Nutrients to Soybean: Enhanced, Supplied, or Suppressed?

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@PurdueSoybean and **Purdue Crop Chat podcast**

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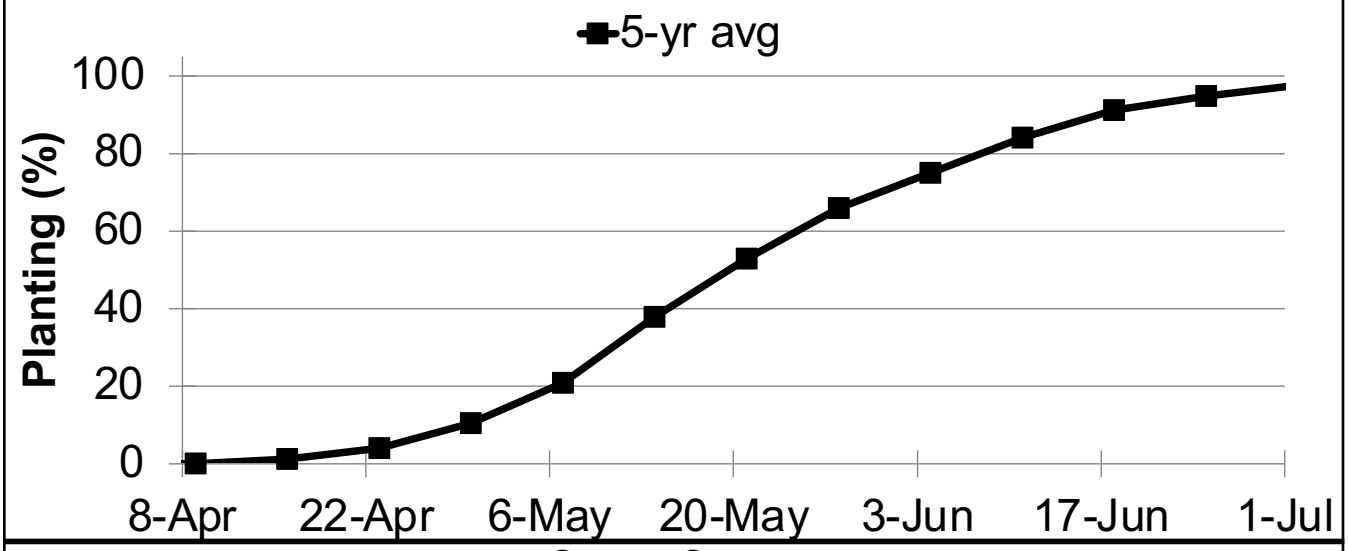
Indiana Soybean Planting: Earliest Years



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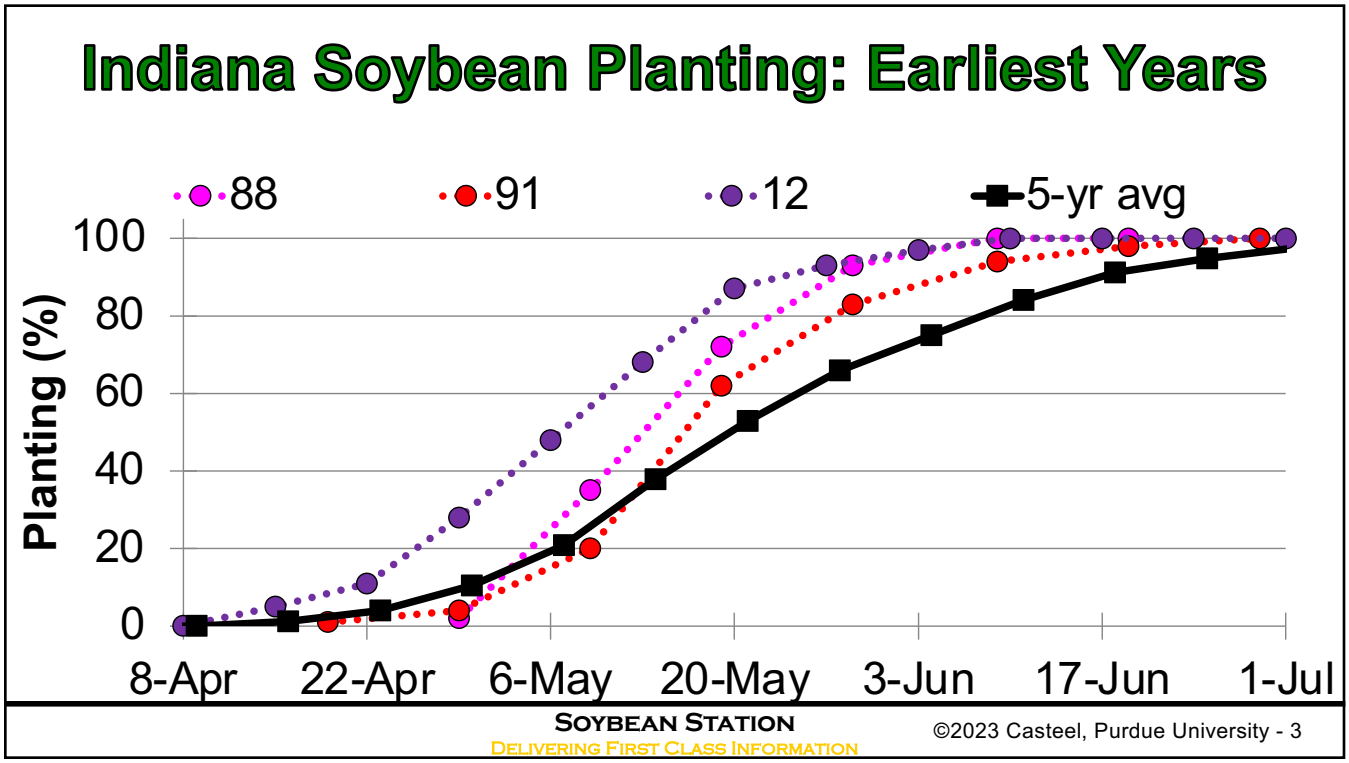
Indiana Soybean Planting: Earliest Years
88
91
12
5-yr avg
Planting (%)
100
80
60
40
20
0
8-Apr
22-Apr
6-May
20-May
3-Jun
17-Jun
1-Jul
Soybean Station
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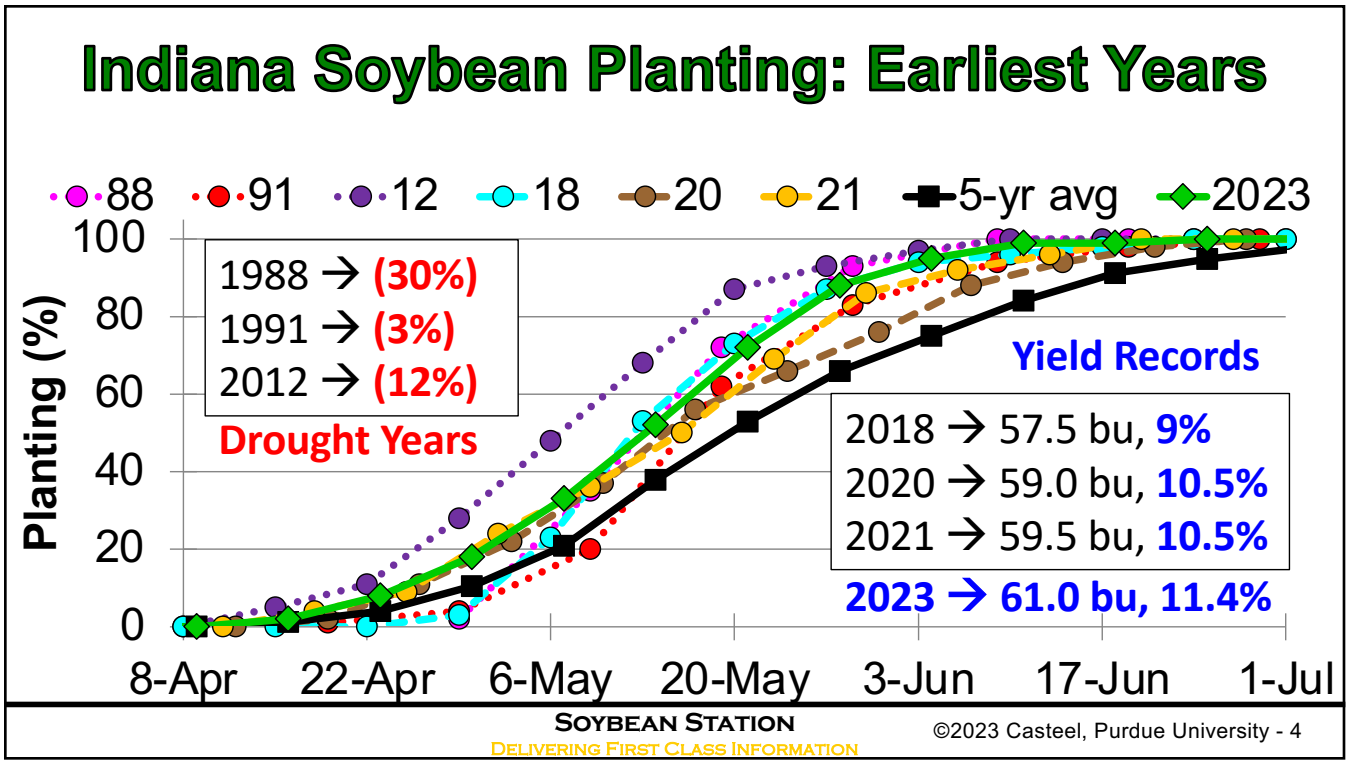
Indiana Soybean Planting: Earliest Years
88
91
12
18
20
21
5-yr avg
2023
Planting (%)
100
80
60
40
20
0
1988 → (30%)
1991 → (3%)
2012 → (12%)
Drought Years
Yield Records
2018 → 57.5 bu, 9%
2020 → 59.0 bu, 10.5%
2021 → 59.5 bu, 10.5%
2023 → 61.0 bu, 11.4%
8-Apr
22-Apr
6-May
20-May
3-Jun
17-Jun
1-Jul
Soybean Station
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Indiana Yields

Year	Planting (50%)	Yield	Changes from Trend	
	d after corn	bu/ac	Percent	bu/ac
2010	29.4	48.5	-0.8%	(0.4)
2011	13.3	45.5	-7.8%	(3.9)
2012	12.6	44.0	-11.7%	(5.8)
2013	7.0	51.5	2.5%	1.2
2014	13.3	55.5	9.4%	4.8
2015	12.6	50.0	-2.3%	(1.2)
2016	9.1	57.5	11.4%	5.9
2017	17.5	54.0	3.7%	1.9
2018	4.2	57.5	9.5%	5.0
2019*	6.3	51.0	-3.7%	(2.0)
2020	5.6	59.0	10.5%	5.6
2021	5.6	59.5	10.5%	5.6
2022	1.4	57.5	5.9%	3.2
2023	1.4	61.0	11.4%	6.2

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Soybean Sulfur Trials in Sandy Loam ~2.5% OM

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Materials and Methods

- **Location:** 5 site-years (2018 to 2022), West Lafayette, IN
- **Soil**
  - Drummer (fine-silty, mixed, superactive, mesic Typic Endoaquolls)
  - OM: 3.8%, CEC: 24 cmolc/kg, pH 6.6, M3P: 25 mg/kg, M3K: 176 mg/kg
- **Design**: Two-way factorial
  - Whole-Plot Factor: Planting Date
  - Sub-Plot Factor: Fertility (nitrogen + sulfur)
  - Arranged in split-plot design with 5 reps

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		2018	2019†	2020	2021	2022
PLANTING						
	EARLY	11-May	11-Jun	12-May	14-May	12-May
	LATE	5-Jun	27-Jun	8-Jun	10-Jun	6-Jun

FERTILITY		SULFUR (S lb/ac	NITROGEN (N lb/ac)
UTC	Untreated	.	.
AMS	Ammonium sulfate	20	17.5
ATS	Ammonium thiosulfate	20	9.3
Gyp	Calcium sulfate	20	.
N + S	AMS or Gyp + Urea	20	40
Urea		.	40

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		2018	2019†	2020	2021	2022
PLANTING						
	EARLY	11-May	11-Jun	12-May	14-May	12-May
	LATE	5-Jun	27-Jun	8-Jun	10-Jun	6-Jun
FERTILITY‡						
	UTC	UTC	UTC	UTC	UTC	UTC
	AMS	AMS	AMS	AMS	AMS	AMS
	ATS	ATS	ATS	ATS	.	ATS
	Gypsum	.	.	Gyp	Gyp	Gyp
	N + S¶	N+S	N+S	N+S	N+S	N+S
	Urea	.	.	.	Urea	Urea

†Wet spring that severely delayed planting

‡Untreated (UTC), Ammonium Sulfate (AMS), Ammonium Thiosulfate (ATS)

Pelletized Gypsum (Gyp) applied prior emergence at 20 lb S/ac

¶N+S, Urea + AMS for 2018-2021, Urea + Gyp for 2022. N total was 40 lb N/ac

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EARLY Planting @ 23 West Lafayette

UTC R3 leaf S ~0.26% S
R3 leaf N:S 19:1

Sulfur R3 leaf S ~0.31% S
R3 leaf N:S 17:1

Picture taken August 30, 2023

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Yield (bu/ac)	2018	
Early Planting	11-May	
UTC	62.4	de
AMS	69.5	bc
ATS	71.5	abc
Gypsum	.	
N + S	74.2	ab
Urea	.	
Late Planting	5-Jun	
UTC	59.2	e
AMS	60.7	e
ATS	61.9	e
Gypsum	.	
N + S	62.8	de
Urea	.	

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Yield (bu/ac)	2018		2020	
Early Planting	11-May		12-May	
UTC	62.4	de	61.9	de
AMS	69.5	bc	79.8	a
ATS	71.5	abc	76.0	ab
Gypsum	.		75.2	abc
N + S	74.2	ab	82.6	a
Urea	.		.	
Late Planting	5-Jun		8-Jun	
UTC	59.2	e	61.9	de
AMS	60.7	e	68.6	bcd
ATS	61.9	e	66.1	de
Gypsum	.		66.7	cde
N + S	62.8	de	66.5	cde
Urea	.		.	.

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Yield (bu/ac)	2018		2020		2021	
Early Planting	11-May		12-May		14-May	
UTC	62.4	de	61.9	de	69.0	cde
AMS	69.5	bc	79.8	a	72.3	abcd
ATS	71.5	abc	76.0	ab	.	.
Gypsum	.		75.2	abc	76.9	a
N + S	74.2	ab	82.6	a	75.2	ab
Urea	.		.		67.3	def
Late Planting	5-Jun		8-Jun		10-Jun	
UTC	59.2	e	61.9	de	54.1	g
AMS	60.7	e	68.6	bcd	56.0	g
ATS	61.9	e	66.1	de	.	.
Gypsum	.		66.7	cde	55.4	g
N + S	62.8	de	66.5	cde	56.0	g
Urea	.		.	.	57.3	g

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Yield (bu/ac)	2018		2020		2021		2022	
Early Planting	11-May		12-May		14-May		12-May	
UTC	62.4	de	61.9	de	69.0	cde	61.8	def
AMS	69.5	bc	79.8	a	72.3	abcd	64.0	bcde
ATS	71.5	abc	76.0	ab	.	.	69.3	ab
Gypsum	.		75.2	abc	76.9	a	67.1	abcd
N + S	74.2	ab	82.6	a	75.2	ab	67.9	abc
Urea	.		.		67.3	def	64.4	bcde
Late Planting	5-Jun		8-Jun		10-Jun		6-Jun	
UTC	59.2	e	61.9	de	54.1	g	59.0	efg
AMS	60.7	e	68.6	bcd	56.0	g	61.4	def
ATS	61.9	e	66.1	de	.	.	53.4	g
Gypsum	.		66.7	cde	55.4	g	64.6	abcde
N + S	62.8	de	66.5	cde	56.0	g	65.3	abcd
Urea	.		.	.	57.3	g	63.9	bcde

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Yield (bu/ac)	2018		2020		2021		2022		Avg
Early Planting	11-May		12-May		14-May		12-May		EARLY
UTC	62.4	de	61.9	de	69.0	cde	61.8	def	63.8
AMS	69.5	bc	79.8	a	72.3	abcd	64.0	bcde	71.4
ATS	71.5	abc	76.0	ab	.	.	69.3	ab	72.3
Gypsum	.		75.2	abc	76.9	a	67.1	abcd	73.1
N + S	74.2	ab	82.6	a	75.2	ab	67.9	abc	75.0
Urea	.		.		67.3	def	64.4	bcde	65.9
Late Planting	5-Jun		8-Jun		10-Jun		6-Jun		LATE
UTC	59.2	e	61.9	de	54.1	g	59.0	efg	58.6
AMS	60.7	e	68.6	bcd	56.0	g	61.4	def	61.7
ATS	61.9	e	66.1	de	.	.	53.4	g	60.5
Gypsum	.		66.7	cde	55.4	g	64.6	abcde	62.2
N + S	62.8	de	66.5	cde	56.0	g	65.3	abcd	62.7
Urea	.		.	.	57.3	g	63.9	bcde	60.6

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Minimum Soil Temperature near Plantings

		2018	2020	2021	2022	Avg
Planting	Week	Minimum Soil Temp @ 4-in (F)				
Early	-1	58.5	47.3	48.2	59.0	53.2
Early	1	63.2	57.9	58.0	66.5	61.4
Early	2	63.4	63.7	65.0	66.4	64.6
Early	3	72.4	65.8	61.3	69.7	67.3
LATE	-1	68.3	69.5	70.5	71.1	69.8
LATE	1	69.1	69.4	72.1	70.7	70.3
LATE	2	73.2	72.3	71.3	76.7	73.4
LATE	3	70.8	70.4	74.8	76.2	73.0

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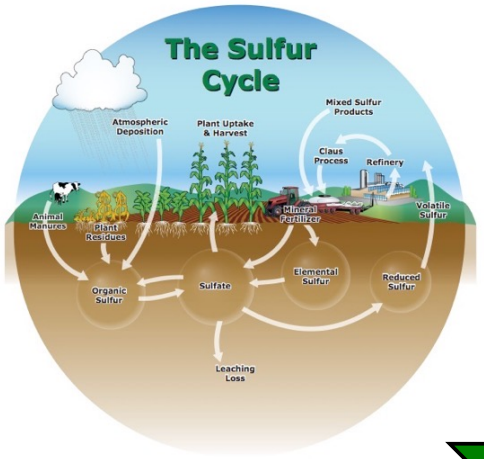

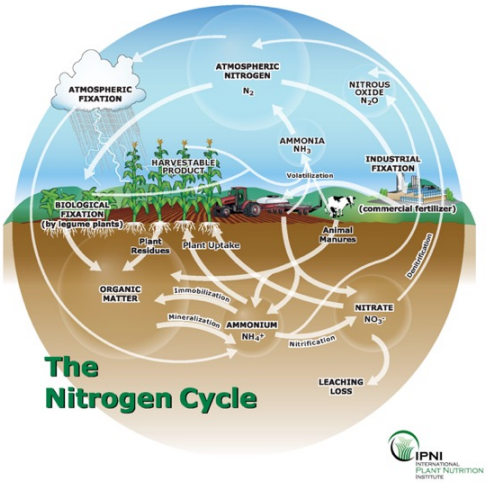

High Yielding Soybeans!

IPNI, 2013

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2023 S x Planting: Yield

Yield (bu/ac)	18-Apr		12-May		7-Jun	
UTC	77.5	de	75.4	def	66.6	g
AMS	98.8	a	90.6	b	71.9	efg
ATS	.		84.5	c	70.9	fg
Gypsum	98.9	a	90.5	b	69.0	g
N + S	101.1	a	92.9	b	72.1	efg
Urea	80.9	cd	77.8	d	68.4	g

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Sulfur Management Considerations

- **Timely planting is foundational** for high yielding soybeans; which seems to be intensified when coupled with PRE applications of N + S.
- **Field conditions** that affect S availability and nodulation + N fixation (soil temp, planting, residue)
- **Synergies** with baseline sulfur and R4 foliar protection seem to have connections to soil conditions (e.g., time of planting) **followed by leaf retention and pod protection for seed fill**

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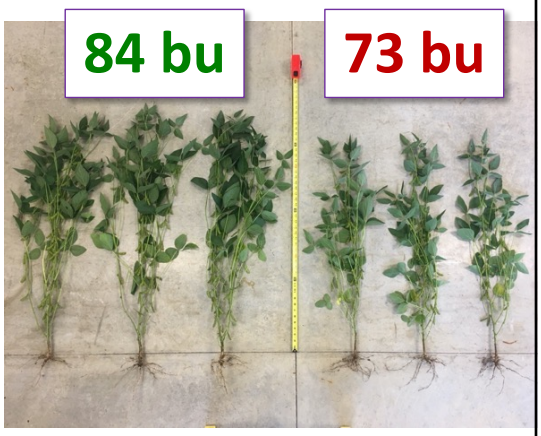
2022-23 Cereal Rye x NS in Soybean

- **2 x 4 Factorial** at field-scale
- **2 Cereal Rye** → Yes, No
- **4 NS Fertility**
  - None
  - Sulfur: 20 lb S/ac (pelletized Gypsum)
  - Nitrogen: 40 lb N/ac (Urea)
  - N+S: 40 lb N, 20 lb S
- **Terminate** ~12-16 inches (April-ish)
- **Indiana**: Columbia City, W. Lafayette, Butlerville
- **Illinois**: Effingham, Urbana



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23 Cereal Rye x NS: West Lafayette

April 18th
Terminate Cereal Rye

May 6th
Apply Fertilizer, Plant Soy

Sept 1st
Response of Soybean

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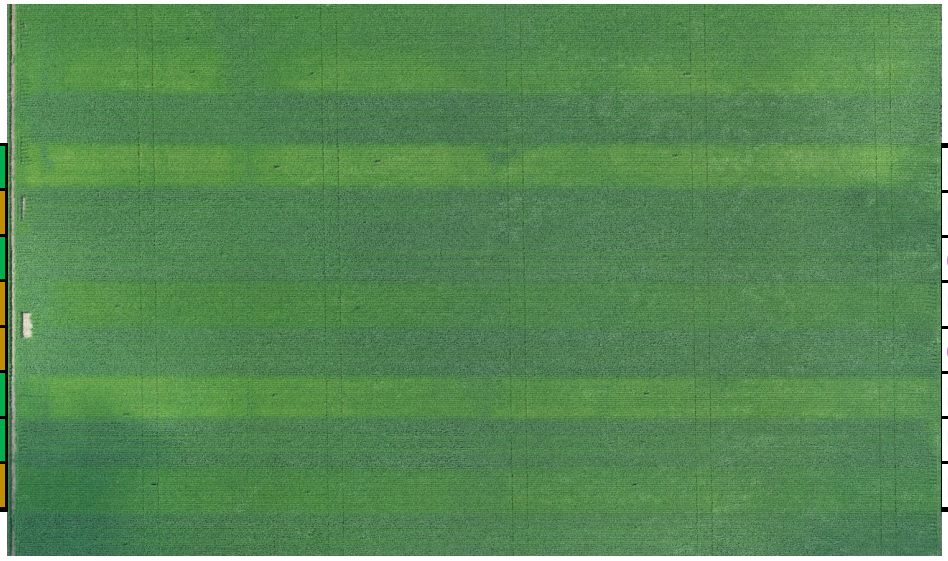
2023 Cereal Rye x NS: West Lafayette



Cereal Rye	Urea
No Cover	Urea + Gypsum
Cereal Rye	Gypsum
No Cover	Urea
No Cover	Gypsum
Cereal Rye	None
Cereal Rye	Urea + Gypsum
No Cover	None

W. Lafayette, Aug. 10, 2023

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Supplying Sulfur to Our Fields

- **~3-4 lb S/ac mineralized per 1% OM per year**
- **Plant Residue – Mineralized or Immobilized?**
  - **C:S Ratio < 200:1 → MINERALIZED SO_4-S**
  - **C:S Ratio > 400:1 → IMMOBILIZED SO_4-S**
  - Corn Stover ~350:1
  - Soybean Stover ~125:1
  - Wheat Straw ~300:1
  - Cover Crop? Other Factors?

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C. Rye x NS in Soybean: 23 West Lafayette

Cover Crop	Fertilizer	Yield (bu/ac)	
None	None	61.2	b
None	Urea	62.4	b
None	Gypsum	71.4	a
None	Urea + Gypsum	74.3	a
Cereal Rye	None	54.7	c
Cereal Rye	Urea	58.2	bc
Cereal Rye	Gypsum	71.0	a
Cereal Rye	Urea + Gypsum	74.8	a

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Sudden Death Syndrome

Fertilizer	Cover Crop	Sudden Death Syndrome					
		Severity (0-9)		Incidence (0-100%)		Disease Index	
None	None	1.6	2.3 a	37.5	47.5	6.8	12.6 a
None	Cereal Rye	2.9		57.5		18.4	
Urea	None	2.0	2.0 a	48.8	48.1	10.8	10.7 a
Urea	Cereal Rye	2.0		47.5		10.6	
Gypsum	None	1.0	1.0 b	27.5	38.8	3.1	3.6 b
Gypsum	Cereal Rye	1.0		37.5		4.2	
Urea + Gypsum	None	1.1	1.1 b	40.0	32.5	5.1	4.8 b
Urea + Gypsum	Cereal Rye	1.1		37.5		4.7	

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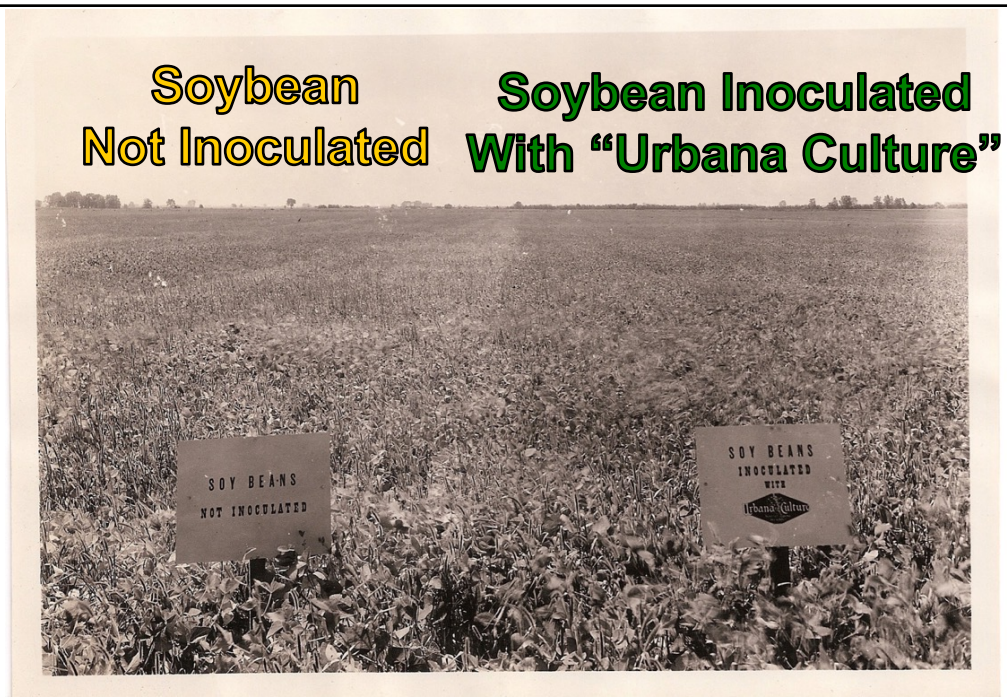
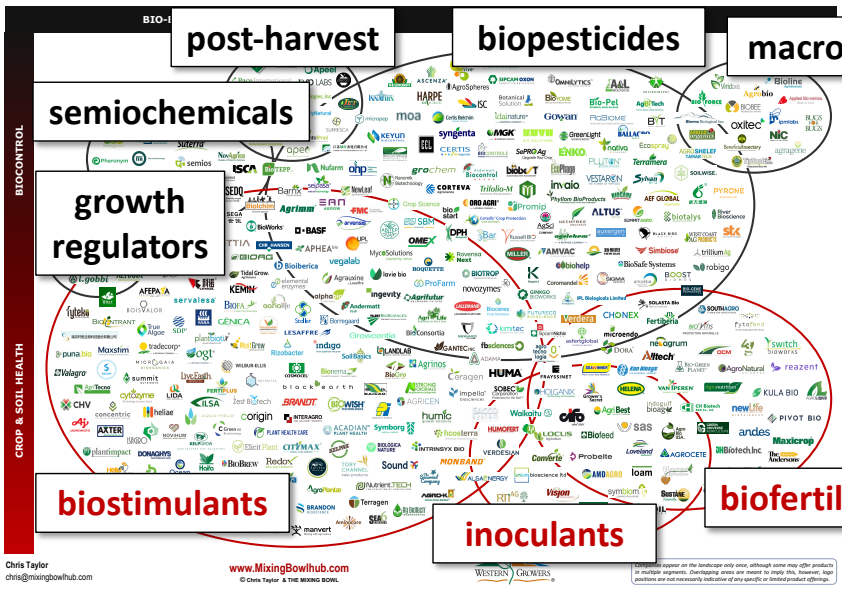


Bio-Based Substances | **Living Organisms**

Crop & Soil Health — **BioControl**



- 400 companies
- ½ in more than one segment
- 2/3 in biocontrol
- 2/3 in crop health
- 1/3 in biocontrol + crop health

https://mixingbowlhub.com/ag-biologicals-landscape-2023/

National Screen of Commercially Available Biological Seed Treatment for Soybean

SCIENCE FOR SUCCESS
FUNDED BY THE SOYBEAN CHECKOFF

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Results – Grain Yield

Analysis of variance (ANOVA) for treatment, location, and treatment x location interaction in 2022.

Source of variation	F-value	Prob > F
Treatment	1.02	0.4229
Location	109.46	<.0001
Treatment x Location	1.10	0.0985

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SCIENCE FOR SUCCESS

2022		
Treatment	W. Laf	Wanatah
UTC	64.8	55.3
BioBuild	62.9	56.1
SabrEx	62.0	55.6
GraphEx	64.1	53.9
Vault_IP	63.7	55.4
Bio_Yield_ST	63.9	55.1
Bio_Yield	63.5	54.4
LAL_Fix_Rise	65.1	54.7
Rise_Shine	63.4	54.4
Myco_Endo	65.7	55.6

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SCIENCE FOR SUCCESS

2022			2023		
Treatment	W. Laf	Wanatah	Treatment	W. Laf	Wanatah
UTC	64.8	55.3	UTC	70.3	76.0
BioBuild	62.9	56.1	BioBuild	68.8	76.7
SabrEx	62.0	55.6	SabrEx	73.7	76.9
GraphEx	64.1	53.9	GraphEx	71.0	77.9
Vault_IP	63.7	55.4	Vault_IP	72.1	77.0
Bio_Yield_ST	63.9	55.1	*Aveo*	71.4	79.0
Bio_Yield	63.5	54.4	*BioWake*	71.6	76.4
LAL_Fix_Rise	65.1	54.7	*Pro_Larise*	72.0	75.9
Rise_Shine	63.4	54.4	Rise_Shine	68.4	75.0
Myco_Endo	65.7	55.6	Myco_Endo	71.7	75.6

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SCIENCE FOR SUCCESS

2022			2023			2022-23
Treatment	W. Laf	Wanatah	Treatment	W. Laf	Wanatah	AVERAGE
UTC	64.8	55.3	UTC	70.3	76.0	67.5
BioBuild	62.9	56.1	BioBuild	68.8	76.7	65.8
SabrEx	62.0	55.6	SabrEx	73.7	76.9	67.8
GraphEx	64.1	53.9	GraphEx	71.0	77.9	67.5
Vault_IP	63.7	55.4	Vault_IP	72.1	77.0	67.9
Bio_Yield_ST	63.9	55.1	*Aveo*	71.4	79.0	.
Bio_Yield	63.5	54.4	*BioWake*	71.6	76.4	.
LAL_Fix_Rise	65.1	54.7	*Pro_Larise*	72.0	75.9	.
Rise_Shine	63.4	54.4	Rise_Shine	68.4	75.0	65.9
Myco_Endo	65.7	55.6	Myco_Endo	71.7	75.6	68.7

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Nutrient Influencing Biologicals

INDIANA SOYBEAN ALLIANCE

- **Nitrogen-Supplying Biologicals (non-rhizobial)** may fix or generate N.
- **Phosphorus Supply:** Biostimulants may provide enzymes (e.g., phosphatase that break and release phosphorus bound to organic matter). Solubilizers may solubilize P from soil minerals.
- **Humic/Fulvic Acids:** may chelate (acquire) cations in the soil to increase P and Zn availability. A general effect on soil and nutrient availability/access. Some may influence plants.
- **Marine Extracts:** may stimulate microbes, roots, and shoots (in general a plant effect).
- **Combinations:** may provide any of the previously mentioned effects depending on microbes in the mix.

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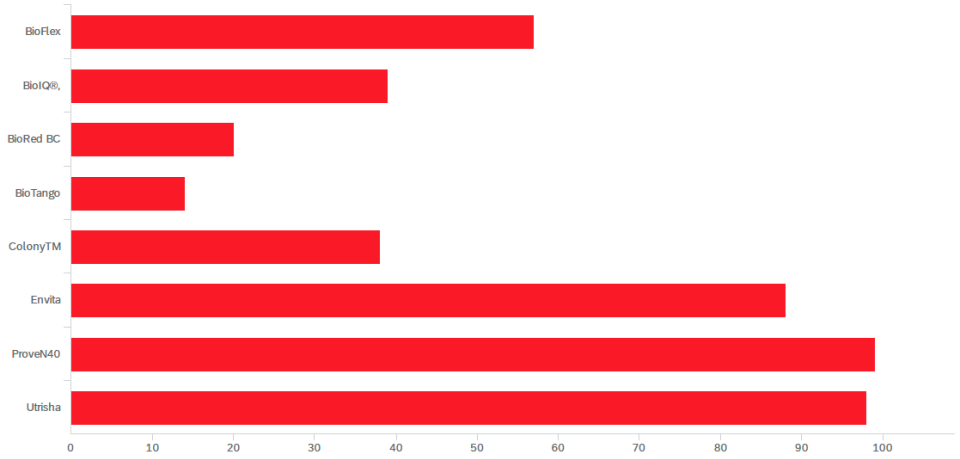
Nitrogen-Supplying Biologicals (non-rhizobial)



INDIANA SOYBEAN ALLIANCE

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Treatment	ACRE	Pinney	Average
UTC	74.2	80.9	77.6
Utrisha	71.7	83.8	77.8
Envita	70.9	84.3	77.6
Optimize	70.1	84.1	77.1
MegaPhos	74.2	81.4	77.8
Phosgard	75.7	82.0	78.9
Rootella	72.3	82.9	77.6
MegaFol	79.6	83.7	81.7
Maritime	72.7	80.3	76.5
QuickRoots	74.6	83.2	78.9
Accomp_Max	76.2	82.2	79.2
PhosN	73.8	81.5	77.6
Env_401	77.3	79.0	78.2
Ferti_Fulvic	73.1	79.7	76.4
Nutra	73.3	79.8	76.5
Hydra	70.3	79.3	74.8

2023 Bio Shotgun

INDIANA SOYBEAN ALLIANCE

- ACRE: NS, CV 8.8%
- Pinney Sand: NS, CV 4.5%

Nitrogen Supply: -4.1 to 3.4 bu

Phosphorus Supply: -1.9 to 2.0 bu

Humic/Fulvic Acids: -3.9 to -1.1 bu

Marine Extracts: -1.5 to 5.4 bu

Combinations: -0.4 to 2.3 bu

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Bio N Supplier x Fertility

- **Three non-rhizobial N supplying biologicals:**
  - Untreated
  - Envita (Azotic): *Gluconacetobacter diazotrophicus*
  - Utrisha (Corteva): *Methylobacterium symbioticum*
- **Four fertility regimes:**
  - Unfertilized
  - N → 40 lb N/ac from Urea (46-0-0)
  - S → 20 lb S/ac from pelletized gypsum (0-0-0-17S)
  - N+S → 40 lb N/ac + 20 lb S/ac (urea + pelletized gypsum)

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23 Bio N Supplier x Fertility: W. Laf

Bio N: none to ~4 bu

Fertility	No Bio		Envita		Utrisha	
None	75.0	c	74.1	c	80.5	b
Nitrogen	77.4	bc	81.2	b	78.2	bc
Sulfur	88.0	a	88.7	a	87.7	a
Nitrogen + Sulfur	90.4	a	91.0	a	89.7	a

Sulfur: +13 bu

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23 Bio N Supplier x Fertility: Wanatah

Fertility	No Bio	Envita	Utrisha
None	82.5	82.7	81.6
Nitrogen	79.5	79.5	82.6
Sulfur	82.7	76.1	78.0
Nitrogen + Sulfur	81.2	79.7	80.0

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23 Bio N Supplier x Fertility: LaCrosse

Fertility	No Bio		Envita		Utrisha	
None	49.3	c	53.2	bc	53.0	bc
Nitrogen	53.7	bc	48.8	c	49.5	c
Sulfur	58.4	ab	57.5	ab	51.3	c
Nitrogen + Sulfur	58.5	ab	59.5	a	61.9	a

Sulfur: +9 bu

LSD0.05, CV(%) 8.3

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Bio N Supplier x R4 Protect

- **Three non-rhizobial N supplying biologicals:**
  - Untreated
  - Envita (Azotic): *Gluconacetobacter diazotrophicus*
  - Utrisha (Corteva): *Methylobacterium symbioticum*
- **Two fertility regimes:**
  - Unfertilized
  - S → 20 lb S/ac from pelletized gypsum (0-0-0-17S)
- **Two foliar protection regimes:**
  - None
  - R4 application of fungicide and insecticide (Revytek + Fastac)

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23 Bio N Supplier x R4 Protect: W. Laf

	Untreated		R4 Protect	
None	77.4	d	78.3	d
Envita	80.6	cd	82.5	bcd
Utrisha	79.2	d	81.5	cd
Gyp	85.4	abc	88.2	a
Gyp_Envita	85.9	abc	87.5	ab
Gyp_Utrisha	84.7	abc	87.6	ab

- **Bio N: NS**
- **R4 Protect: NS**
- **Gypsum: +8 bu**
- **Gyp + R4 Protect: highest yields**

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QUESTIONS?

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