence the term “white bud” was coined to describe Zn deficient corn plants); internodes are short resulting in stunted plants.

http://www.cropsoil.uga.edu/~oplank/diagnostics70/Symptoms_/Corn/Images-Corn/images-corn.html

Zinc

High pH, cool weather and very high P levels increase the likelihood of Zn deficiency. If very high P levels have resulted from manure applications, Zn deficiency is less likely.

Soil test levels of Zn are poor indicators of yield response to the application of Zn.

Application of Zn

Soil applied

Favorable responses have been observed for both banded and broadcast applications of Zn (2-4 lbs Zn/ac if banded or 4-8 lbs if broadcast)

Foliar applied

Favorable responses have also been observed for foliar Zn applied at 1 lb/ac Zn (sulfate form) or 0.15 lb Zn (chelate form).

Iron Chlorosis

Soybeans normally outgrow the stunted, yellow appearance of Fe chlorosis. As a result, it has been difficult to measure yield losses or decide whether or how to treat affected areas.

Research in Minnesota has shown that timing of Fe application is critical to attaining a response. Researchers recommend that 0.15 lb/acre of iron as iron chelate be applied to foliage within 3 to 7 days after chlorosis symptoms develop (usually in the second-trifoliate stage of growth). Waiting for soybeans to grow to the fourth- or fifth-trifoliate stage before applying iron resulted in no yield increase.

Some interesting research in Minnesota

Impact of oat intercropping on Fe chlorosis

No oats

Oats killed at 12”

http://www.extension.umn.edu/AgProfessionals/components/CPM/Lamb_Soybean.pdf

Elevated soil nitrate promotes Fe chlorosis
Competition for nitrate by oat reduces Fe chlorosis

Molybdenum

Molybdenum (Mo) differs from most of the other micronutrients in that it increases in availability with an increase in pH.

Historically Mo deficiency has primarily been reported for legumes grown on very acid soils but recent investigations suggest that Mo deficiency may be much more widespread.

The most practical solution is often to apply lime but Mo seed treatments and foliar applications can be of value.

Mighty micronutrient

By ANN TONER

KANSAS crop consultant Matt Hagny saw some fields in 2007 that puzzled him. It began with one of his client's odd wheat fields that was pale and simply not doing as well as he expected.

It was a mystery at first. The field had been in no-till for several years, but the wheat had adequate levels of nitrogen and the other major plant nutrients. So what was the problem?

Detective work

Hagny's friend, Wayne Smith, an Australian agronomist, had described similar symptoms — including a slow response to N — Down Under. The problem there was a molybdenum deficiency. Plants need miniscule amounts of molybdenum to grow well and set seed.

Ray Ward, head of Ward Laboratory, says it's been generally assume... that crops in... adequate mol...

But among... samples, som... 0.01-parts-per... denum — whi... was no molyb... tected in the s...

STRUGGLING: Soybeans found with a molybdenum deficiency looked like this when samples were taken.

Key Points

- Mysteriously pale crops require investigation.
- Consultant discovers fields can be deficient in molybdenum.
- Rescue is cheap, but be sure of the problem before treating.

at. It costs about $1.50 per acre

sweaty palms can be enough to change the reading.

Too much molybdenum (around 40 to 50 ppm) is toxic to plants. Also, feed containing too much molybdenum interferes with copper nutrition in animals.

Generally, if a seed has been grown in soils with sufficient ... seed itself ... of the nu... wing plant it ... g-time treat... f the grower ... was needed. ... ed that had ... molybdenum-

Some evidence suggests that crop seeds are increasingly likely to be low in Mo

http://magissues.farmprogress.com/ksf/KS12Dec07/ksf024.pdf

Molybdenum-enriched soybean seeds enhance N accumulation, seed yield, and seed protein content in Brazil

Rubens José Campo[a], Ricardo Silva Araujo[a, b] and Mariangela Hungria[a, b]

[a]Embrapa Soja, Cx. Postal 231, 86001-970, Londrina, Paraná, Brazil

[b]Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq-MCT), Brasília, Federal District, Brazil

Received 11 May 2008; revised 8 September 2008; accepted 8 September 2008. Available online 26 October 2008

Abstract

High soybean yields require large amounts of nitrogen (N), which can be obtained mainly from symbiotic N_2 fixation. However, the efficiency of this

biological proces ... vely to

fertilization with M ... seed

treatment, howev ... death and

reductions in nod ... atment,

allowing elite ino ... g Mo-rich

seeds of several ... nterval of 10

days between spr ... parison to

seeds obtained f ... ply.

inoculation of Mo- ... t cases,

Mo-rich soybean s ...

We demonstrated the feasibility of producing Mo-rich seeds of several soybean cultivars by means of foliar sprays of ~ 1/3rd of a lb of Mo/ac, between the R3 and R5 stages with a minimum interval of 10 days between sprays… in field experiments performed in soils with low N content and without N fertrilizer, Mo-rich seeds produced plants with higher yields of total N and grain.

Keywords: Soybean; Molybdenum; Seed enrichment; *Bradyrhizobium*; Biological nitrogen fixation; Seed protein content

Field Crops Research Volume 110, Issue 3, 28 February 2009, Pages 219-224

Summary

Soil tests for micronutrients are NOT very reliable for predicting crop response to fertilization.

If soil test levels are high, the likelihood of response to fertilization is low. If soil test levels are low to medium, response to fertilization is inconsistent.

Decisions about micronutrient fertilization should take into account:

1) sensitivity of the crop to be grown

2) soil characteristics that affect the availability of the element, such as soil pH, organic matter, soil texture, and soil P level

3) tissue test levels

4) soil test levels

If multiple factors indicate potential for deficiency, fertilization on a trial basis is a good strategy.

Coating of the Fertilizer Granules

Coating the fertilizer granules provides an even distribution of the micronutrient material on all the granules.

FR Home
About the Site
FR Listserv
FR Search
Contact Us
Selected Electronic Dockets
Regulatory Agenda
Executive Orders
Current Laws and Regulations

Zinc Fertilizers Made From Recycled Hazardous Secondary Materials

[Federal Register: July 24, 2002 (Volume 67, Number 142)]
[Rules and Regulations]
[Page 48393-48415]
From the Federal Register Online via GPO Access [wais.access.gpo.gov]
[DOCID:fr24jy02-12]

ENVIRONMENTAL PROTECTION AGENCY

40 CFR Parts 261, 266, 268 and 271

Coal-deficiency syndrome hurting corn

By **clay** *on July 8, 2008*   http://www.mitchellfarms.com/?p=84

One of the externalities of reduced sulfur dioxide emissions brought about by the clean air act is increasing sulfur deficiency in crops, which must be corrected with applied fertilizer. I started seeing some sulfur deficiency last year in a few corn fields but didn't quite believe my eyes. This year I saw the same symptoms– yellow striping of the leaves. It isn't in all the fields, varies somewhat by hybrid, and is often in spots or streaks. There was only one field where it was apparent in the whole field. In that field all hybrids showed the symptoms, and the plants recently had started turning more and more yellow throughout.

Is S a limiting nutrient ?

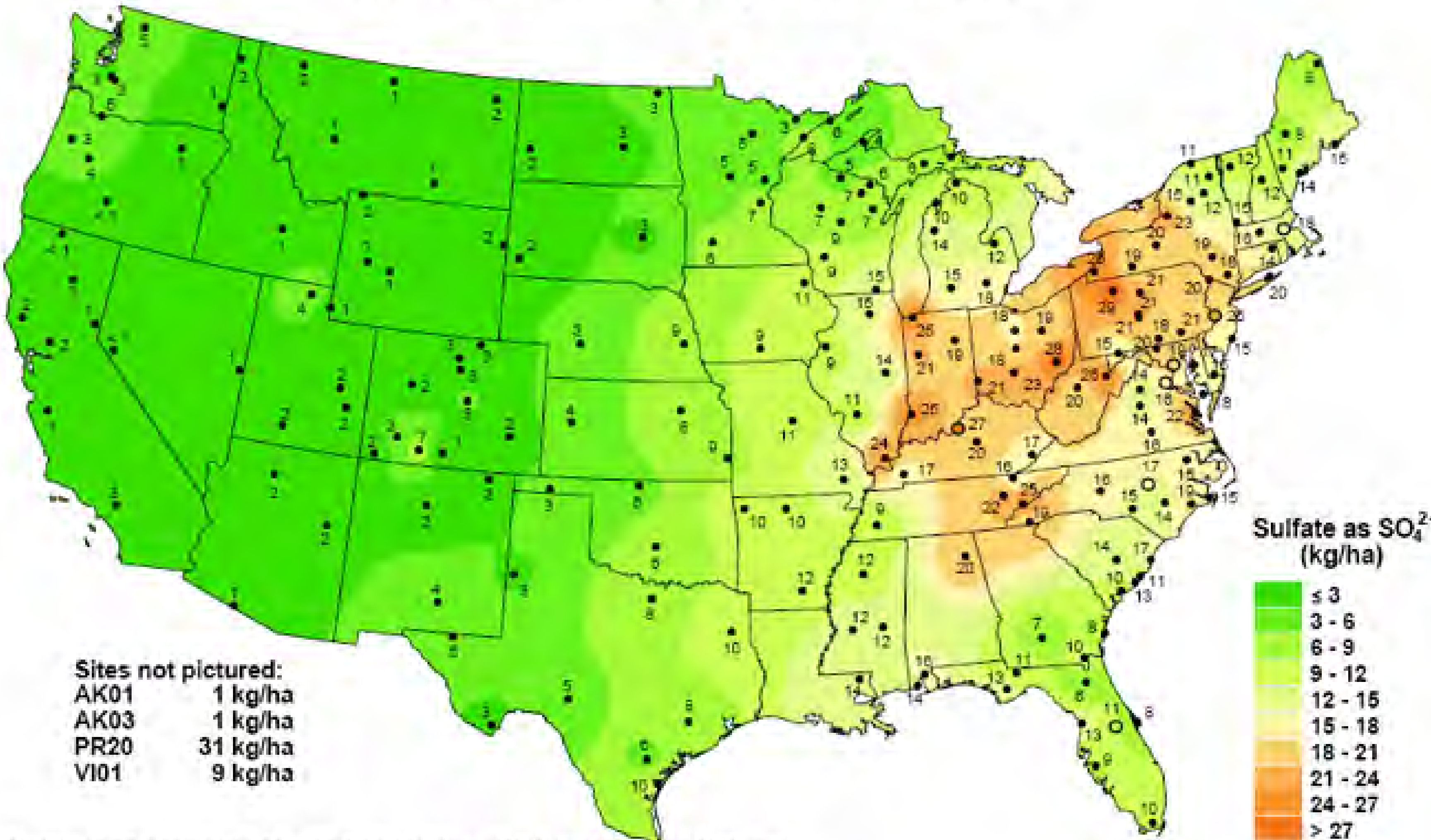
Sulfur deficiencies are increasingly common

- Enforcement of clean air standards has reduced SOx emissions from power plants and industry by > 50% in the last 2 decades

- Higher crop yields are removing higher amounts of S from soils as well as increasing the need for S

- The amount of S applied in fertilizer materials (often unintentionally) has decreased.

Sulfate ion wet deposition, 2006



National Atmospheric Deposition Program/National Trends Network
http://nadp.sws.uiuc.edu

Sulfur Deficiency in Corn

Unlike N,
S is not
readily
remobilized
from older to
younger
plant parts.

Overall light green color, worse on new leaves during rapid growth.

Sulfur Deficiency in Wheat

Sulfur deficiency in Alfalfa

Important S concepts

When S is deficient, plants tend to accumulate non-protein N, which raises the N/S ratio in the plant. A N/S ratio of 9:1 to 12:1 is especially important in forages that will be used for animal feed, so that the rumen microorganisms can effectively use the N.

Grasses are more competitive for sulfate (SO_4^{2-}) than legumes and tend to crowd out legumes in S deficient pastures.

Brassicas like canola and radish cover crops have a high demand for S.

So what can you apply if your soil needs S?

Ammonium sulfate (21-0-0) – 24%

Ammonium thiosulfate (12-0-0) – 26% S

Potassium sulfate (0-0-50) - 18% S

Sul-Po-Mag (0-0-22-S) - 23% S, 11% Mg

Gypsum aka calcium sulfate - 17% S

Elemental S – ~~100~~% S (ES95, ES90, ES85)

Animal manures – 0.1-0.3% of DM

Example of an elemental S product

Enhanced Formulation

Agtiva sulphur fertilizer's **new formulation** offers a superior level of degradability, and excellent handling characteristics. Customer feedback let us know that you wanted an extremely degradable plant nutrient sulphur product, with as high an analysis as possible. In response, Keg River has combined two exceptional bentonite clays with elemental sulphur to produce our newly improved Agtiva.

Product Profile

Guaranteed Analysis

Sulphur (Actual)	85%
Non-plant Food Ingredients (Bentonite Clay)	15%

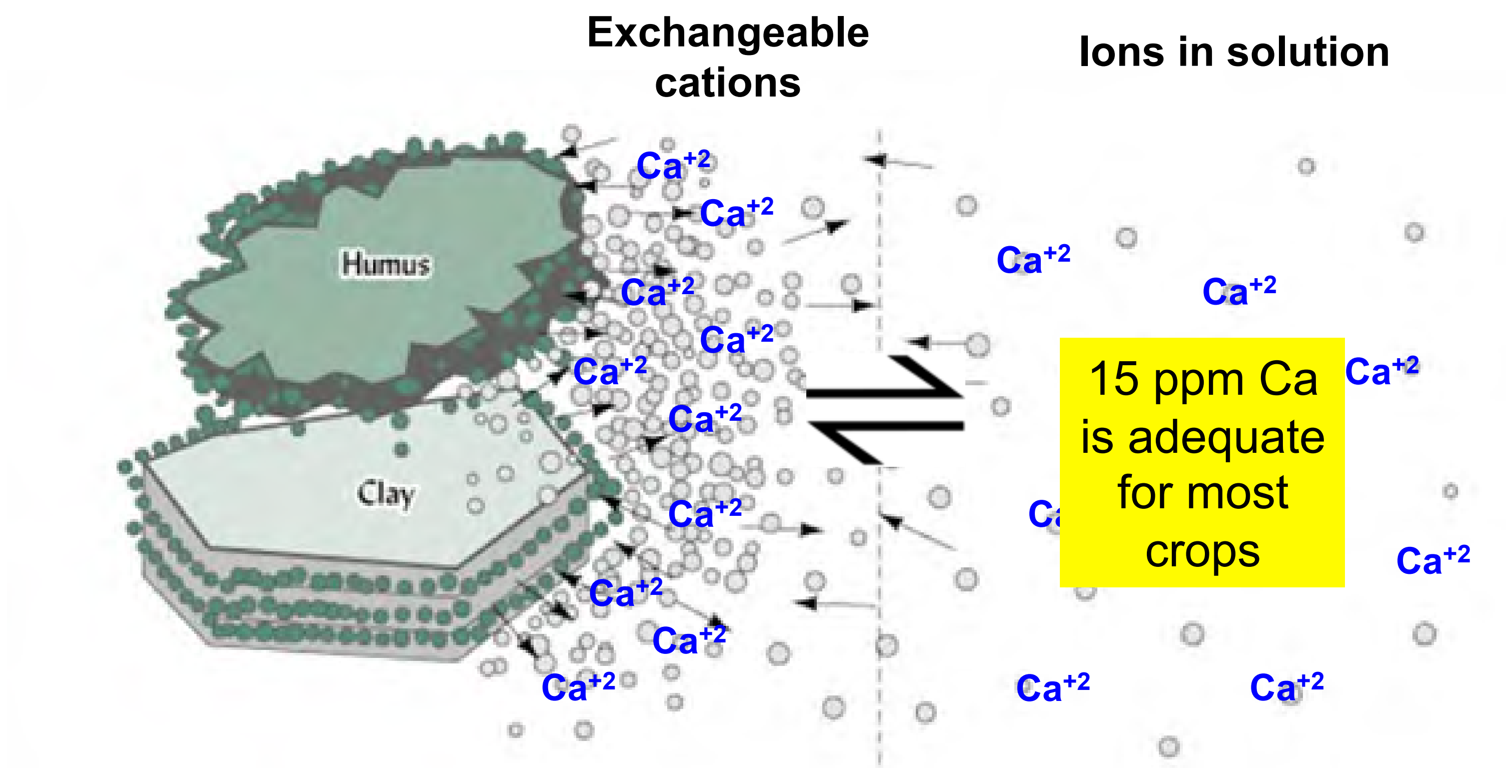
Typical Properties

Angle of Repose	29 degrees ?	Bulk Density	75 lbs per ft^3 or 1230 kgs per m^3
Particle Size	Size Guide Number (SGN) 260	Breakage Characteristics	Less than 0.20% is – 42 mesh at truck loading.

Packaging Options

Shipped in bulk via truck or rail cars. Mini-bulk totes in 907 kg (2000 lb), 1000 kg (2204 lb), 1134 kg (2500 lb), 1361 kg (3000 lb) or 1500 kg (3307 lb) sizes. Plastic bags in 22.7 kg (50 lb) and 25 kg (55 lb) sizes, palletized and wrapped.

Ca^{+2} should be the dominant exchangeable cation and ion in solution



Solution concentrations of Ca in temperate region soils tend to range from ~30 to ~300 ppm.

Solution concentrations are not the same as extractable (soil test) concentrations.

Magnesium deficient corn

Recent Popular Press Articles about FGD Gypsum in Conservation Tillage

Functions of Gypsum in Agriculture

- Ca and S for crop nutrition
- Ameliorate subsoil acidity
  - Increases crop rooting depth
  - Increases water and nutrient uptake at depth
- Improve water infiltration and drainage
- Reduce soil crusting for better seedling emergence

?

- Ameliorate sodium-affected soils

Title: Using Gypsum to Affect Soil Erosion Processes and Water Quality

Author: Dale Norton

Technical Abstract: A driving force in soil erosion is the low electrolyte content of rain water. Various electrolyte sources have proven useful in serving as electrolyte sources such as phosphogypsum, lime and various salts, however, each has other potential problems. We performed a number of studies on low cost gypsum from scrubbing of coal fired power plants (FGD gypsum) and found the neutral salt gypsum to be an excellent electrolyte source which is slowly soluble in rainwater and has few if any potential environmental problems. It has proven very useful in keeping soil clays flocculated and maintaining greater infiltration rates, therefore, reducing runoff and erosion.

"PRO CAL 40" Effects on Leachate Levels

	PRO CAL 40(2T/A)	Untreated
	PPM	PPM
Calcium	396	37
Magnesium	70	9
Potassium	162	7

(Archer)

Extractable K (Mehlich)
Before and 1 year after treatment