Soybean Micronutrient Management

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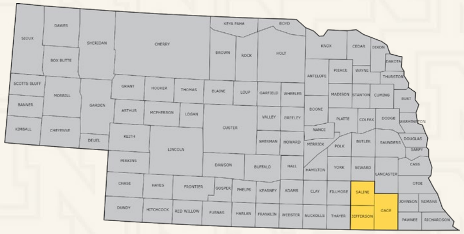

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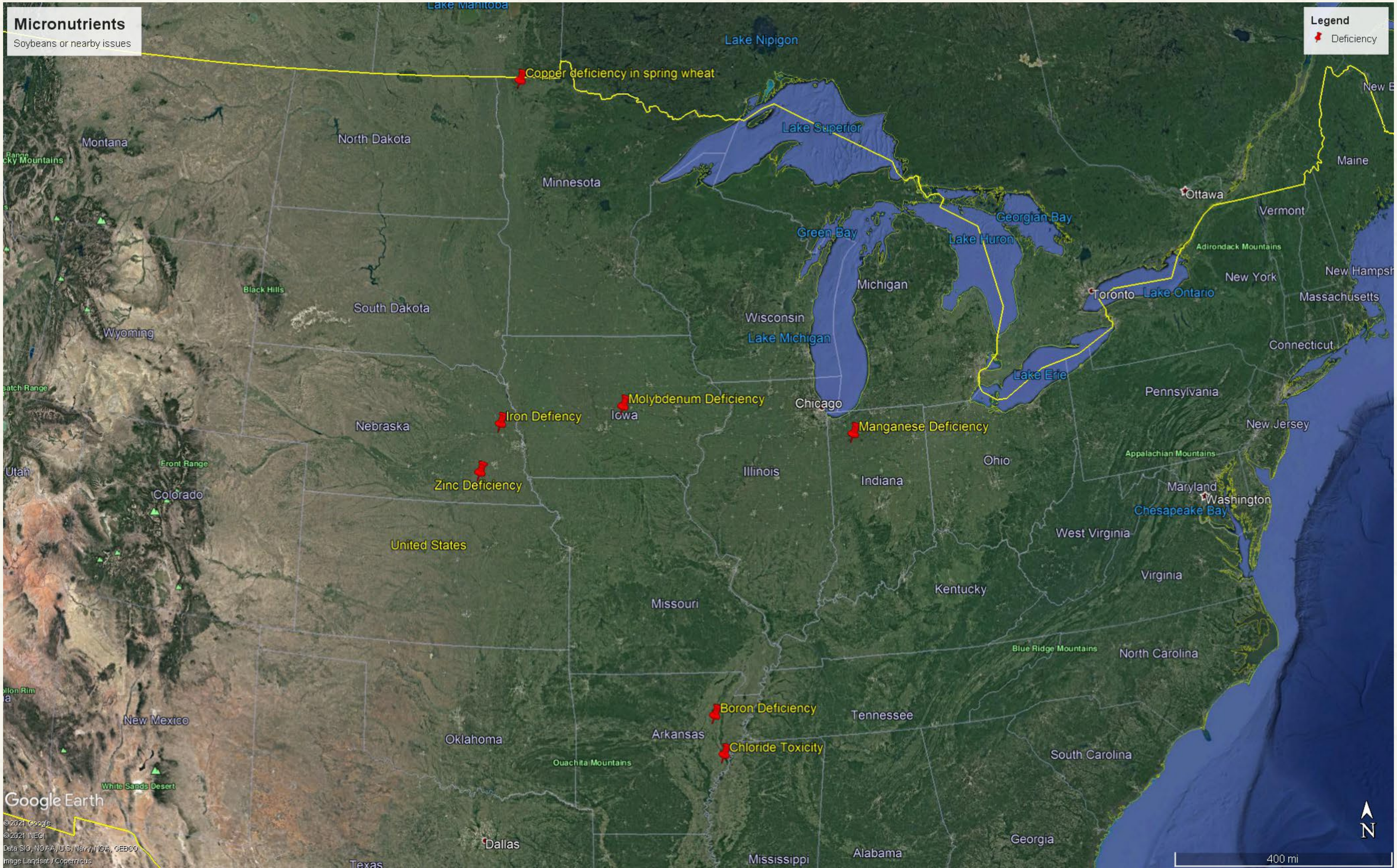
Soybean Micronutrients

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



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

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Where to focus first?

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

Plant Tissue Analysis

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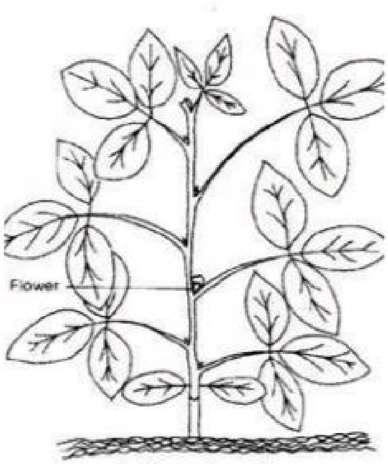
Soybean Growth Stages (R1-R2)

R1 – BEGINNING BLOOM:

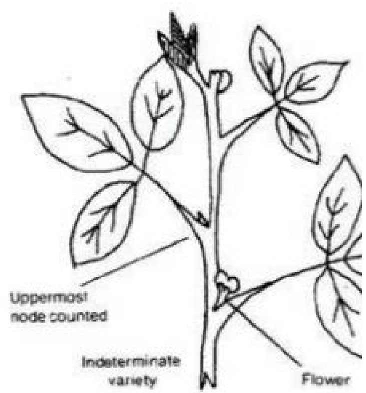
An open flower will be visible at a ma
plantings will be node 6 or 7 in MG III



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:

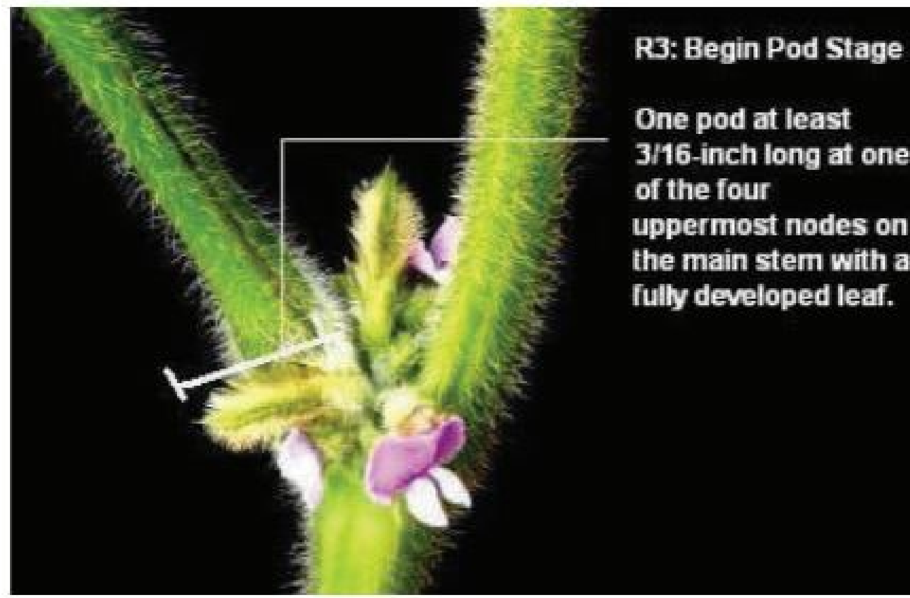
One open flower will be visible at on
"fully expanded" leaves. Many flowe



Indeterminate MG III varieties (us
will continue to successively pro
every 3.7 days at the main stem
al. 2008], **but also produce up to t**
axils in those newest nodes. It ma
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

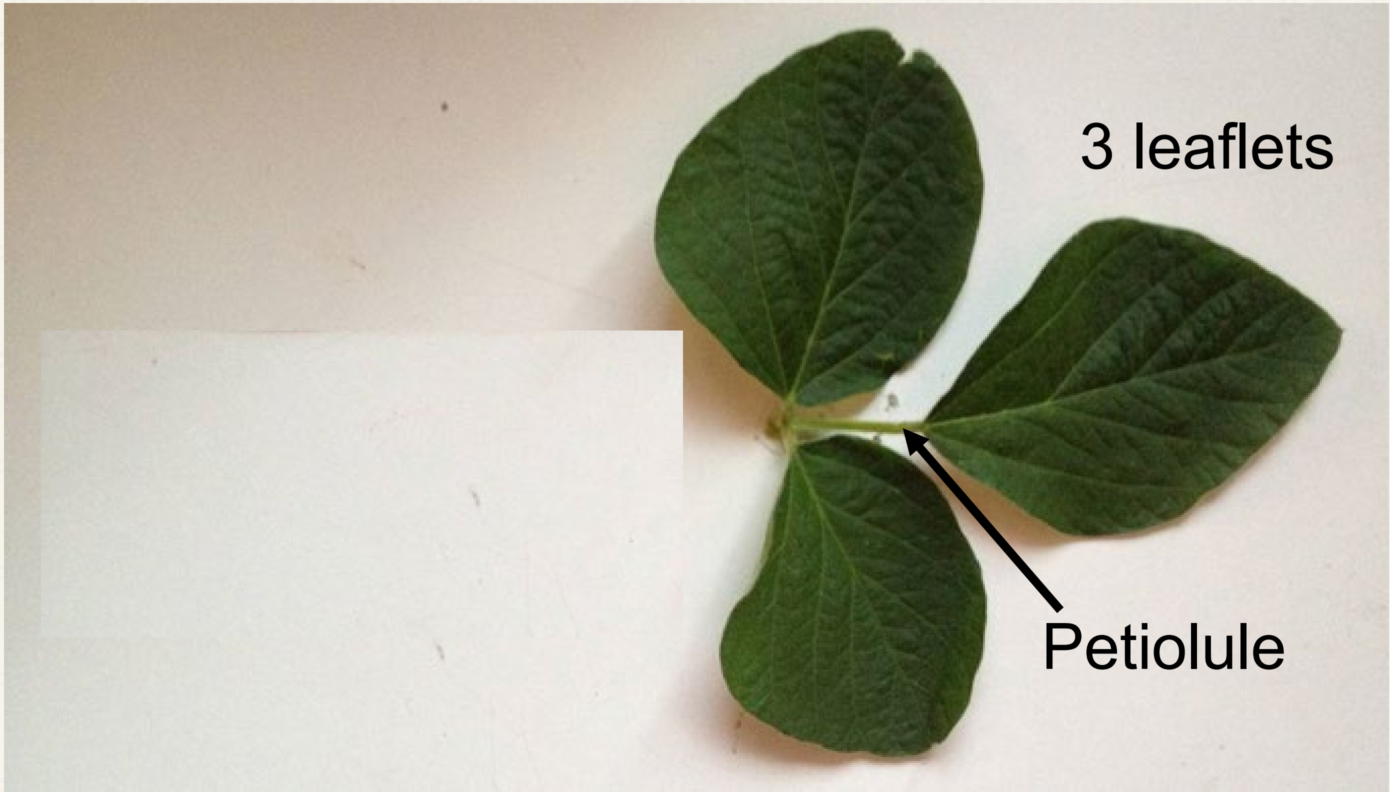
R3 – BEGINNING POD:

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	Petiole	Tri + Pet
Fe	ppm	148	43	122
Mn	ppm	96	34	81
Zn	ppm	39	27	36
Cu	ppm	13	7	12
B	ppm	43	23	38

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
Chloride (Cl)*	%	<0.01	0.01- 0.019	0.02 - 0.14	>0.20
Copper (Cu)	ppm	<4	4 - 5	6 - 20	>50
Iron (Fe)**	ppm	<50	50 - 54	55 - 300	>500
Manganese (Mn)	ppm	<20	20 - 29	20 - 100	>200
Molybdenum* (Mo)	ppm	<0.2	0.2 – 0.9	1.0 – 5.0	-
Zinc (Zn)	ppm	<20	20 – 24	25 – 60	>75

* Chloride & molybdenum for another $6 to $7 per sample.

** Requires proper washing of leaves to get accurate results

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Iron (Fe)

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Visible symptoms of deficiency

- Iron Deficiency Chlorosis (IDC)
  - Yellow leaves with green veins called interveinal chlorosis
  - Leaves so yellow almost can look white
- Key micronutrient involved with:
  - chlorophyll for photosynthesis
  - respiration
  - Not very mobile from old to new tissue

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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 numerous growing regions

Soil Testing

- Soil test analysis (DTPA extraction method) for iron in our mineral soils is obtained along with the other metal micronutrients (Zn, Mn,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

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
  - Multi-hybrid planter for varieties
  - Variable-rate in-furrow starter fertilizer prescriptions

Zinc (Zn)

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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

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.

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.

Molybdenum (Mo)

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Visible symptoms of deficiency

- ✓Deficiency
  - ✓Similar to nitrogen deficiency – pale green plants with leaf veins not prominent and eventually pale yellow older leaves.
  - ✓Somewhat mobile from old to new tissue

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

- 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.

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
- Uptake less than 0.1 lbs per acre, so truly micro amounts needed, seed treatment could be an option

Boron (B)

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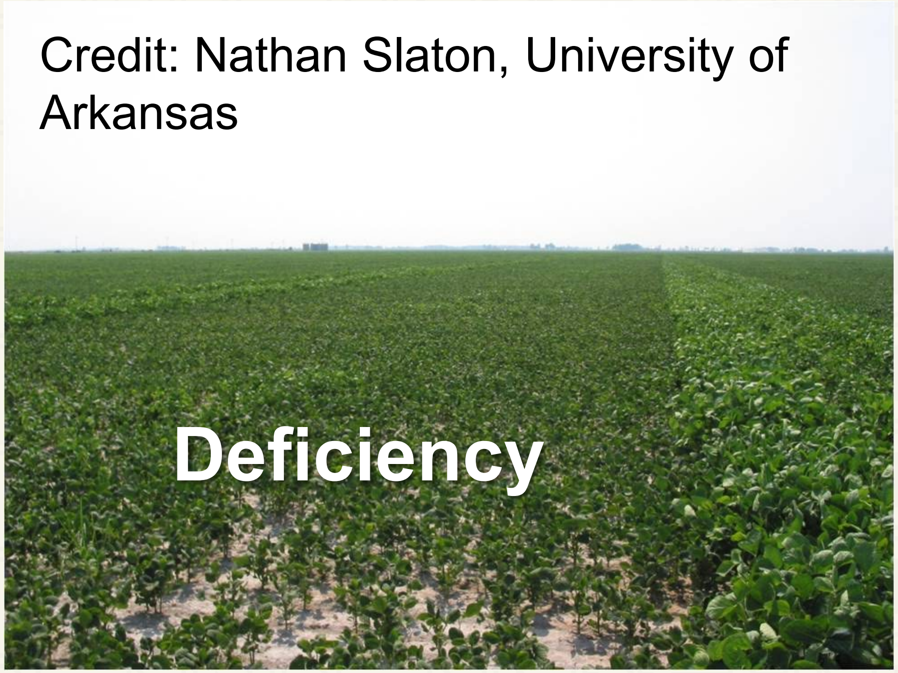
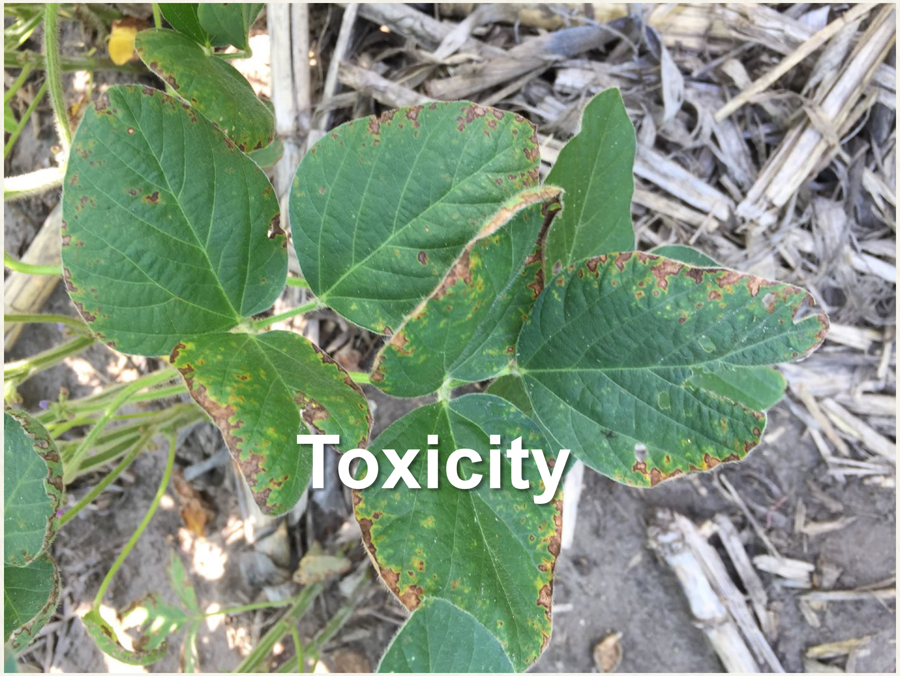
Visible symptoms of deficiency & toxicity





- ✓ 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

N EXTENSION

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

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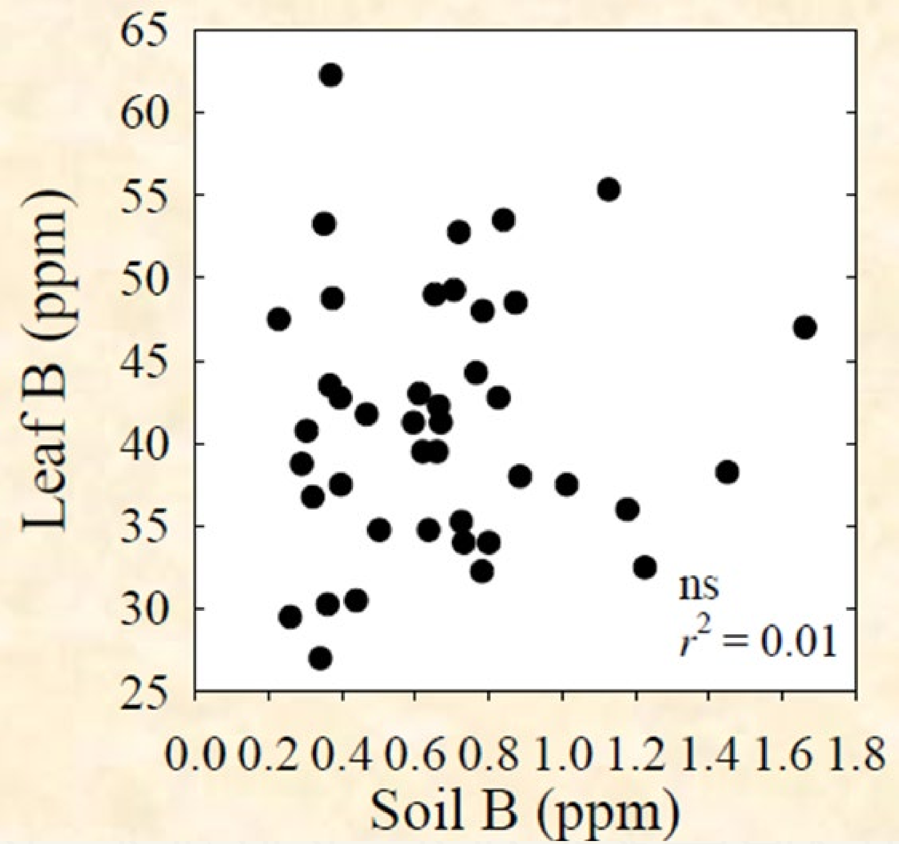
Soil testing

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



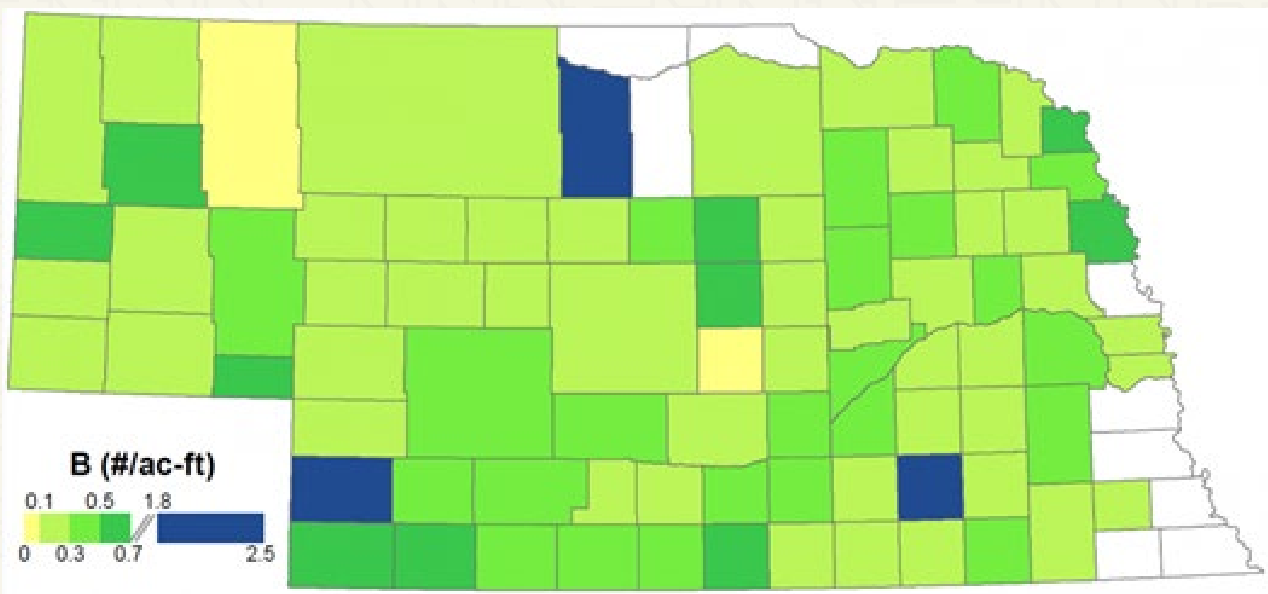
Source: Iowa State University – Antonio Mallarino

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)

B Cl Co Cu Fe Mn Mo Ni Zn

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

Soybean plant tissue analysis best option to monitor

Manganese (Mn)

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Manganese Fast Facts

- ✓Regional issue
- ✓Deficiency: Yellow leaves with green veins
- ✓Soil test DTPA values less 3.0 ppm would suggest increased chances of a management response
- ✓High levels of iron and zinc can reduce uptake, but not enough to cause yield loss
- ✓Form of soil-applied manganese fertilizer matters, you can make things worse
- ✓Plant tissue and soil test analysis both tools to verify potential issue

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Literature, resources, and full slide set for all micronutrients at croptechcafe.org/soybeans

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