Bio-what? Biostimulants, Biologicals, Biofertilizers: Reviewing the Market and Tips to Their Use

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2015:
"we got a little 'ole convoy"

2019:
"we got a great big convoy"

2021:
"we got a mighty convoy"

2023:
"we crashed the gate doin' 98…"

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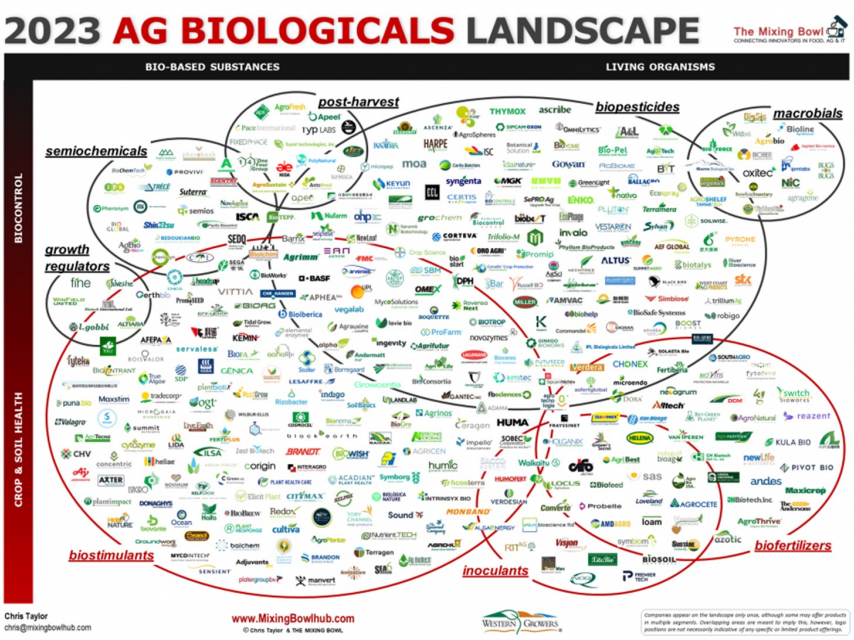

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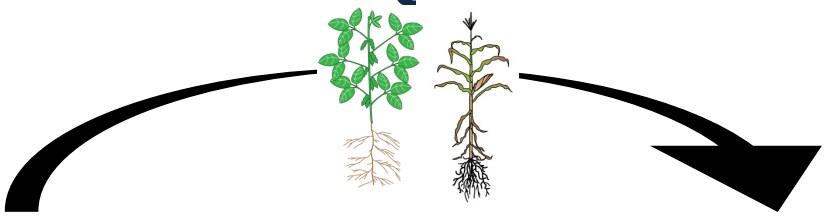
What is Driving the Convoy?



There is a New Shift to Biology Based Systems > Chemical Based

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Last 11 Years of Biostimulant/Biological Trials

Year	Corn	Soybean
	Number of Trials	
2014	6	6
2015	10	6
2016	9	5
2017	10	7
2018	11	11
2019	13	7
2020	28	11
2021	23	7
2022	26	5
2023	26	9
2024	28	12

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What is the right terminology?

Biostimulants

or…

Biologicals?

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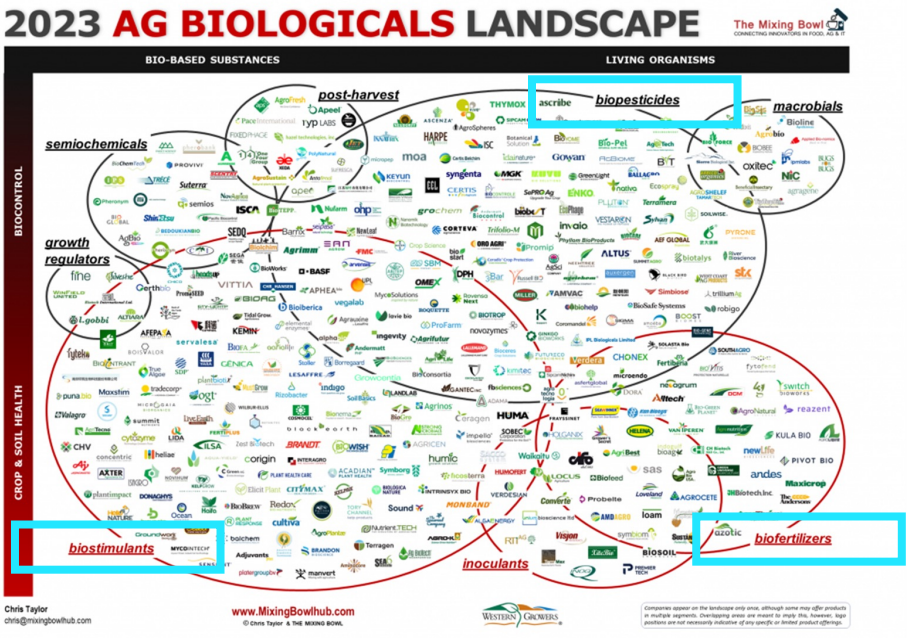
Biologicals:

The term "biologicals" is not currently defined, but generally has been used by AAPFCO, BPIA, and others to collectively refer to biostimulants, biopesticides, and biofertilizers



How do we define biostimulants?

- **2018 Farm Bill: First Mention of "Plant Biostimulant"**

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How do we define biostimulants?

"…a substance or microorganism that, when applied to seeds, plants, or the rhizosphere, stimulates natural processes to enhance or benefit nutrient uptake, nutrient efficiency, tolerance to abiotic stress, or crop quality and yield" – 2018 Farm Bill

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Biostimulant Sub-Categories

- Nitrogen-Fixing Bacteria
- P-Solubilizing Microbes
- Mycorrhizal Fungi
- Residue Degradation

Microbes

- Enzymes (Phosphatases)
- Humic/Fulvic Acids
- Marine Extracts
- Sugars

Substances

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How do we define biostimulants?

- **2018 Farm Bill: First Mention of "Plant Biostimulant"**
- **Plant Biostimulant Act of 2023: Tried to amend FIFRA, never enacted**
- **Plant Biostimulant Act of 2025: Latest attempt to update regulation (May 22nd)**

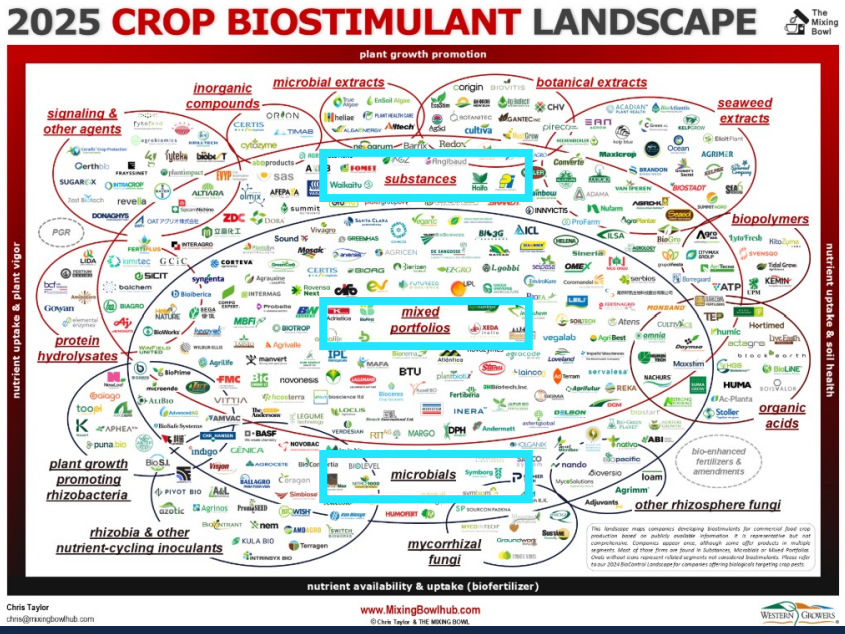
2025 Plant Biostimulant Act (proposed May 22nd, not yet enacted)

"…a substance, microorganism, or mixture thereof, that, when applied to seeds, plants, the rhizosphere, soil, or other growth media, acts to support a plant's natural processes independently of the nutrient content of that substance, microorganism, or mixture thereof, and that thereby improves-

(1) Nutrient availability, uptake, or use efficiency;

(2) Tolerance to abiotic stress; and

(3) Consequent growth, development, quality, or yield.



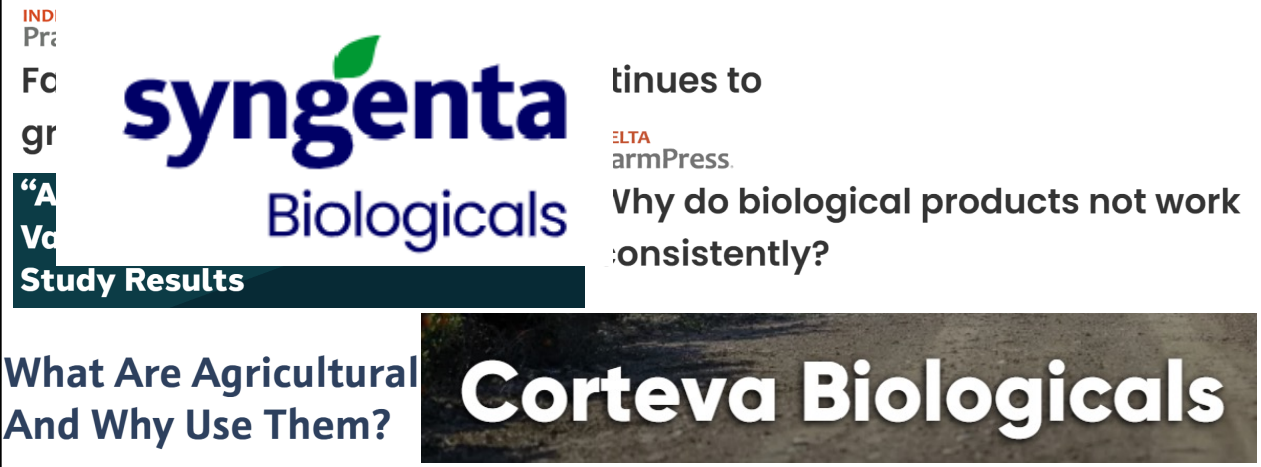
Prior to Understanding BioProducts

After Understanding BioProducts

Following regulatory approach, academics utilize the biostimulant term

So, where is the "biological" terminology?

Enter Biologicals…



What is the right terminology?

Biostimulants

or…

Biologicals?

What is the right terminology?

Biostimulants – Term used in regulatory and by academics in peer-review literature

Biologicals – Term adopted by industry and farmers

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What is the right terminology?

Biostimulants – Non-microbials…

Biologicals – Microbials…

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Last 11 Years of Biostimulant/Biological Trials

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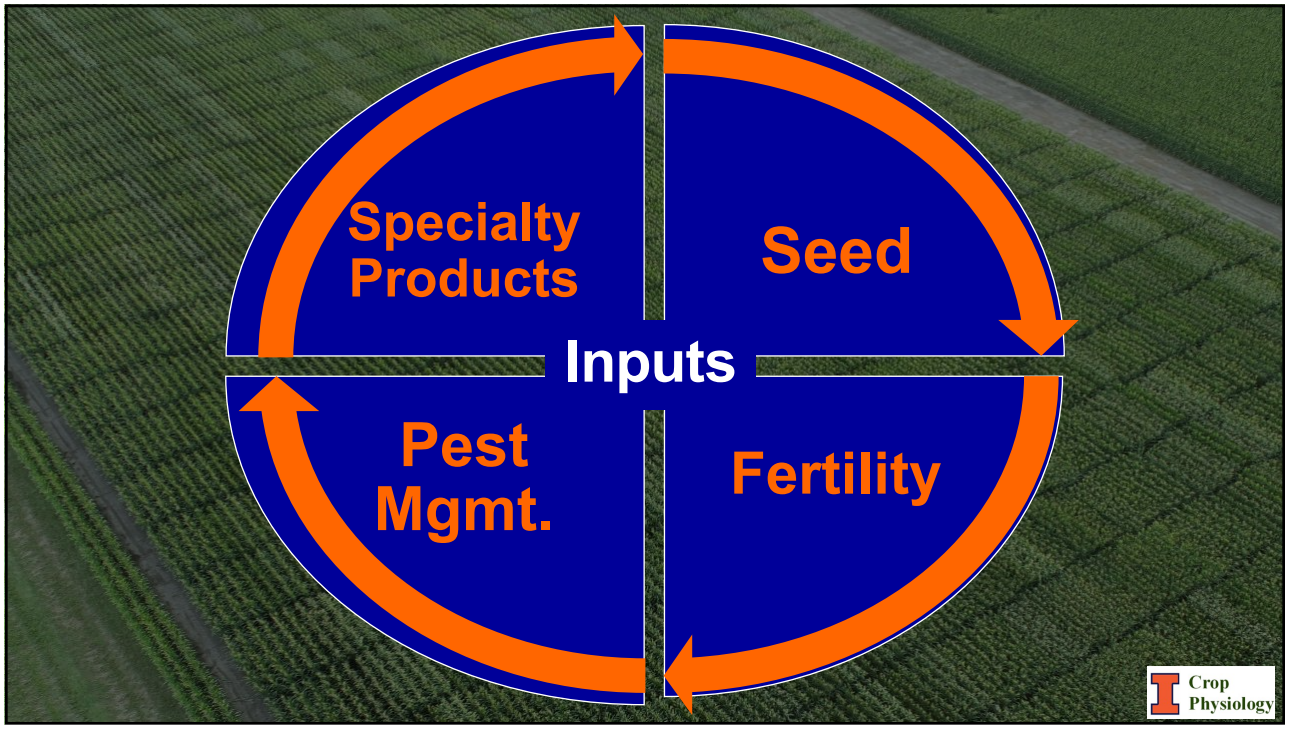

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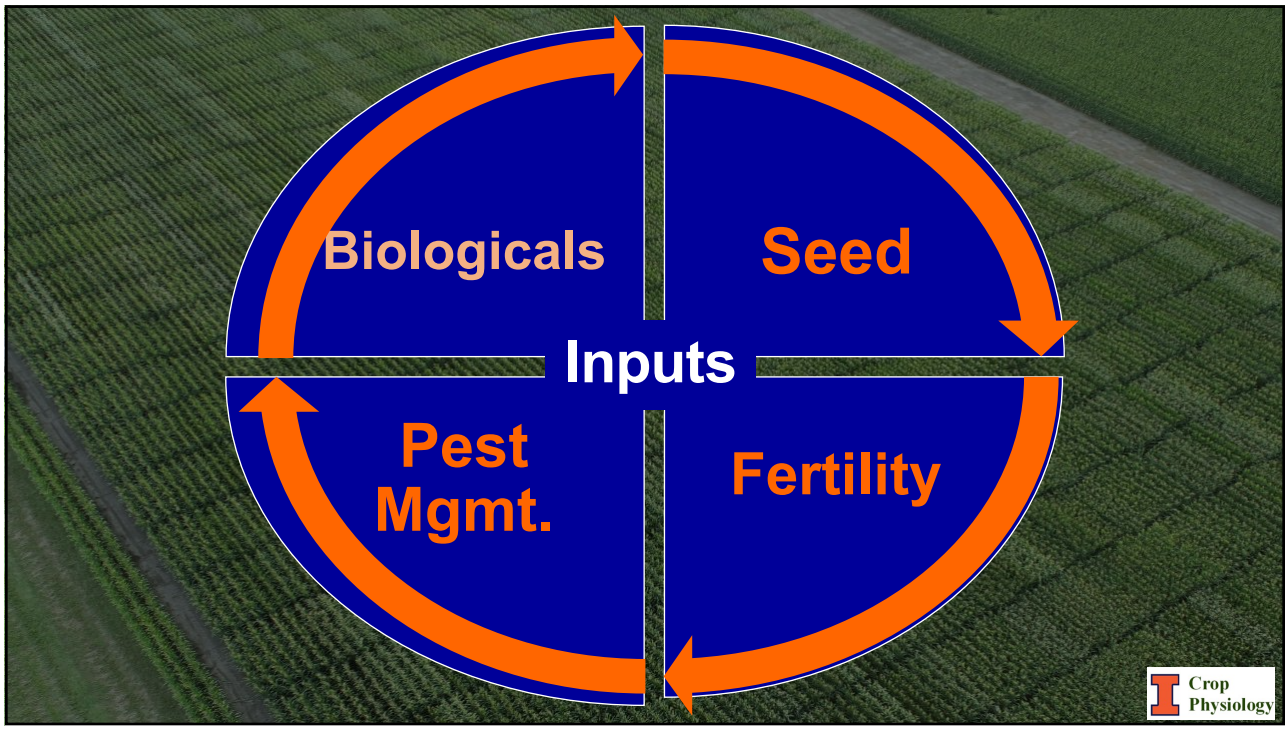

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Recommendation #1

Ensure the basics are covered!

Biologicals are a next step input, not a replacement for good agronomic management.

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What are we using?

- **Beneficial Microbes**

"The Living"

- **Biostimulants**

"The Dead"

Recommendation #2

Know if your is product alive or dead.

Some products require a commitment to ensure they remain viable from delivery to application.

What are Biologicals?

•Beneficial Microbes

"The Living"

Microbial Species †	%‡	Microbial Species (cont)	%	Microbial Species (cont.)	%
Bacillus amyloliquefaciens	26.5	*Brevibacillus laterosporus*	1.8	*Lactobacillus acidophilus*	0.9
Bacillus licheniformis	23.9	*Cellulomonas cellasea*	1.8	*Lactobacillus bulgaricus*	0.9
Bacillus megaterium	21.2	*Clostridium pasteurianum*	1.8	*Lactobacillus casei*	0.9
Bradyrhizobium japonicum	20.4	*Curtobacterium salicis*	1.8	*Lactobacillus delbrueckii*	0.9
Bacillus subtilis	19.5	*Delftia acidovorans*	1.8	*Lactobacillus diacetylactis*	0.9
Bacillus pumilus	15.9	*Gluconacetobacter diazotrophicus*	1.8	*Lactobacillus fermentum*	0.9
Azospirillum brasiliense	14.2	*Klebsiella variicola*	1.8	*Lactobacillus lactis §*	0.9
Trichoderma harzianum	13.3	*Methylobacterium gregans*	1.8	*Lactobacillus plantarum*	0.9
Azotobacter chroococcum	9.7	*Methylobacterium hispanicum*	1.8	*Laticaseibacillus manihotivorans*	0.9
Azotobacter vinelandii	9.7	*Pantoea eucalypti*	1.8	*Laticaseibacillus rhamnosus*	0.9
Glomus intraradices	7.1	*Penicillium bilaiae*	1.8	*Lentilactobacillus parakefiri*	0.9
Azospirillum lipoferum	6.2	*Phanerochaete chrysosporium*	1.8	*Levilactobacillus acidifarinae*	0.9
Pseudomonas xanthomarina	2.7	*Coniochaeta nivea*	0.9	*Saccharomyces pastorianus*	0.9
Rhizobium leguminosarum	2.7	*Ensifer meliloti*	0.9	*Sporolactobacillus inulinus*	0.9
Rhizophagus irregularis	2.7	*Flavobacterium spp*	0.9	*Sporolactobacillus putidus*	0.9
Thiobacillus sulfooxidans	2.7	*Funneliformis mosseae*	0.9	*Streptococcus thermophilus*	0.9
Trichoderma afroharzianum	2.7	*Geobacillus thermodenitrificans*	0.9	*Streptomyces gelaticus*	0.9
Wickerhamomyces anomalus	2.7	*Gluconacetobacter rhaeticusi*	0.9	*Streptomyces ghanaensis*	0.9
Acetobacter diazotrophicus	1.8	*Janthinobacterium lividum*	0.9	*Streptomyces violascens*	0.9
Aspergillus niger	1.8	*Klebsiella aerogenes*	0.9	*Trichoderma hypocrea lixii*	0.9
Bacillus macerans	1.8	*Kosakonia sacchari*	0.9	*Trichoderma koningii*	0.9
Bacillus methylotrophicus	1.8	*Lactiplantibacillus pentosus*	0.9	*Xanthobacter autotrophicus*	0.9
Bacillus nitrophilus	1.8	*Lactiplantibacillus plantarum*	0.9		
Bacillus piscicola	1.8	*Lactobacillus acidifarinae*	0.9		

139 unique microbial species (active ingredients) surveyed from 155 products

Top Ten Species Listed on Label among 155 Products

26.5% ***Bacillus amyloliquefaciens***	*15.9%* ***Bacillus pumilus***
23.9% ***Bacillus licheniformis***	*14.2%* ***Azospirillum brasiliense***
21.2% ***Bacillus megaterium***	*13.3%* ***Trichoderma harzianum***
20.4% ***Bradyrhizobium japonicum***	*9.7%* ***Azotobacter chroococcum***
19.5% ***Bacillus subtilus***	*9.7%* ***Azotobacter vinelandii***

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Biological Sub-Categories

- Nitrogen-Fixing Bacteria
- P-Solubilizing Microbes
- Mycorrhizal Fungi
- Residue Degradation

Beneficial Microbes

- Enzymes (Phosphatases)
- Humic/Fulvic Acids
- Marine Extracts
- Sugars

Biostimulants

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Biological Sub-Categories

- Nitrogen-Fixing Bacteria – Increase Plant Available N
- P-Solubilizing Microbes
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Nitrogen-Fixing Bacteria

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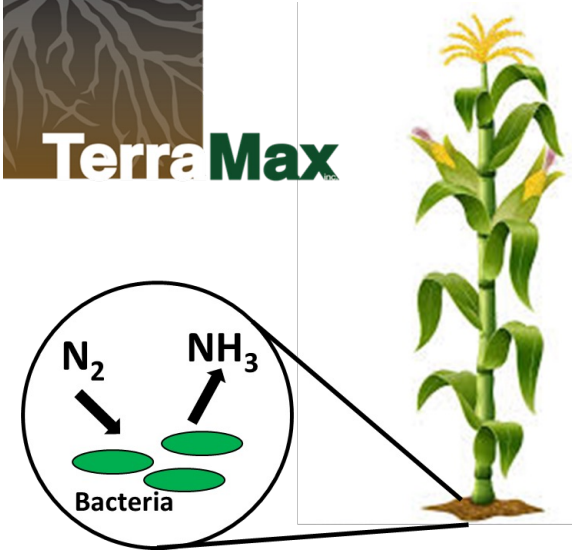
PIVOT BIO PROVEN

TerraMax

envita

Utrisha™ N



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Recommendation #3

Know what biological you are working with.

Go beyond the general category, know some specifics. How does this product differ from others like it?

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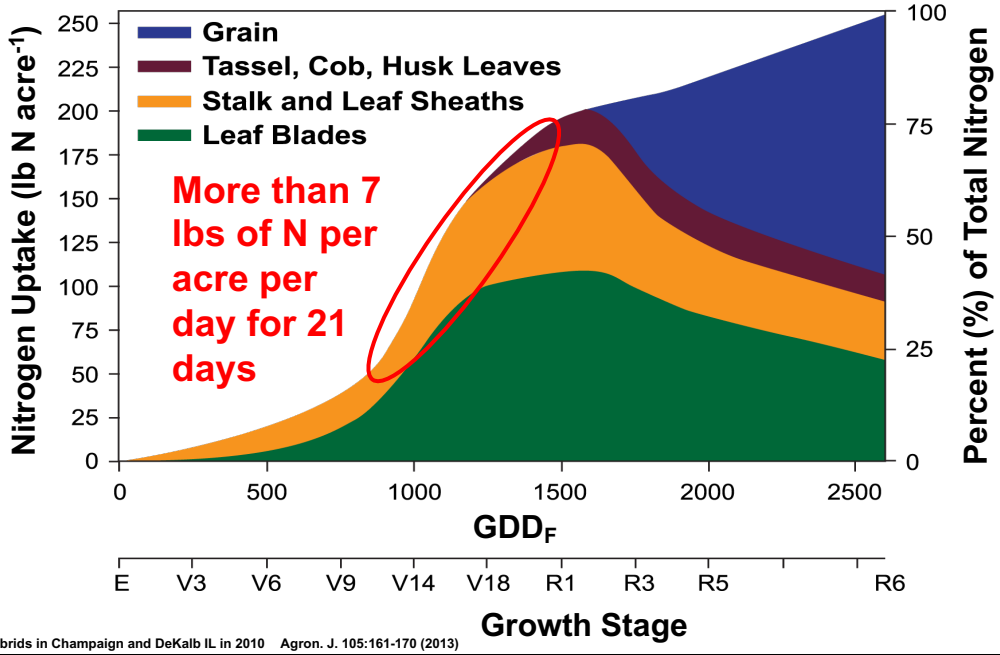
Nitrogen Uptake and Partitioning for 230 Bushel Corn



Average of 6 hybrids in Champaign and DeKalb IL in 2010 Agron. J. 105:161-170 (2013)

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Recommendation #4

Today's N-Fixing inoculants are a third source of N, helping to supplement when the soil or the supplied N falls short.

Cutting N rate too much may limit final yield potential.

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Biological Sub-Categories

- Nitrogen-Fixing Bacteria – Increase Plant Available N
- P-Solubilizing Microbes – Increase Availability of Mineral P
- Mycorrhizal Fungi
- Residue Degradation
- Enzymes (Phosphatases)
- Humic/Fulvic Acids
- Marine Extracts
- Sugars

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Phosphorus-Solubilizing Bacteria

Or rather than release soil P, does chelating cations prevent fertilizer-P tie-up?

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Key Takeaways – PSB

- In-furrow applied PSB has resulted in the greatest yield benefit (need to optimize biological placement)
- Optimization of grain yield with PSB relies on adequate soil contact near the growing root
- Crop Physiology studies show PSB better when supplied with P fertilizer, increasing efficiency of applied P, rather than try to release soil P

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Recommendation #5

Biologicals that influence P availability need proper placement near the root.

Available P may quickly be bound back to the soil system, whereas proximity to root increases chance of uptake.

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Biological Sub-Categories

- Nitrogen-Fixing Bacteria – Increase Plant Available N
- P-Solubilizing Microbes – Increase Availability of Mineral P
- Mycorrhizal Fungi – Extension of the Root System
- Residue Degradation
- Enzymes (Phosphatases)
- Humic/Fulvic Acids
- Marine Extracts
- Sugars

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Key Takeaways – AMF

- Seed inoculation of AMF provides the biological with the greatest potential of success by placing the product as close to the seedling as possible
- Hyphae explore the soil system. Practices like in-season coulter side-dress or manual weed cultivation may disrupt fungal network, reducing efficacy

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Biological Sub-Categories

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- Marine Extracts
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Where does residue come from?

Cover Crops (cereal rye)	Double Crops	Higher Yields

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Common C:N Ratios

Residue	C:N Ratio	
Rye Straw	82:1	Induces N immobilization
Wheat Straw	80:1	
Corn Stover	57:1	
Rye Cover Crop (vegetative)	26:1	
Alfalfa	25:1	
Clover	20:1	Induces N mineralization
Hairy Vetch	11:1	
Soil Microorganisms	8:1	

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Can multiple approaches to crop residue management be synergistic?

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Where does residue come from?

Cover Crops (cereal rye)

Double Crops

Higher Yields

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Cover Crop Treatment Table

Cover Crop		Sulfur		Biological
None	X	None	X	None
				Residuce Complete
Cereal Rye		ATS		NeoVita43 + Hydra-Hume

ATS; ammonium thiosulfate applied at 7 gal/acre to supply 20 lb S/acre

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Common C:N Ratios

Residue	C:N Ratio
Rye Straw	82:1
Wheat Straw	80:1
Corn Stover	57:1

Induces N immobilization

Corn Stalks Can Have a Carbon to Sulfur Ratio of ~350:1

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Active Ingredients

Living (Residuce Complete)	Non-Living (NeoVita43 + Hydra-Hume)
Bacillus amyloliquefaciens *Bacillus licheniformis* *Bacillus megaterium* *Bacillus pumilus* *Bacillus coagulans* *Phanerochaete chrysosporium* *Trichoderma harzianum*	**Sugar** **+** **Humic Acid**

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2023-2025 Grain Yields

Treatment	Grain Yield		
	23' Soy	24' Corn	25' Soy
	bushels/acre		
UTC	87	262	76
Cover Crop			
+ Residuce Complete			
+ NeoVita 43 & Hydra-Hume			
+ ATS			
+ ATS + Residuce Complete			
+ ATS + NeoVita 43 & Hydra-Hume			
LSD (.05)			

ATS; ammonium thiosulfate applied at 7 gal/acre to supply 20 lb S/acre

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2023-2025 Grain Yields

Treatment	Grain Yield		
	23' Soy	24' Corn	25' Soy
	bushels/acre		
UTC	87	262	76
Cover Crop	81 -6	254 -8	75 -1
+ Residuce Complete			
+ NeoVita 43 & Hydra-Hume			
+ ATS			
+ ATS + Residuce Complete			
+ ATS + NeoVita 43 & Hydra-Hume			
LSD (.05)	4	8	NS

ATS; ammonium thiosulfate applied at 7 gal/acre to supply 20 lb S/acre

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2023-2025 Grain Yields

Treatment	Grain Yield		
	23' Soy	24' Corn	25' Soy
	bushels/acre		
UTC	87	262	76
Cover Crop	81 -6	254 -8	75 -1
+ Residuce Complete	83 +2	254 ±0	76 +1
+ NeoVita 43 & Hydra-Hume	81 ±0	256 +2	74 -1
+ ATS	87 +6	257 +3	77 +2
+ ATS + Residuce Complete			
+ ATS + NeoVita 43 & Hydra-Hume			
LSD (.05)	4	8	NS

ATS; ammonium thiosulfate applied at 7 gal/acre to supply 20 lb S/acre

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2023-2025 Grain Yields

Treatment	Grain Yield		
	23' Soy	24' Corn	25' Soy
	bushels/acre		
UTC	87	262	76
Cover Crop	81 -6	254 -8	75 -1
+ Residuce Complete	83 +2	254 ±0	76 +1
+ NeoVita 43 & Hydra-Hume	81 ±0	256 +2	74 -1
+ ATS	87 +6	257 +3	77 +2
+ ATS + Residuce Complete	87 +6	261 +7	78 +3
+ ATS + NeoVita 43 & Hydra-Hume	87 +6	264 +10	79 +4
LSD (.05)	4	8	NS

ATS; ammonium thiosulfate applied at 7 gal/acre to supply 20 lb S/acre

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Recommendation #6

Biologicals for residue management have an uphill battle against carbon…

Pairing residue biologicals with N/S fertility provides the needed tools. Biologicals are for a system approach

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Spray Conditions

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Recommendation #7

Biologicals for residue management need time to work into the residues.

Spray on a cloudy day or in the evening to let an overnight dew work the microbes into the residue/soil.

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Biological Sub-Categories

- Nitrogen-Fixing Bacteria – Increase Plant Available N
- P-Solubilizing Microbes – Increase Availability of Mineral P
- Mycorrhizal Fungi – Extension of the Root System
- Residue Degradation – Enhance Release of Organic Nutrients
- Enzymes (Phosphatases) – Release Organic P
- Humic/Fulvic Acids
- Marine Extracts
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- Enzymes (Phosphatases) – Release Organic P
- Humic/Fulvic Acids – Chelate Soil Cations and Feed Microbes
- Marine Extracts
- Sugars

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Key Takeaways – Humic/Fulvic Acids

- Humic/Fulvic acids come in all shapes, sizes, colors, liquid, dry, etc…
- Depending upon which product you use and how it is placed determines the fit for you
- Bulk dry as a soil amendment?
- Dry powder as a fertilizer coating?
- Liquid in-furrow as a root stimulant?

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2020-2022 Carbon Study

Treatment	Grain Yield			
	2020	2021	2022	Avg.
	bushels/acre			
Untreated Control				
Preplant Soil Broadcast Molasses Extract				
Preplant Soil Broadcast Humic Acid				
In-Furrow Molasses Extract				
In-Furrow Humic Acid				
LSD (.05)				

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2020-2022 Soybean Yields

Treatment	Grain Yield			
	2020	2021	2022	Avg.
	bushels/acre			
Untreated Control	53.5	82.9	80.5	72.3
Preplant Soil Broadcast Molasses Extract	+1.9	-0.3	-0.2	+0.3
Preplant Soil Broadcast Humic Acid	+0.7	0.0	0.0	+0.3
In-Furrow Molasses Extract	-0.7	-3.6	-0.7	-1.7
In-Furrow Humic Acid	+0.9	-1.7	+0.5	-0.2
LSD (.05)	NS	NS	NS	NS

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2020-2022 Corn Yields

Treatment	Grain Yield			
	2020	2021	2022	Avg.
	bushels/acre			
Untreated Control	181	241	258	226
Preplant Soil Broadcast Molasses Extract	-2	-6	+4	-2
Preplant Soil Broadcast Humic Acid	+2	+4	+8	+6
In-Furrow Molasses Extract	+6	+4	+11	+8
In-Furrow Humic Acid	+4	+6	+8	+6
LSD (.05)	NS	NS	NS	3

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Recommendation #8

Biologicals are more consistent when supplied to corn vs. soybean

Corn makes yield decisions at key growth stages, whereas soybean makes yield decisions everyday.

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Biological Sub-Categories

- **Nitrogen-Fixing Bacteria –** Increase Plant Available N
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- **Mycorrhizal Fungi –** Extension of the Root System
- **Residue Degradation –** Enhance Release of Organic Nutrients
- **Enzymes (Phosphatases) –** Release Organic P
- **Humic/Fulvic Acids –** Chelate Soil Cations and Feed Microbes
- **Marine Extracts –** Foliar: Stress Mitigation, Soil: Enhance Root Zone
- **Sugars**

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Marine Extracts - General

- Marine Extracts are complex blends of metabolites providing versatility in their use
- When foliar applied they can mitigate drought stress by regulating water use of the crop
- Soil applications promote root growth and soil microbial activity for an improved rhizosphere

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- Enzymes (Phosphatases) – Release Organic P
- Humic/Fulvic Acids – Chelate Soil Cations and Feed Microbes
- Marine Extracts – Foliar: Stress Mitigation, Soil: Enhance Root Zone
- Sugars – Soil: Stimulate Microbes/Roots, Foliar: Stress??

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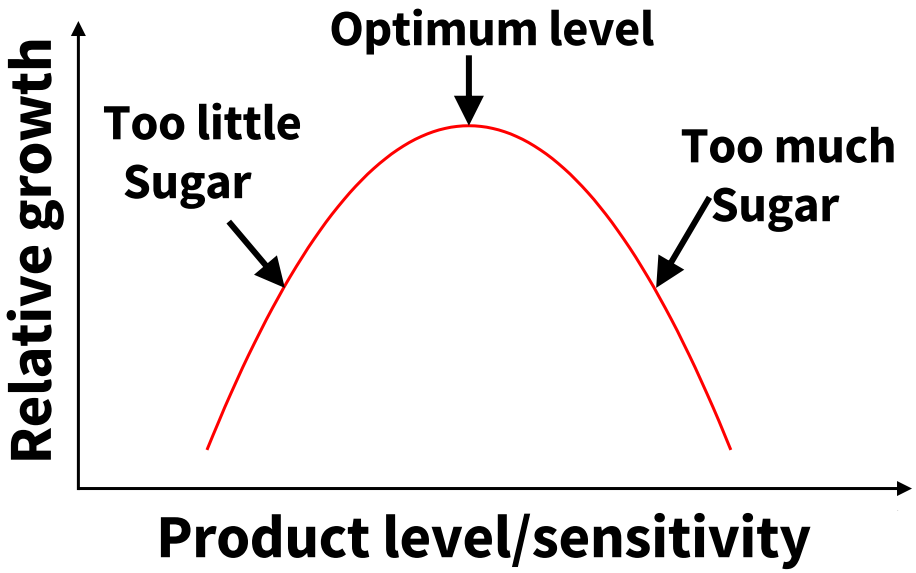
Plant Response to Foliar Products



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Recommendation #9

Stress mitigating biostimulant applications need to be proactive, not reactive.

The crop needs time to build the defense so it is able to tolerate the stress when it arrives.

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In Summary

- **Biologicals are Expanding Rapidly**
  - **Farmer Adoption and Product Options**
- **These products are a next step input**
  - **They won't fix the major challenges**
  - **Consider how to fit them into your existing management, do not let them replace good practices**
  - **Know what that microbe does, fit accordingly**

Thank You to Indiana CCA!

More info at:

Crop Physiology Laboratory

University of Illinois

http://cropphysiology.cropsci.illinois.edu

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