Indiana CCA Conference 2022

Soybean Micronutrient Deficiencies and Foliar Fertilizers

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1

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THE OHIO STATE UNIVERSITY

CERTIFIED CROP ADVISER

COOL BEAN

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2

Agenda

Overview of soybean micronutrient needs

Visual symptoms of nutrient deficiency

Sampling to diagnose nutrient deficiencies

Recent multi-state foliar fertilizer trials

Applying micronutrients

Considerations for evaluating future foliar fertilizer products

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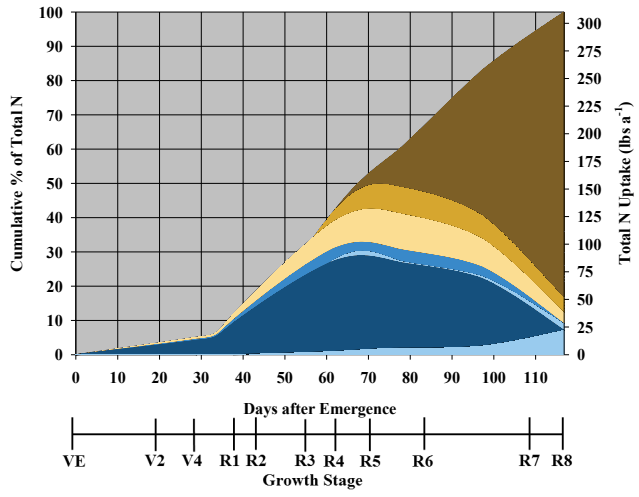
3

Nitrogen (N) uptake and partitioning



(Gaspar, Naeve & Conley, 2018)

**82 bu/acre total seed yield*

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4

Soybean Nutrient Uptake and Removal

Nutrient	Total Uptake	Removal in Grain†	Removal in Stover‡
	lbs/bu	lbs/bu	lbs/ton DM
N	3.75 ± 0.12	3.30 ± 0.08	19.0
P (P_2O_5)*	0.90 ± 0.04	0.74 ± 0.02	5.2
K (K_2O)	2.30 ± 0.14	1.17 ± 0.02	39.0
S	0.21 ± 0.01	0.16 ± 0.01	2.2
Mg	0.51 ± 0.04	0.16 ± 0.003	9.3
Ca	0.96 ± 0.1	0.12 ± 0.01	27.5
Zn	0.003#	0.002	0.03
Mn	0.004	0.002	0.14
Cu	0.001	0.001	0.01
Fe	0.006	0.002	0.17
B	0.002	0.001	0.05

(Gaspar, Naeve & Conley, 2018)

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5

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S	0.21 ± 0.01	0.16 ± 0.01	2.2
Mg	0.51 ± 0.04	0.16 ± 0.003	9.3
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(Gaspar, Naeve & Conley, 2018)

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6

Where will we see deficiency symptoms?

Deficiencies of nutrients that are *mobile* in plant tissues will show up first in *older leaves* (bottom of the plant)

- Mobile: nitrogen, potassium, sulfur, chlorine, nickel
- Slightly less mobile: phosphorous, magnesium

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7

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- Mobile: nitrogen, potassium, sulfur, chlorine, nickel
- Slightly less mobile: phosphorous, magnesium

Deficiencies of nutrients that are *immobile* in plant tissues will show up first in *younger* leaves (top of the plant)

- Calcium, boron, copper, iron, manganese, zinc, cobalt

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8

Where will we see deficiency symptoms?

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- Mobile: nitrogen, potassium, sulfur, chlorine, nickel
- Slightly less mobile: phosphorous, magnesium

Deficiencies of nutrients that are *immobile* in plant tissues will show up first in *younger* leaves (top of the plant)

- Calcium, boron, copper, iron, manganese, zinc, molybdenum, cobalt

Timing of availability is most important for nutrients that are relatively immobile in plant tissues but highly mobile in soil.

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9

Macronutrient Deficiency Symptoms

Macronutrients (with the exception of calcium) are mobile in plant tissues-- deficiencies will show up in older tissue first.

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10

Macronutrient Deficiency Symptoms

Macronutrients (with the exception of calcium) are mobile in plant tissues-- deficiencies will show up in older tissue first.

Phosphorous (right)

Image from UNL: https://cropwatch.unl.edu/soils/soybean-nutrients

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11

Macronutrient Deficiency Symptoms

Macronutrients (with the exception of calcium) are mobile in plant tissues-- deficiencies will show up in older tissue first.

Potassium

Image from Iowa State: https://crops.extension.iastate.edu/cropnews/2019/08/upper-soybean-leaves-began-showing-potassium-deficiency-symptoms-early-august-some

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12

Macronutrient Deficiency Symptoms

Macronutrients (with the exception of calcium) are mobile in plant tissues-- deficiencies will show up in older tissue first.

Magnesium

Image from UNL: https://cropwatch.unl.edu/soils/soybean-nutrients

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13

Macronutrient Deficiency Symptoms

Macronutrients (with the exception of calcium) are mobile in plant tissues-- deficiencies will show up in older tissue first.

Sulfur (right)

Photo Credit: https://content.ces.ncsu.edu/mid-season-soybean-sulfur-deficiency

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14

Macronutrient Deficiency Symptoms

Macronutrients (with the exception of calcium) are mobile in plant tissues-- deficiencies will show up in older tissue first.

Nitrogen (left)

Sulfur (right)

Photo Credit: https://content.ces.ncsu.edu/mid-season-soybean-sulfur-deficiency; https://cropwatch.unl.edu/soils/soybean-nutrients

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15

Summary of Macronutrient Deficiencies

Nitrogen: yellow leaves that are worse at the bottom of the plant

Phosphorous: dark green stunted plants, sometimes with red veins or lesions

Potassium: yellow leaf margins in bottom or near the center of the plant

Magnesium: mottled yellow leaves at base of plant, sometimes with interveinal necrosis

Sulfur: yellowing leaves all over the plant

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16

Micronutrient Deficiencies– Mo

Molybdenum is immobile

It is crucial for nodulation, so early Mo deficiency will appear as N deficiency

Image from https://content.ces.ncsu.edu/mid-season-soybean-molybdenum-deficiency

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17

Micronutrient Deficiencies– Mn

Manganese is immobile– deficiencies appear in new growth

More common on soils with pH > 7.5

Photo Credit: Left, Michael Staton

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18

Micronutrient Deficiencies– Fe

Iron is immobile– yellowing will be primarily on new growth

More common on saturated soils or fields with neutral-to-high pH (>7)

Image from https://www.krugerseed.com/en-us/agronomy-library/late-season-soybean-nutrient-deficiency-identification.html

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19

Micronutrient Deficiencies– Zn

Zinc is immobile in plant tissue, so symptoms appear on young leaves

Zinc is less available when pH is above 7.5

Figure 10. Zinc deficiency. Picture courtesy of Dr. Bobby Golden, Mississippi State University.

Photo Credit: https://www.krugerseed.com/en-us/agronomy-library/late-season-soybean-nutrient-deficiency-identification.html

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20

Micronutrient Deficiencies– B

Boron is immobile– symptoms will be near the growing point

More common on very sandy soils in the southeast US

Image from https://content.ces.ncsu.edu/mid-season-soybean-boron-deficiency

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21

Too Much of a Good Thing: Micronutrient Toxicities

Boron– necrosis and scorching on leaf edges

Zinc– stem splitting and stunting

Manganese– yellow new growth and dark, necrotic, cupped older leaves

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22

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23

Sulfur Deficiency Symptoms

Image from: https://content.ces.ncsu.edu/mid-season-soybean-sulfur-deficiency

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24

Sulfur Deficiency Symptoms

What else could this be?

- Other Nutrient Deficiencies
- Environmental Conditions
- Varietal Differences

Image from: https://content.ces.ncsu.edu/mid-season-soybean-sulfur-deficiency

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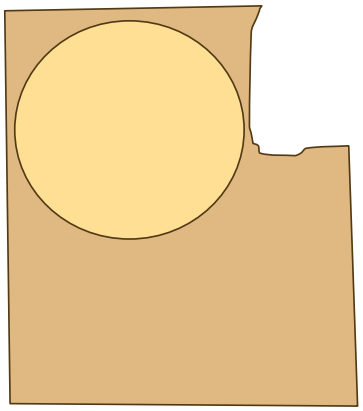
25

Tissue Sampling for Nutrient Deficiencies



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26

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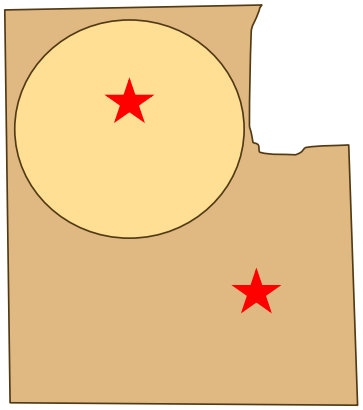

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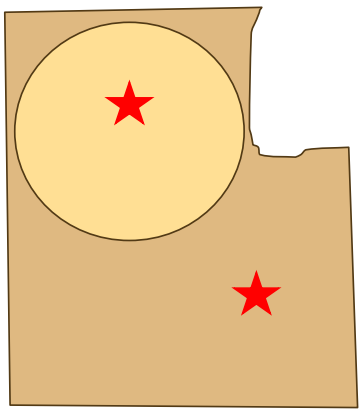
27

Tissue Sampling for Nutrient Deficiencies

Check your lab's recommendations for tissue tests

- Growth stage
- Number of trifoliates to collect
- Petiole or no petiole?
- Ship samples wet or dry?



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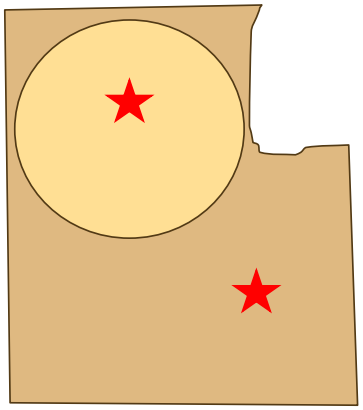
28

Tissue Sampling for Nutrient Deficiencies

Check your lab's recommendations for tissue tests
- Growth stage
- Number of trifoliates to collect
- Petiole or no petiole?
- Ship samples wet or dry?

Label your samples so you know which was which!
- Compare the lab results between the samples



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29

Alternatives to Paired Sampling

Critical Tissue Concentrations

Sufficiency Ranges

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30

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Critical Tissue Concentrations

Sufficiency Ranges

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31

Alternatives to Paired Sampling

Critical Tissue Concentrations

Sufficiency Ranges

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32

Tri-State Sufficiency Ranges

Table 32. Micronutrient Plant Tissue Sufficiency Ranges for Corn, Soybean, Alfalfa, and Wheat

Element	Corn Ear leaf sampled at initial silking	Soybean Uppermost fully developed trifoliate sampled prior to initial flowering	Alfalfa Top 6 inches sampled prior to initial flowering	Wheat Upper leaves sampled prior to initial bloom
	parts per million (ppm)			
Manganese (Mn)	20–150	21–100	31–100	16–200
Iron (Fe)	21–250	51–350	31–250	11–300
Boron (B)	4–25	21–55	31–80	6–40
Copper (Cu)	6–20	10–30	11–30	6–50
Zinc (Zn)	20–70	21–50	21–70	21–70
Molybdenum (Mo)	–	1.0–5.0	1.0–5.0	–

33

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How do I know if a sufficiency range I see published will be accurate for my sample?

- Same Crop
- Same Plant Part
- Same Growth Stage

34

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35

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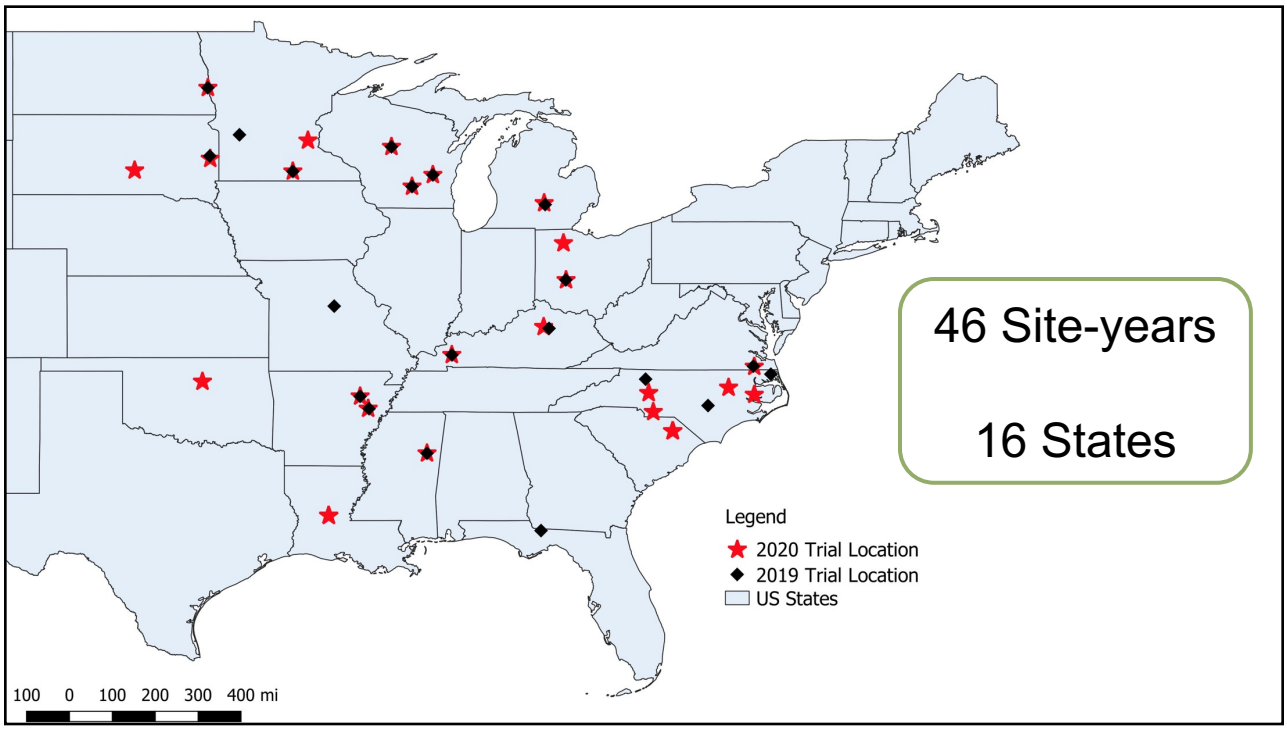
36



37

Products and Nutrient Rates

Treatment Name	Application Rate	Cost of Product	N	P	K	S	Mn	Fe	Mo	Zn	B	Other
		USD ha^{-1}	kg ha^{-1}									
FertiRain	28.0 l ha^{-1}	$55	3.1	1.0	1.0	0.6	0.02	0.03	-	0.03	-	-
Sure-K	28.0 l ha^{-1}	$48	0.7	0.3	1.0	-	-	-	-	-	-	-
HarvestMore Ureamate	2.8 kg ha^{-1}	$12	0.1	0.3	-	-	0.01	-	0.002	0.01	-	Ca, Mg, B, Co, Cu
Smart B-Mo	1.2 l ha^{-1}	$9	-	-	-	-	-	-	0.007	-	0.08	-
Smart Quatro Plus	4.7 l ha^{-1}	$16	-	-	-	0.04	0.09	-	0.003	0.09	0.07	-
Maximum NPact K	14.0 l ha^{-1}	$52	2.1	-	2.1	-	-	-	-	-	-	-
Untreated Control	-	-	-	-	-	-	-	-	-	-	-	-

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38

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39

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Maximum NPact K	14.0 l ha^{-1}	$52	2.1	-	2.1	-	-	-	-	-	-	-
Untreated Control	-	-	-	-	-	-	-	-	-	-	-	-

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40

In-season Measurements

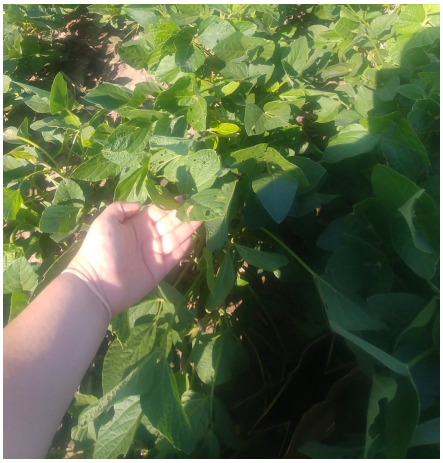

Photo Credit (left): Lindsay Chamberlain

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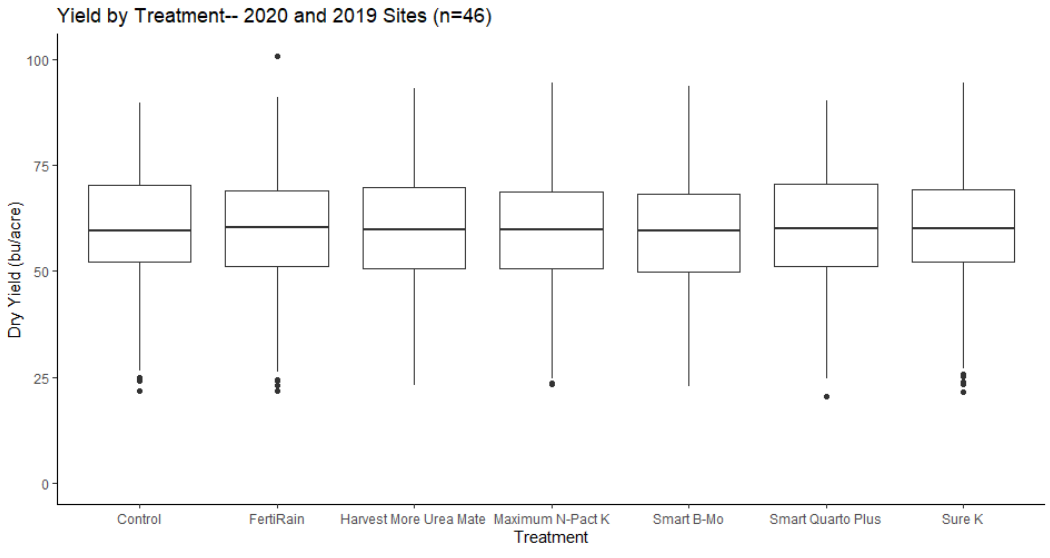
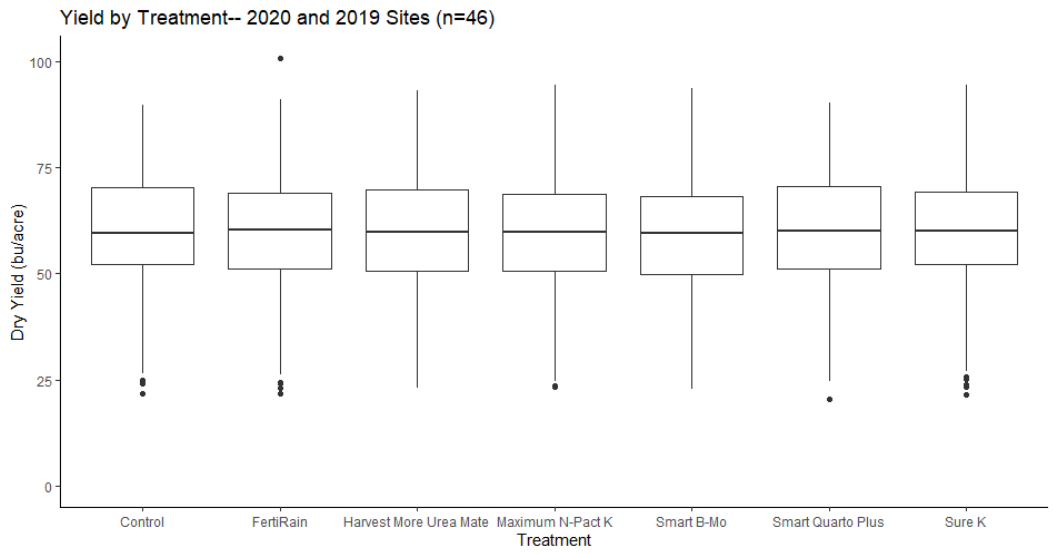
41

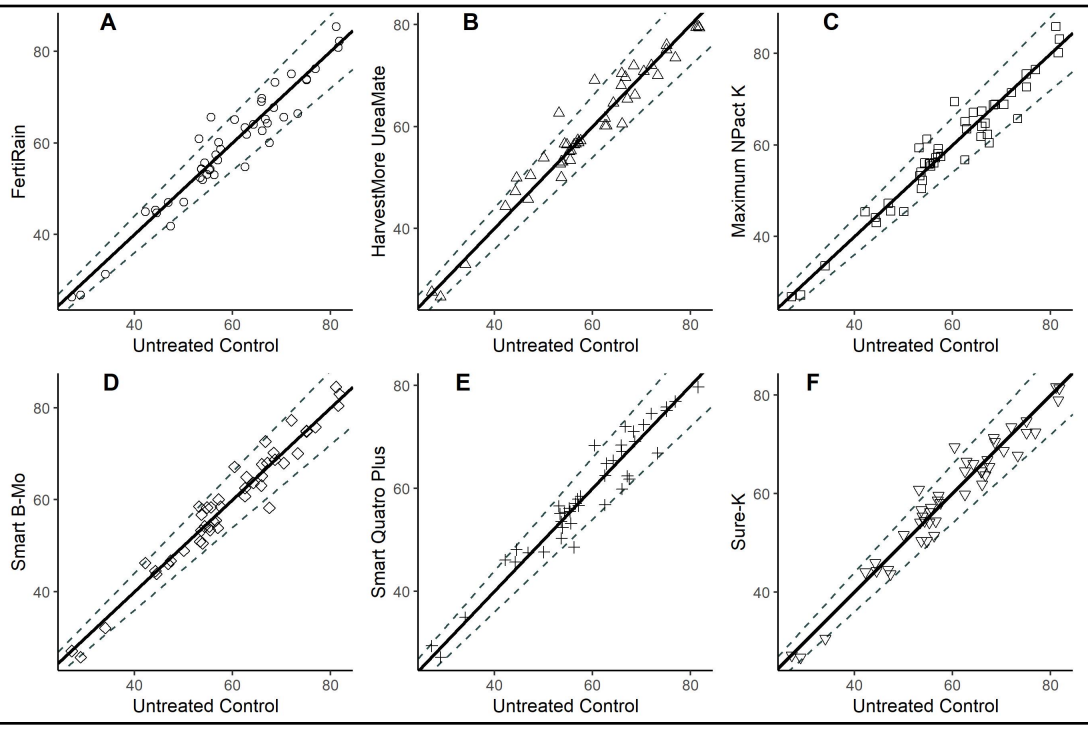


42

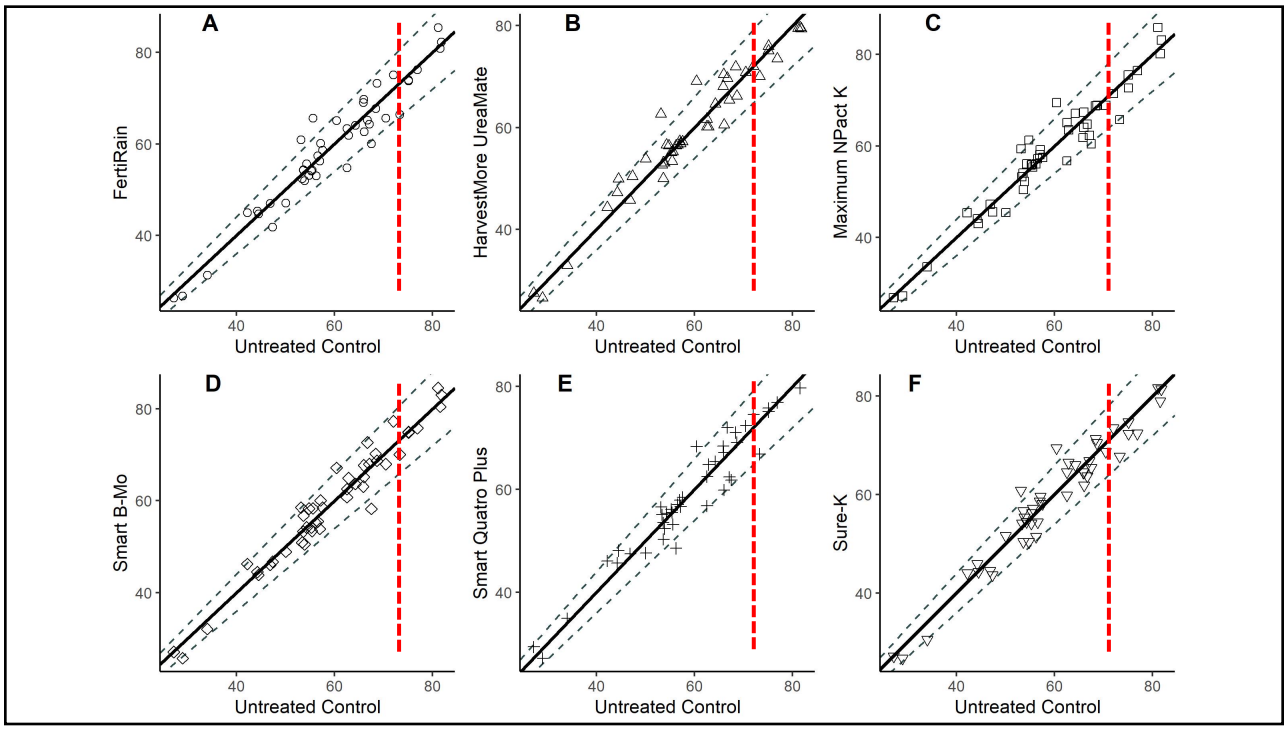


There were no significant differences in yield among treatments (F = 0.08, p = 0.998).

43



44



45

Foliar Fertilizers Reduced Profitability

Treatment	Mean partial profit at soybean grain price of $15/bu	Mean partial profit at soybean grain price of $10/bu
Untreated Control	2202 a*	1470 a
Smart B-Mo	2198 ab	1464 a
HarvestMore UreaMate	2193 ab	1459 a
Smart Quatro Plus	2168 ab	1442 ab
FertiRain	2151 ab	1417 b
Sure-K	2149 ab	1418 b
Maximum NPact K	2142 b	1412 b

*Means not sharing common letters within each column denote statistical differences among treatments (α = .05). Bonferroni adjustments were used to adjust for multiplicity.

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46

Increased Economic Risk When Applying Foliar Fertilizers without Tank Mixing

Making a separate pass costs money

Damage from wheel tracks reduces yield by 1-5% for every sprayer pass after R1

47

What we learned from 46 site-years of data:

Lack of yield response was relatively uniform across sites
- Even sites with very low soil P and soil K did not respond to foliar fertilizers
- High-yielding soybeans didn't respond to foliar fertilizers

Foliar fertilizer application did not have an effect on grain protein and oil concentrations

Leaf tissue macronutrient concentrations didn't differ between treated and untreated plots, but some micronutrient concentrations did

48

Multistate Research Team

Core Team:
Dr. Rachel Vann (NCSU)
Dr. Laura Lindsey (OSU)
Dr. Shawn Conley (UW-Madison)

Bean Team:
John Gaska
Adam Roth
Lindsay Chamberlain
Haleigh Ortmeier-Clarke

Collaborators:
Drs. Jeremy Ross, David L. Wright, Carrie Knot, Chad D. Lee, Maninder Singh, Seth Naeve, Trent Irby, William Wiebold, Hans Kandel, Jonathan Kleinjan, and David Lee Holshouser

Publication available in Agronomy Journal: Matcham, E. G., Vann, R., Lindsey, L. E., Gaska, J. M., Lilley, D. T., Ross, J., Wright, D. L., Knott, C., Lee, C. D., Mosely, D., Singh, M., Naeve, S., Irby, T., Weibold, W., Kandel, H., Lofton, J., Inman, M., Kleinjan, J., Holshouser, D. L., and Conley, S. P. (2021). Foliar Fertilizers Rarely Increase Yield in US Soybean. *Agronomy Journal*. https://doi.org/10.1002/agj2.20889

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49

Which fields are most likely to have micronutrient deficiencies?

Table 30. Crop and Soil Conditions Under Which Micronutrient Deficiencies May Occur

Micronutrient	Soil	Crop
Boron (B)	Sandy soils or highly weathered soils low in organic matter	Alfalfa and clover
Copper (Cu)	Acid peats or mucks with pH < 5.3 and black sands	Wheat, oats, corn
Manganese (Mn)	Peats and mucks with pH > 5.8, black sands and lakebed/ depressional soils with pH > 6.2	Soybean, wheat, oats, sugar beets, corn
Molybdenum (Mo)	Acid prairie soils	Soybean
Zinc (Zn)	Peats, mucks and mineral soils with pH > 6.5	Corn and Soybean

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50

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51

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52

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Molybdenum (Mo)	Acid prairie soils	Soybean
Zinc (Zn)	Peats, mucks and mineral soils with pH > 6.5	Corn and Soybean

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53

How can we best manage recurrent micronutrient deficiencies?

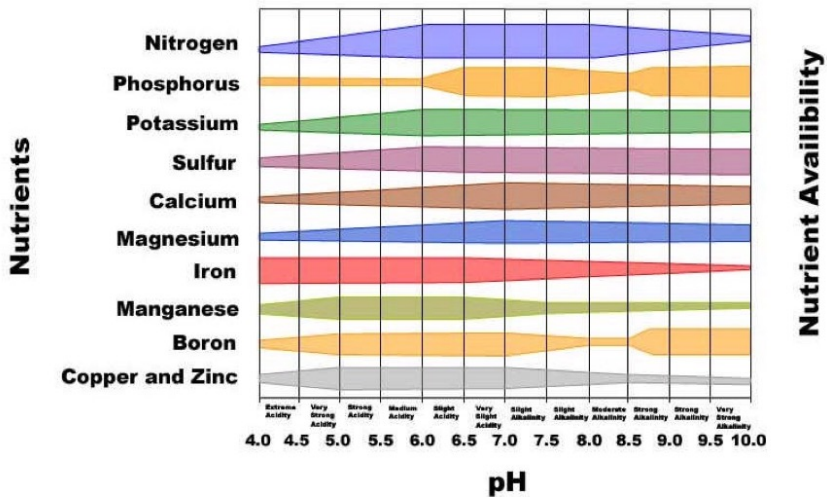

Image from:https://fruit.wisc.edu/2020/04/24/adjusting-soil-ph-for-cranberry-production/

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54

When may rescue applications increase yield?

When the application rate meets crop need

When the plant is still growing and accumulating nutrients

When nutrients are in fact limiting crop growth, and other conditions like insects or weather aren't *more* severely limiting growth

55

When may rescue applications increase yield?

When the application rate meets crop need

When the plant is still growing and accumulating nutrients

When nutrients are in fact limiting crop growth, and other conditions like insects or weather aren't *more* severely limiting growth

Address nutrient deficiencies in a timely fashion, and don't expect foliar nutrient products to solve pest or weather problems.

56

When may rescue applications increase yield?

When the application rate meets crop need

When the plant is still growing and accumulating nutrients

When nutrients are in fact limiting crop growth, and other conditions like insects or weather aren't *more* severely limiting growth

There are trade-offs between soil-applied and foliar application of micronutrients.

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57

Of the common nutrient deficiencies, all macronutrients are mobile and all micronutrients are immobile in plant tissues.

58

Of the common nutrient deficiencies, all macronutrients are mobile and all micronutrients are immobile in plant tissues.

Symptoms of deficiency at the bottom of the plant probably need to be addressed with application rates higher than can typically be applied with foliar fertilizers.

59

How do we know if a rescue application helped?

Leave an untreated check in the field

Visually inspect plants ~10 days after application

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60

If you're going to make a preventative micronutrient application…

- Focus on just a few micronutrients
- Consider leaving an untreated check strip
- Include micronutrients in with another fertilizer product or tank-mixed with crop protection products

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61

Agenda

- ~~Overview of soybean micronutrient needs~~
- ~~Visual symptoms of nutrient deficiency~~
- ~~Sampling to diagnose nutrient deficiencies~~
- ~~Recent multi-state foliar fertilizer trials~~
- ~~Applying micronutrients~~
- Considerations for evaluating future foliar fertilizer products

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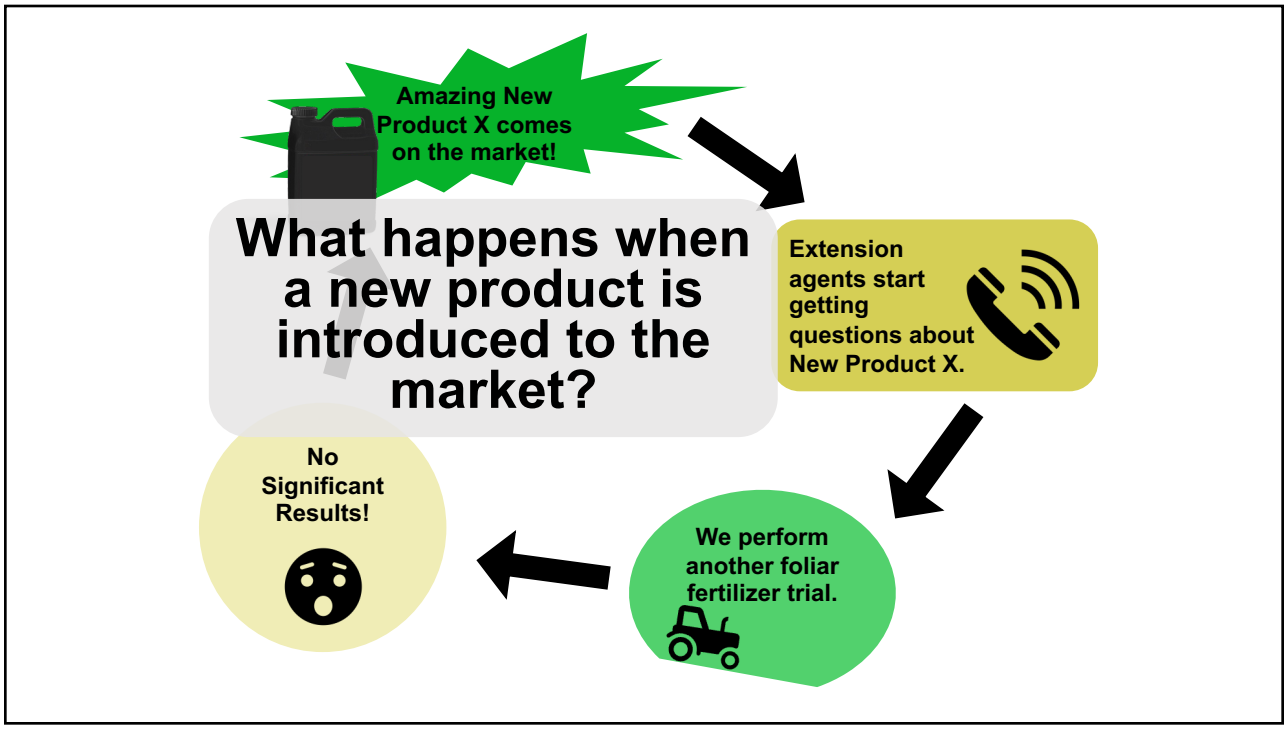
62

What happens when a new product is introduced to the market?

63



64

As new products come out, here are 3 things think about:

1. Are you seeing trial results that took place over multiple years and multiple sites?
2. Can you get information from someone who isn't selling the product?
3. Can you try the product on some test strips on your own farm before trying it on a larger scale?

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65

Take Home Messages

Prophylactic foliar fertilizers generally do not increase soybean yields

Foliar fertilizers are likely to reduce farm profits in the absence of visual symptoms of nutrient deficiencies

Wait to apply foliar fertilizers until after you see visual symptoms of nutrient deficiencies

Macronutrient deficiencies should usually be addressed using soil-applied fertilizers, not foliar products

Pull paired tissue and soil samples if you suspect nutrient deficiencies to help diagnose the underlying cause

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66

Thank You!

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67

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68

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69