Soybean Micronutrients & NE
Honestly, it's not for every micro

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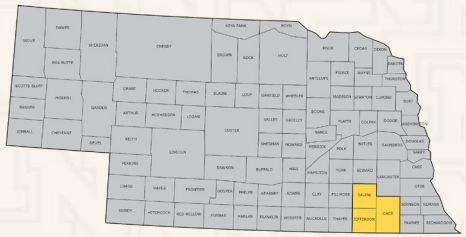


EXTENSION

Overview of Soybean Micronutrients

- Overview of micronutrients for soybeans
- Plant tissue analysis
- Micronutrient by micronutrient
- Summary and resourcs

N EXTENSION

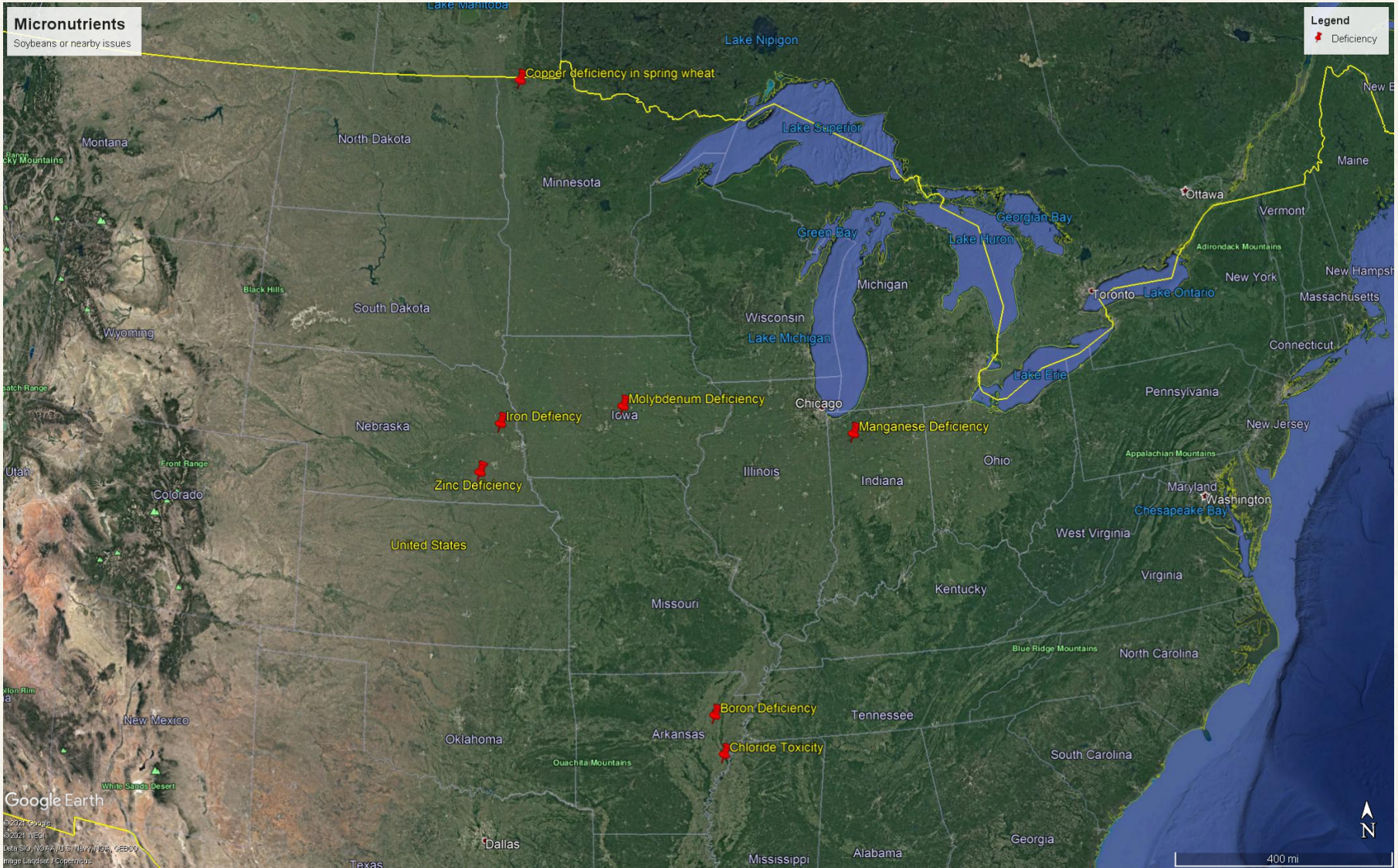
Overview of Micronutrients for Soybeans

EXTENSION

Micronutrients

1. Needed by soybeans to complete life-cycle.
2. Nine essential micronutrient for soybean production (Bo, Cl, Co*, Cu, Fe, Mn, Mo, Ni, & Zn)
3. Equally important in soybean plant nutrition as macros
4. Less than 1 pound per acre of uptake other than iron and chloride
5. Soybean micronutrient issues are region and soil specific

Google Earth View of Soybean Issues



Micronutrient Fertilizer Approach

- Crop removal programs used by some universities and industry for P and K fertilization rates.
- No university in the region recommends using removal program for micronutrients
- In the long-term, continued removal may result in decreased availability of some micronutrients.
- Soil or tissue testing for sufficiency

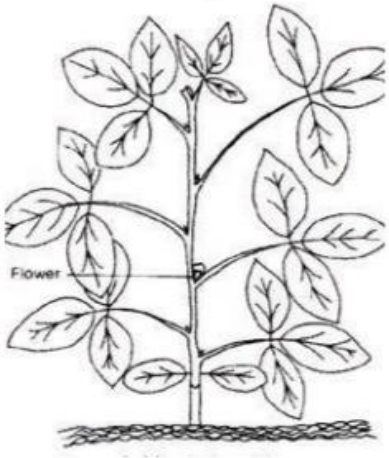
Plant Tissue Analysis

EXTENSION

Soybean Growth Stages (R1-R2)

R1 – BEGINNING BLOOM:

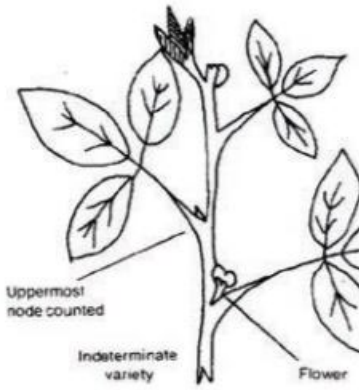
An open flower will be visible at a ma
plantings will be node 6 or 7 in MG III



**The first open flower (R1)can be e
about 28 to 32 days after V1** in ind
3.0-4.0 (see guide pages 47 and 64
to occur thereafter, peaking at **R2**, b
around **R5** (see guide page 58). In la
flower will be generally found at a lo
plants typically abort many flowers (
80 percent).

R2 – FULL BLOOM:

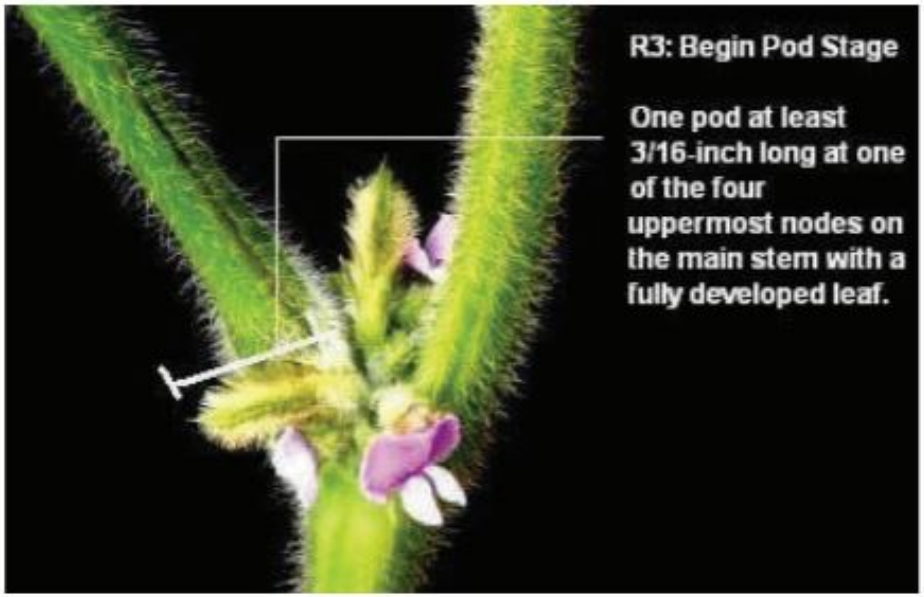
One open flower will be visible at on
"fully expanded" leaves. Many flowe



**Indeterminate MG III varieties (us
will continue to successively pro
every 3.7 days at the main stem
al. 2008], <u>but also</u> produce up to t
axils in those newest nodes.** It m
that newly open flowers near the ste
up with the new Vn nodes forming th
intersection with the Rn seasonal tre
chart of guide page 62). Irrigation ap

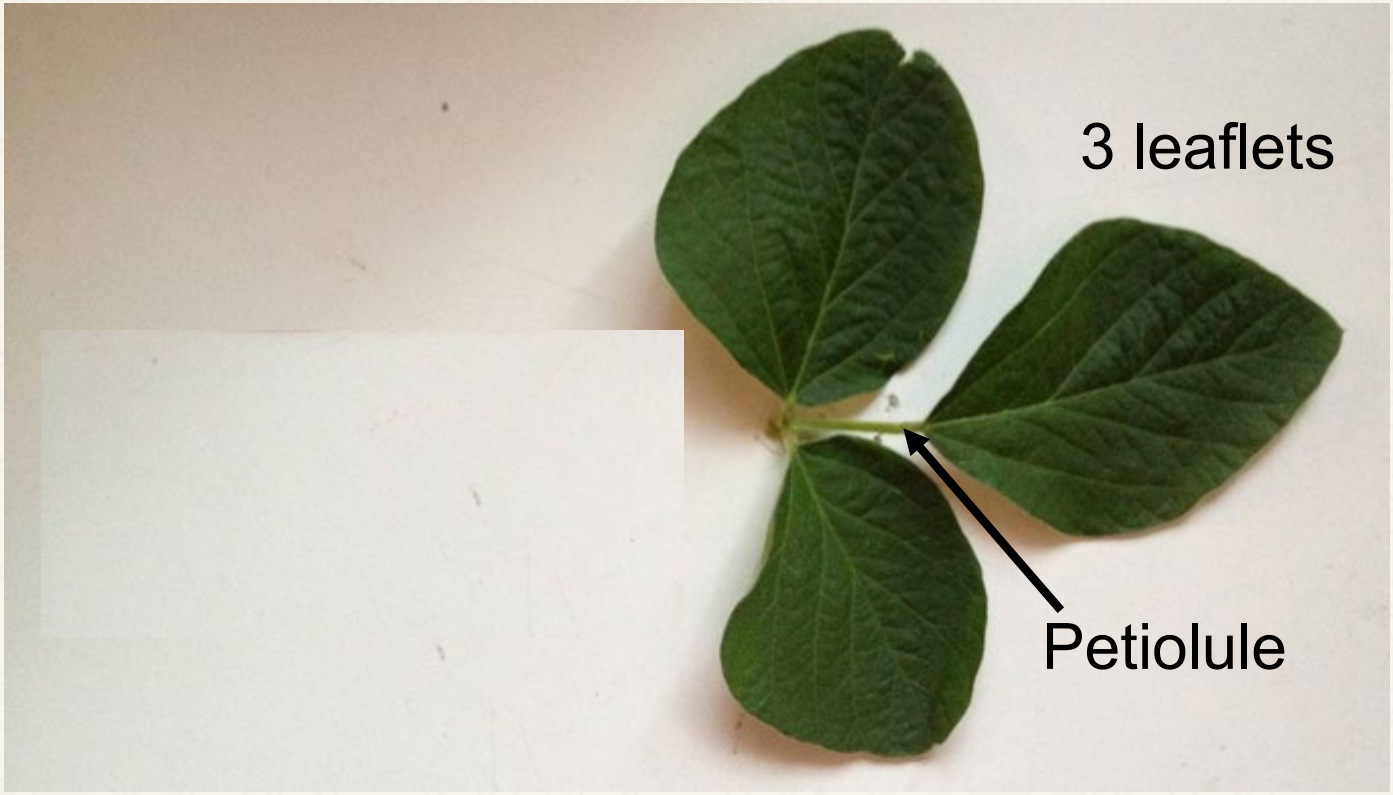
R3 – BEGINNING POD:

At least **one pod 5 mm (3/16 inch) in length** is present at any of the top four nodes with "fully expanded" leaves.



Flowers will still be forming at the R3 stage, continuing up to the end of flowering at R5 (begin seed) stage [Reference: Bastidas et al. (2008)]. The sensitivity of soybean plants to

Soybean Plant Tissue Analysis



- Sample at R1-R2 the uppermost fully expanded trifoliolate w/o petiole from 30-50 plants

Impact of including the petiole in your results (12 varieties, 3 reps, 36 samples). Uppermost fully expanded trifoliolate at R1-R2 was 76% of biomass weight. Mueller data, unpublished

Nutrient	Unit	Trifoliolate	Tri + Pet	Petiole
N	%	5.65	4.85	2.36
P	%	0.41	0.38	0.30
K	%	1.74	2.33	4.17
S	%	0.30	0.27	0.17
Ca	%	0.99	1.05	1.25
Mg	%	0.55	0.56	0.60
Fe	ppm	148	122	43
Mn	ppm	96	81	34
Zn	ppm	39	36	27
Cu	ppm	13	12	7
B	ppm	43	38	23

Micronutrient by Micronutrient

EXTENSION

Boron (B)

EXTENSION

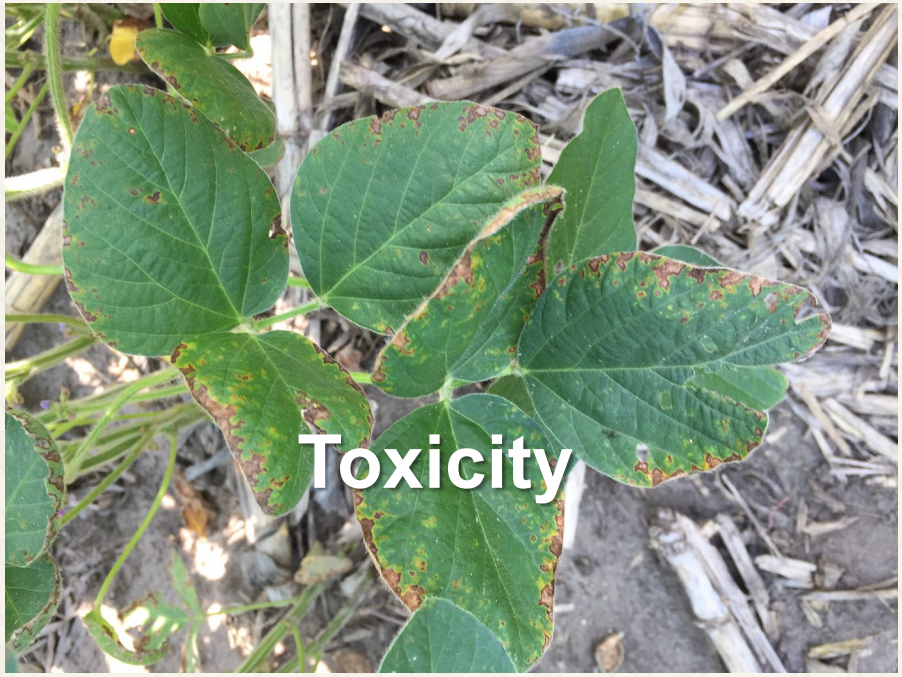
Boron

- Needed for cell walls and membrane function so important in cellular expansion
- Normal development and function of root nodules for nitrogen fixation
- Boron not mobile from old to new tissue
- Soybeans rather insensitive to deficiency, but very sensitive to toxicity
- Total plant uptake of 0.2 lbs/ac (65 bu/ac yield)

Visible symptoms of deficiency & toxicity

Credit: Nathan Slaton, University of Arkansas

- ✓ Stunting and swollen nodes
- ✓ Death of terminal growing point
- ✓ Young leaves are small and exhibit interveinal chlorosis
- ✓ Older leaves appear thick, dark green, leathery & cupped or twisted downward
- ✓ Delayed senescence



- ✓ Scorching and necrosis of the leaf edges
- ✓ Can occur anywhere in the canopy soon after uptake

B Cl Co Cu Fe Mn Mo Ni Zn

Factors of Availability

Exists as a non-ionized molecule in the soil solution

$B(OH)_3$

Soil pH

5.0 – 7.0

Availability controlled by adsorption/desorption on surfaces of aluminum/iron oxides, clay minerals, $CaCO_3$, & OM

Deficiency?

Most likely on low organic matter sandy soils

Toxicity? Fertilizer app

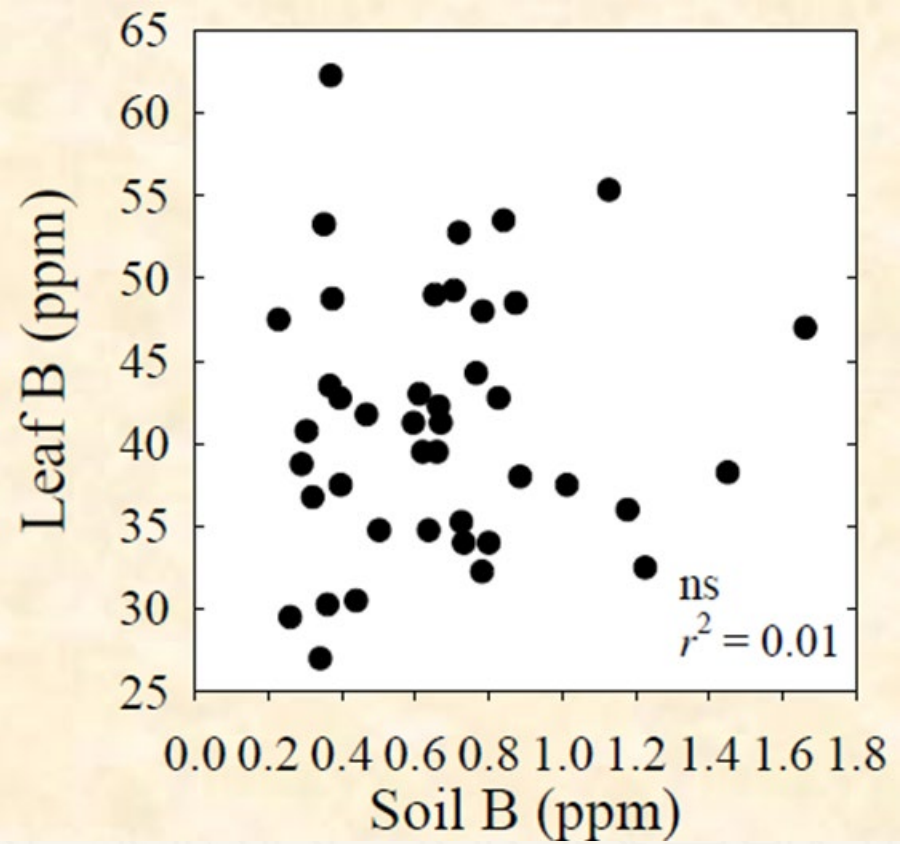
Soil testing

Mehlich-3

"Routine soil testing with Mehlich-3 extractant is not able to distinguish between B-deficient and sufficient soils making tissue analysis the preferred method of identifying fields that may require B fertilization" - Ross et al. 2006

Hot-water extractable B

"Soil test B ranged from 0.3 to 1.1 ppm and was an unreliable predictor of soybean yield response to B" - University of Minnesota



Source: Iowa State University – Antonio Mallarino

B Cl Co Cu Fe Mn Mo Ni Zn

Plant Tissue Analysis

Nutrient Sufficiency Ranges – Interpretive categories

Nutrient	Unit	Likely Responsive	Small probability of response	Sufficiency Range (or ideal)	Excessive or Toxic
Boron (B)	ppm	<20	20 - 24	25 - 60	>80

B

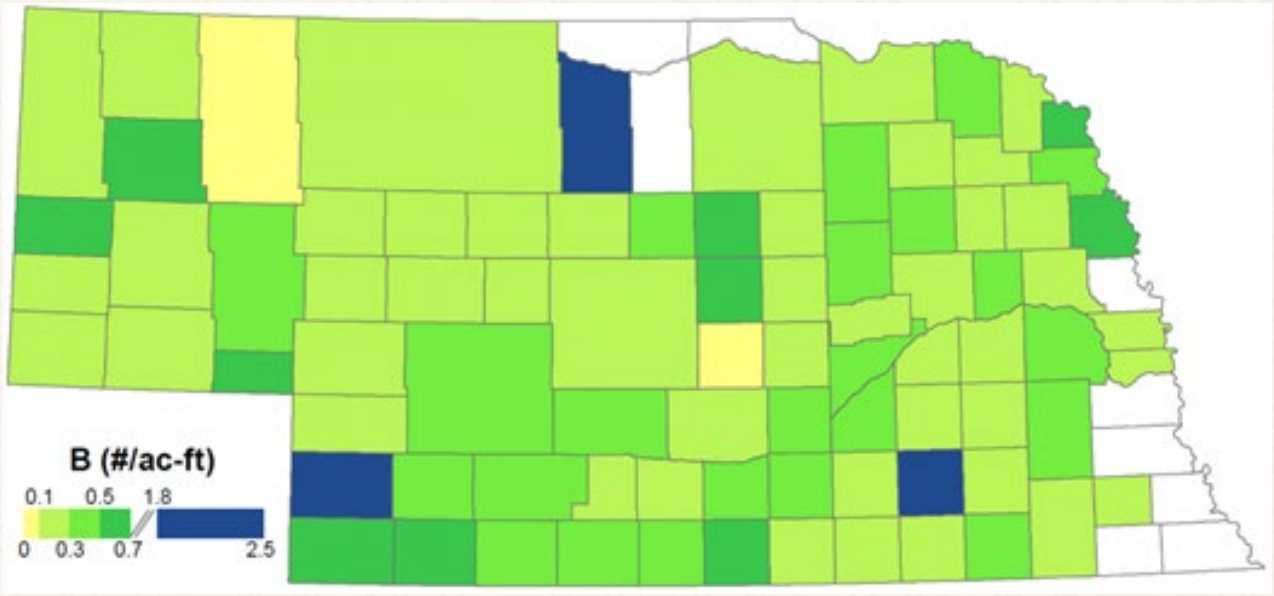
EXTENSION

Fertilizer recommendations

Irrigation Water Credit

Concentration, Acre-Foot of Water

- Min = 0.01 ppm, 0.03 lbs/acre ft
- Mean = 0.14 ppm, 0.37 lbs/acre ft
- Median = 0.11 ppm, 0.3 lbs/acre ft
- Max = 0.9 ppm, 2.45 lbs/acre ft



Source: Charles Wortmann (2019)

Fertilizer recommendations

"There has been no widely documented evidence of soybean grain yield increases from fertilization with B in the region. Soybean is very sensitive to excess B, however. Results from Minnesota have shown that a B applications often results in a yield decrease"

Micronutrients for Soybean Production in the North Central Regions – Multi-state publication in 2017

Summary

- Boron deficiency unlikely. Maybe sandy soils low in organic matter under dry conditions
- Soil test not very predictive/reliable
- Account for irrigation water containing boron
- **Soybean plant tissue analysis best option to monitor**

Chloride (Cl)

EXTENSION

Chloride

- Needed for osmotic regulation in plant cells
- **Mobile from old to new tissue**
- Soybeans very insensitive to deficiency

B Cl Co Cu Fe Mn Mo Ni Zn

Visible symptoms of deficiency & toxicity

- ✓Deficiency
  - ✓Not clearly described, may include chlorosis and wilting of leaves
  - ✓Not documented in the region at all in soybeans
- ✓Toxicity
  - ✓Leaf tip scorching
  - ✓Premature yellowing or bronzing of leaves
  - ✓Leaf loss
  - ✓Varieties can be categorized as chloride "includers" or "excluders". Research in Arkansas found that concentrations high enough to cause a 5% yield reduction was 1885 ppm for chloride excluders and 3923 ppm for includers.

N EXTENSION

B Cl Co Cu Fe Mn Mo Ni Zn

Factors of Availability

Monovalent anion in soil solution

Cl^-

Weakly held in soil and can be leached with high rainfall and irrigation

Availability controlled by amounts in rainfall, irrigation water, fertilizers, crop residue/OM, and salts found in saline soils

Deficiency = Rare

Toxicity = Maybe

B Cl Co Cu Fe Mn Mo Ni Zn

Soil Testing

- Sampling from 0 – 24 inches
  - Interpretations developed for wheat, corn, & sorghum, but not for soybeans

B Cl Co Cu Fe Mn Mo Ni Zn

Plant Tissue Analysis

Nutrient Sufficiency Ranges – Interpretive categories

Nutrient	Unit	Likely Responsive	Small probability of response	Sufficiency Range (or ideal)	Excessive or Toxic
Chloride (Cl)	%	<0.01	0.01- 0.019	0.02 - 0.14	>0.20

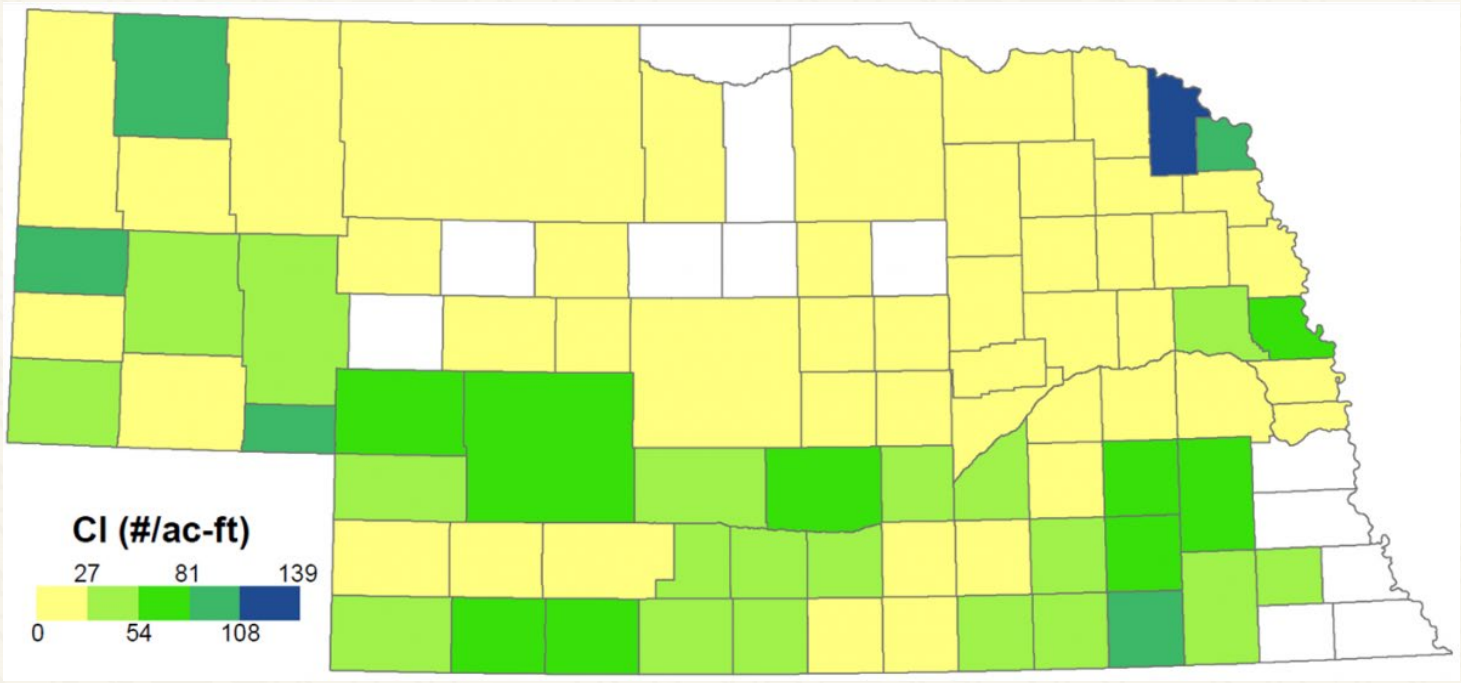
Chloride along with molybdenum can be added to a routine plant tissue analysis for another $6 to $7 per sample.

Cl

Fertilizer Recommendations

- None

Concentration, Acre-Foot of Water
Min = 0.04 ppm, 0.1 lbs/acre ft
Mean = 12 ppm, 31 lbs/acre ft
Median = 9 ppm, 25 lbs/acre ft
Max = 51 ppm, 139 lbs/acre ft



Source: Charles Wortmann (2019

Summary

- **Chloride deficiency extremely unlikely for soybeans**
- Soil test interpretations developed for other crops
- Combination of high potash rate plus irrigation water high in chloride could potentially be a toxicity issue
- Soybean plant tissue analysis best option to monitor

Cobalt* (Co)

EXTENSION

Fast Facts on Cobalt

- Cobalt is a beneficial nutrient, not truly an essential plant nutrient
- In soybeans, **Co^{2+}** is needed by *Bradyrhizobium* bacteria for nitrogen fixation, **Co^{2+}**

✓ Deficiency

- ✓ Similar to nitrogen deficiency with planting yellowing and reduced growth
- ✓ Not documented in the region at all for any crops

- 6 studies from 2015-2018
- No statistical differences between the check and the micronutrient mix
- **Numerically**, the yield differences were 0, 0, 0, 0, 0.6, and 2.0 bushels per acre (treatment – check).
- Website: resultsfinder.unl.edu

Copper (Cu)

EXTENSION

Copper

- Key micronutrient for different enzymes that are involved with:
  - photosynthesis
  - respiration
  - lignin production
  - Metabolism
- Not very mobile from old to new tissue
- Soybeans less sensitive to deficiency that other crops grown in the region
- Total plant uptake of 0.06 lbs/ac (65 bu/ac yield)

Cu

B Cl Co Cu Fe Mn Mo Ni Zn

Visible symptoms of deficiency

- Deficiency
  - Stunted growth, yellowing of leaves, and browning of leaf tips
  - Not documented in the region at all in soybeans

Factors of Availability

Divalent cation like other transition metals (iron, cobalt)

Cu^{2+}

Held by the cation exchanges capacity and tightly by SOM even in solution

Deficiencies observed on acidic high OM poorly drained soil like peat, muck, and sandy alkaline soils

Deficiency?

Extremely Rare

Soil Testing

- Sampling from 0 – 8 inches
- Soil test analysis (DTPA extraction method) for copper in our mineral soils is obtained along with the other metal micronutrients (Zn, Mn, Fe, Cu)
- Soil test DTPA values less on 0.2 ppm would suggest increased chances of a fertilizer response

B Cl Co **Cu** Fe Mn Mo Ni Zn

Plant Tissue Analysis

Nutrient Sufficiency Ranges – Interpretive categories

Nutrient	Unit	Likely Responsive	Small probability of response	Sufficiency Range (or ideal)	Excessive or Toxic
Copper (Cu)	ppm	<4	4 - 5	6 - 20	>50

Cu

EXTENSION

B Cl Co Cu Fe Mn Mo Ni Zn

Nebraska On-Farm Research Network

- Research in Nebraska, Kansas and Iowa has found no yield increases from copper fertilization.
- 7 studies in NE from 2015-2018
- Micronutrients in a mix applied as a soybean seed treatment, in-furrow, or as a foliar
- No statistical differences between the check and the micronutrient mix (included copper)
- Numerically, the yield differences were -5, -2, 0, 0, 0, 0, 1, and 2 bushels per acre (treatment – check).
- Website: resultsfinder.unl.edu

N EXTENSION

Summary

- Copper fertilization not recommended
- **Manure can be a good source of copper and manure as some other benefits**

Cu

Iron (Fe)

EXTENSION

B Cl Co Cu Fe Mn Mo Ni Zn

Iron

- Key micronutrient involved with:
  - chlorophyll for photosynthesis
  - respiration
- Not very mobile from old to new tissue
- Soybeans more sensitive to deficiency that other crops grown in the region
- Iron Deficiency Chlorosis (IDC) or Platte Valley Yellows
- Total plant uptake of 0.54 lbs/ac (65 bu/ac yield)

Fe

B Cl Co Cu **Fe** Mn Mo Ni Zn

Visible symptoms of deficiency

- ✓Deficiency (IDC)
  - ✓Yellow leaves with green veins called interveinal chlorosis
  - ✓Leaves so yellow almost can look white

B Cl Co Cu Fe Mn Mo Ni Zn

Factors of Availability

Divalent cation like other transition metals **Fe^{2+}**	Soil pH, free carbonates, moisture, aeration, and nitrate concentrations
Soybean varietal differences. Soybeans excrete acids and reductants to uptake the reduced iron	Deficiency common in Nebraska

Soil Testing

- Sampling from 0 – 8 inches
- Soil test analysis (DTPA extraction method) for copper in our mineral soils is obtained along with the other metal micronutrients (Zn, Mn, Fe, Cu)
- Soil test DTPA values less 4.5 ppm would suggest increased chances of a management response.
- However, iron deficiency does occur with values well above 4.5 ppm, so history of chlorosis best indicator of potential response to management

B Cl Co Cu **Fe** Mn Mo Ni Zn

Plant Tissue Analysis - *not great for Fe*

Nutrient Sufficiency Ranges – Interpretive categories

Nutrient	Unit	Likely Responsive	Small probability of response	Sufficiency Range (or ideal)	Excessive or Toxic
Iron (Fe)*	ppm	<50	50 - 54	55 - 300	>500

*Requires proper washing of leaves to get accurate results

Fe

EXTENSION

B Cl Co Cu Fe Mn Mo Ni Zn

Management recommendations

- In-furrow ortho-ortho EDDHA chelated iron fertilizer (e.g. Soygreen®)
- Cover crops to reduce soil nitrate levels
- Variety selection
- Seeding rates/row spacing
- Precision ag planting
  - Multihybrid planter for varieties
  - Variable-rate in-furrow starter fertilizer prescriptions

B Cl Co Cu Fe Mn Mo Ni Zn

Summary

- Fourth most common nutrient in soil, but the most deficient micronutrient in Nebraska soybeans
- Use a combination of management practices to deal with IDC

Fe

N EXTENSION

Manganese (Mn)

EXTENSION

B Cl Co Cu Fe Mn Mo Ni Zn

Manganese

- Key micronutrient involved with:
  - photosynthesis
  - free radical protections
  - nitrogen fixation
- Not very mobile from old to new tissue
- Soybeans more sensitive to deficiency that other crops grown in the region
- Total plant uptake of 0.44 lbs/ac (65 bu/ac yield)

Mn

B Cl Co Cu Fe **Mn** Mo Ni Zn

Visible symptoms of deficiency

- ✓ Deficiency
  - ✓ Yellow leaves with green veins called interveinal chlorosis

Factors of Availability

Divalent cation like other transition metals

Mn^{2+}

Soil pH, moisture, aeration, soil organic matter

High levels of iron and zinc can reduce uptake, but not enough to cause yield loss

Soil manganese concentration

B Cl Co Cu Fe Mn Mo Ni Zn

Soil Testing

- Sampling from 0 – 8 inches
- Soil test analysis (DTPA extraction method) for copper in our mineral soils is obtained along with the other metal micronutrients (Zn, Mn, Fe, Cu)
- Soil test DTPA values less 3.0 ppm would suggest increased chances of a management response
- Soil pH and SOM levels

B Cl Co Cu Fe **Mn** Mo Ni Zn

Plant Tissue Analysis

Nutrient Sufficiency Ranges – Interpretive categories

Nutrient	Unit	Likely Responsive	Small probability of response	Sufficiency Range (or ideal)	Excessive or Toxic
Manganese (Mn)	ppm	<20	20 - 29	20 - 100	>200

Mn

EXTENSION

B Cl Co Cu Fe Mn Mo Ni Zn

Fertilizer recommendations

- Not likely needed in Nebraska
- Form of soil-applied manganese fertilizer matters, you can make things worse

Summary

- Not an issue like other areas of soybean production in the Midwest
- Plant tissue and soil test analysis both tools to verify potential issue

Mn

Molybdenum (Mo)

EXTENSION

B Cl Co Cu Fe Mn Mo Ni Zn

Molybdenum

- Key micronutrient involved with two important enzymes with nitrogen in the plant and nitrogen-fixing *Rhizobia*
- **Somewhat mobile from old to new tissue**
- Soybeans more sensitive to deficiency that other crops grown in the region
- Uptake less than 0.1 lbs per acre

Visible symptoms of deficiency

- Deficiency
  - Similar to nitrogen deficiency – pale green plants with leaf veins not prominent and eventually pale yellow older leaves.

B Cl Co Cu Fe Mn **Mo** Ni Zn

Factors of Availability

Anion called Molybdate MoO_4^{2-}	Found in soil minerals.
Less available at low pH	Anion is absorbed or held by soil organic matter, carbonates, & oxide/hydroxides.

Soil Testing

- Sampling from 0 – 8 inches

- The soil test for molybdenum is a hot water extraction method, but it is not a routine soil test, so it does cost another $5 to $6 per sample.

B Cl Co Cu Fe Mn **Mo** Ni Zn

Plant Tissue Analysis

Nutrient Sufficiency Ranges – Interpretive categories					
Nutrient	Unit	Likely Responsive	Small probability of response	Sufficiency Range (or ideal)	Excessive or Toxic
Molybdenum (Mo)	ppm	<0.2	0.2 – 0.9	1.0 – 5.0	-

Molybdenum along with chloride can be added to a routine plant tissue analysis for another $6 to $7 per sample.

Mo

B Cl Co Cu Fe Mn Mo Ni Zn

Fertilizer recommendations

- Due to both *Rhizobia* bacteria and soybeans, it is beneficial to maintain soil pH above 6.0 and closer to a pH of 6.5 to maximize yield potential.
- Lime application the best option over Mo application
- Truly micro amounts needed, seed treatment could be an option

Summary

- Not an issue if low soil pH <5.5 is correct with lime application

Nickel (Ni)

EXTENSION

Fast Facts on Nickel

- Ni^{2+} less available at high soil pH above 7.0 to 7.5
- There is no published research in this area on nickel and no current agronomic soil and tissue testing available.
- Soil contains about 20 ppm total Nickel near Fremont, NE

- Essential micro in 1987
- Ni needed for nitrogen metabolism of urea-like compounds and can benefit symbiosis between *Rhizobia* bacteria and soybeans.
- Plants contain less than 1 ppm in tissue

Zinc (Zn)

EXTENSION

B Cl Co Cu Fe Mn Mo Ni Zn

Zinc

- Key micronutrient in enzymes and healthy metabolic function in the plant
- Soybeans are less sensitive to deficiency than corn
- Total plant uptake of 0.21 lbs/ac (65 bu/ac yield)

Zn

Visible symptoms of deficiency

- Deficiency
  - Zinc deficiency symptoms includes yellow mottling between the leaf veins and appears in the upper leaves first.

- Deficiency symptoms are likely to show up in corn first (large yellow to white band in upper leaves) since it is more sensitive to low zinc availability

Factors of Availability

A divalent cation like many of the other micros

Zn^{2+}

Found in soil minerals and SOM. Held by CEC

Availability lower in calcareous soils (soil pH above 7.3 and excess free lime), where topsoil has been lost/moved, or very sandy soils

Most common deficiency after iron

B Cl Co Cu Fe Mn Mo Ni Zn

Soil Testing

- Sampling from 0 – 8 inches
- Soil test analysis is very effective at predicting the need and crop response to zinc fertilization.
- Soil test (DTPA extraction) zinc critical level for corn is on 0.8 ppm (1.0 ppm for 6” depth)
- Soil sampling by management zone or grid can help to identify low soil zinc areas within fields.

B Cl Co Cu Fe Mn Mo Ni Zn

Plant Tissue Analysis

Nutrient Sufficiency Ranges – Interpretive categories

Nutrient	Unit	Likely Responsive	Small probability of response	Sufficiency Range (or ideal)	Excessive or Toxic
Zinc (Zn)	ppm	<20	20 – 24	25 – 60	>75

Plant tissue analysis can be used as a quality control check for your zinc soil test analysis and fertilization program.

Zn

Fertilizer recommendations

- Zinc fertilizers should be chosen based on solubility, cost per pound of zinc, ease of application, and residual effect.

- On non-calcareous low zinc testing soil, 3 to 5 pounds of zinc per acre as zinc sulfate (9 to 15 lbs/acre of product) dry blended with other fertilizers is an effective option.

Summary

- After iron, the next most common micronutrient deficiency in soybean production in Nebraska
- Soil test analysis, interpretations, and recommendations pretty good

Zn

Summary and Resources

EXTENSION

Nebraska. “Honestly, it’s not for every micro”

Micronutrient	Soil Conditions	Soybean Sensitivity	Likelihood of yield response to fertilizer application
Boron (B)	Low OM sandy soil, drought	Moderate	Low
Chloride (Cl)		Low	Very Low
Cobalt* (Co)			Very Low
Copper (Cu)		Low	Very Low
Iron (Fe)	**Calcareous soil, pH>7**	**High**	**Moderate**
Manganese (Mn)	Calcareous soil, pH>7	High	Low
Molybdenum (Mo)	Sandy or low pH<5.5	High	Low
Nickel (Ni)			Very Low
Zinc (Zn)	**Calcareous soil, low soil test DTPA**	**Moderate**	**Moderate**

Micronutrient Resources

- Micronutrient Management in Nebraska (2018)
- Micronutrients for Soybean Production in the North Central Region (2017)
- Nebraska Soybean and Corn Pocket Field Guide – 2019 Edition (Free copy – email nathan.mueller@unl.edu)
- Symptoms Identification Key for Nutrient Deficiencies in Soybeans (2017)
- Soybean Nutrient Analysis: Do your soybeans have the right stuff (2020)

View at croptechcafe.org/soybeans

N EXTENSION

Soybean Cafe

Crop Tech Cafe

Know your crop, know your tech, know your bottom line... feeding you agronomic information for your farm in southeast Nebraska

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Winter Wheat Cafe for East and South Central Nebraska

2020 Winter Wheat Variety Trial near Fairbury in Jefferson County

Positioning your farm to manage manure, control tough weeds, and improve soil health are just some of the advantages to growing winter wheat in east and south central Nebraska.

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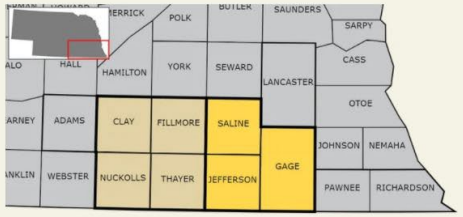

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