Delivery of Biological Products: Meeting the Challenge

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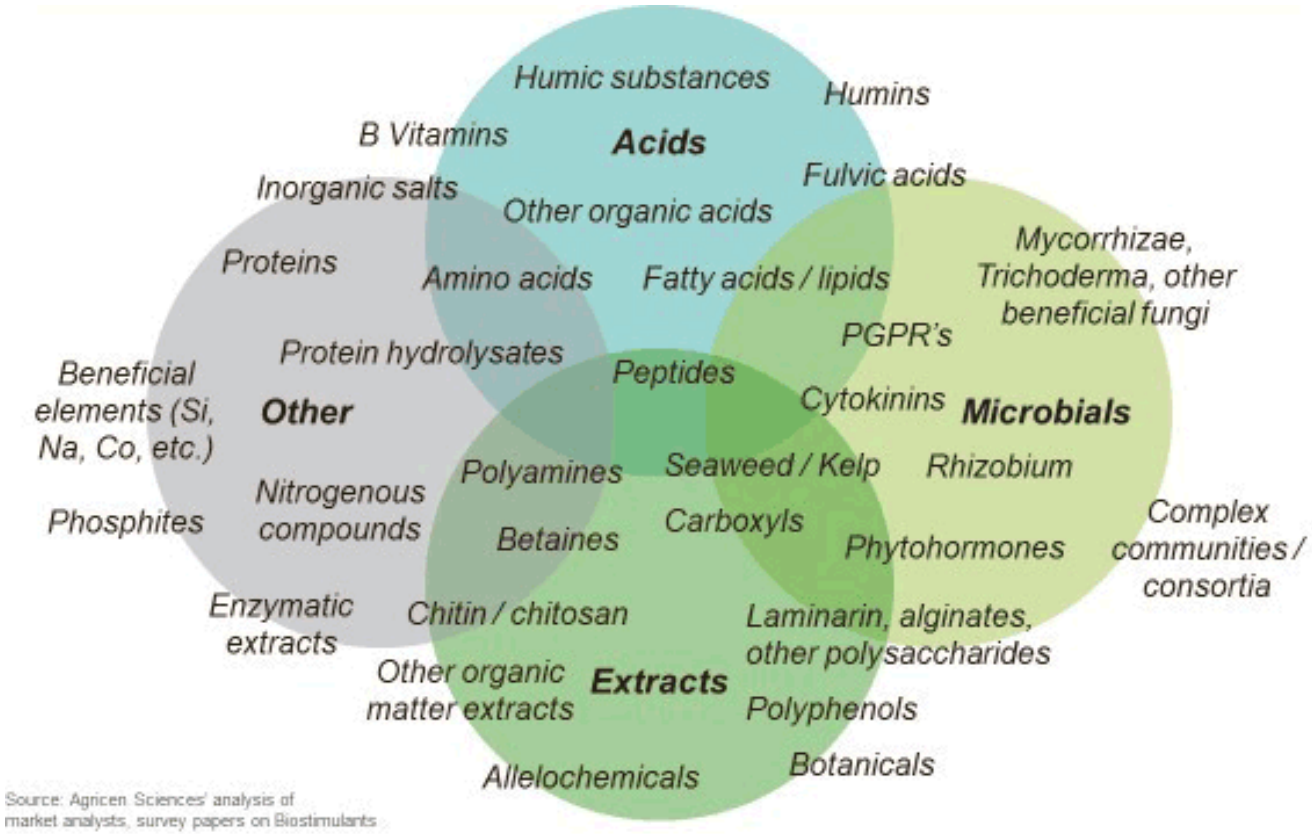
Science. *Nature.* Yield.

Company Summary

- Based in Columbus, OH
- Founded November 2013
- Licensed technology from The Ohio State University
- Novel microbial inoculant delivery system
- Funding $3M from grants and seed round investment

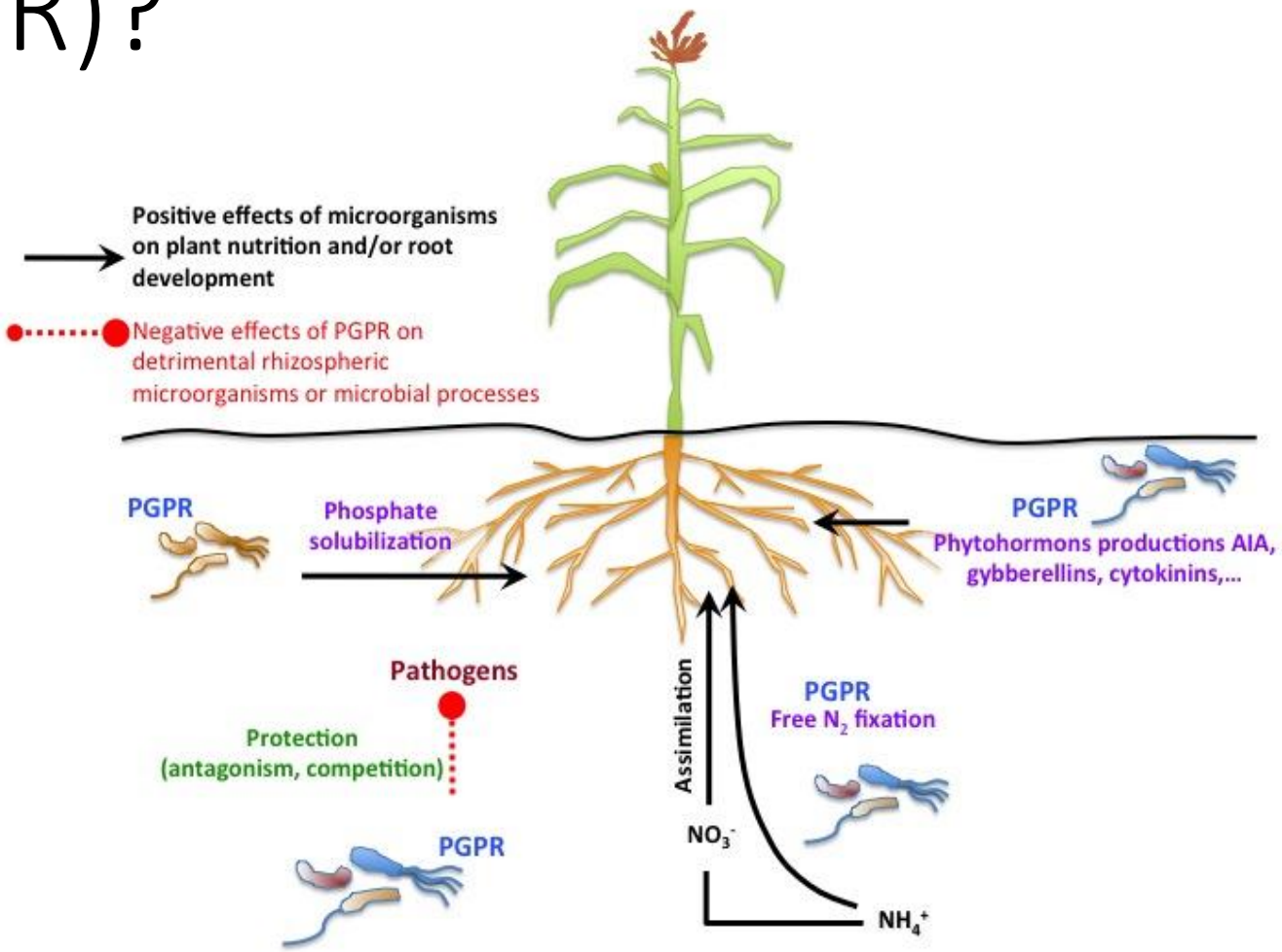
What are biofertilizers?

- **Microbial Biostimulant:** Main active ingredient is a microorganism (bacteria, fungi) that promotes plant growth by one of more mechanisms.
- **Microbial Biofertilizers:** Subset of Microbial Biostimulants, promotes plant growth by increasing the supply and/or availability of nutrients to plants.
- **Microbial Biopesticide:** Contains living or dormant microorganisms which have the capacity to control pests and pathogens; US EPA registered products.



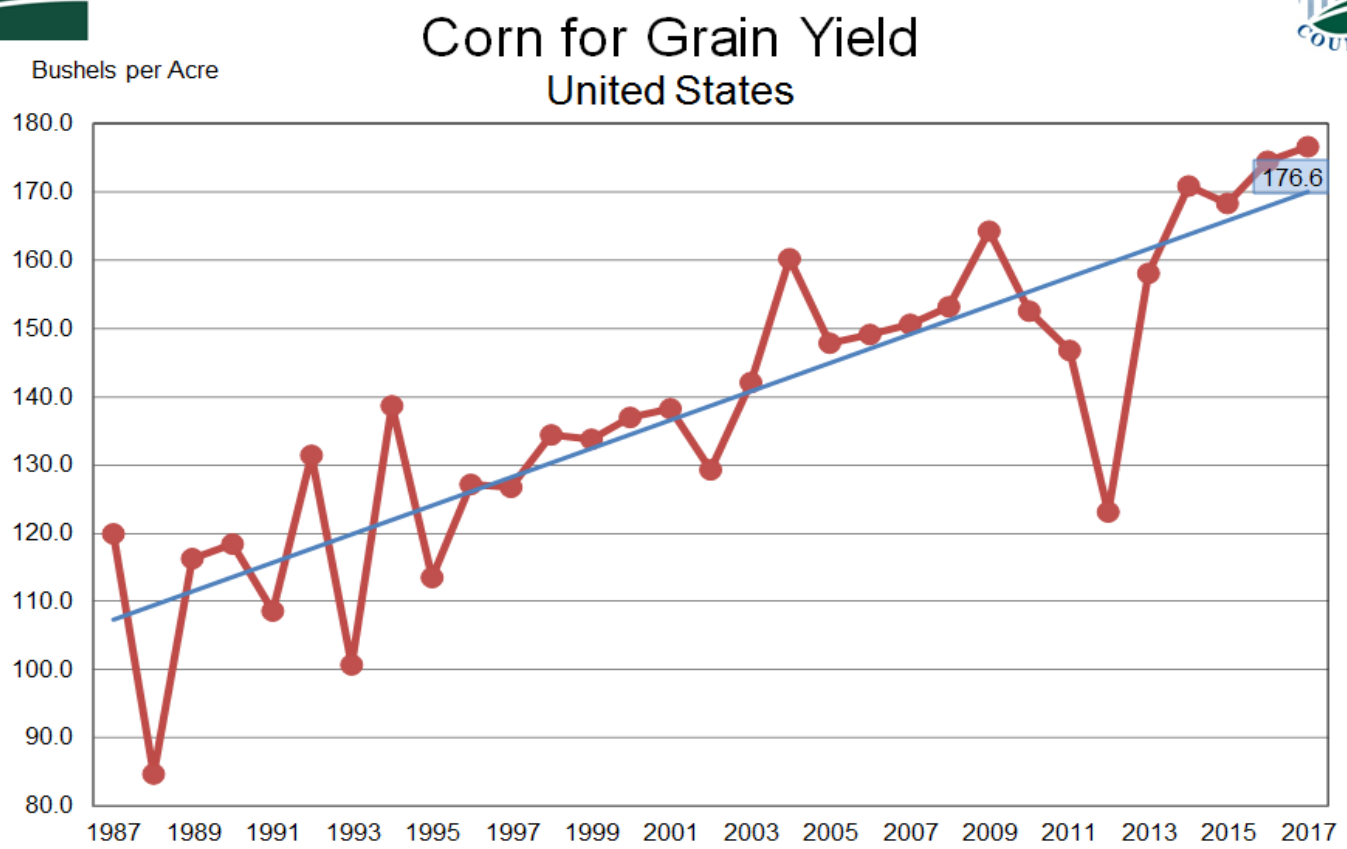
What are plant growth promoting (rhizo)bacteria (PGPR)?

- **Bacteria** that occupy the **rhizosphere** of many plant species and have beneficial effects on host plant.
- Benefits provided by PGPRs depend on ability to **colonize plant roots** and to **survive and proliferate** over extended periods in presence of other microbes.



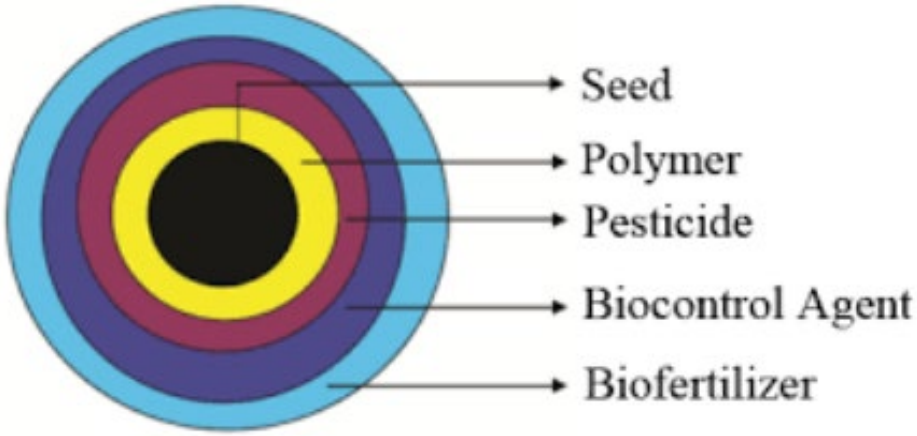
Source: Ecologie Microbienne, http://www.ecologiemicrobiennelyon

Closing yield gap against headwinds



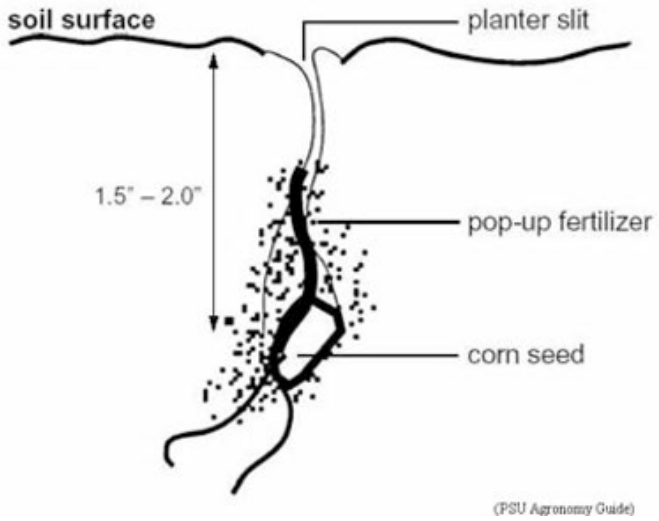
GENETIC POTENTIAL
>500 bu/ac?

Seed treatment



- Limited space on seed
- Compatibility of chemicals and biologicals
- On-seed shelf life issues with biologicals
- Limited diversity of biologicals used (*Bacillus* spp., *Trichoderma* spp.)

Liquid In-furrow



- Low salt fertilizers ("pop-up")
- Tank mix fertilizer with insecticide, fungicide and/or biological
- Compatibility of chemicals and biologicals
- Increased diversity of biologicals possible

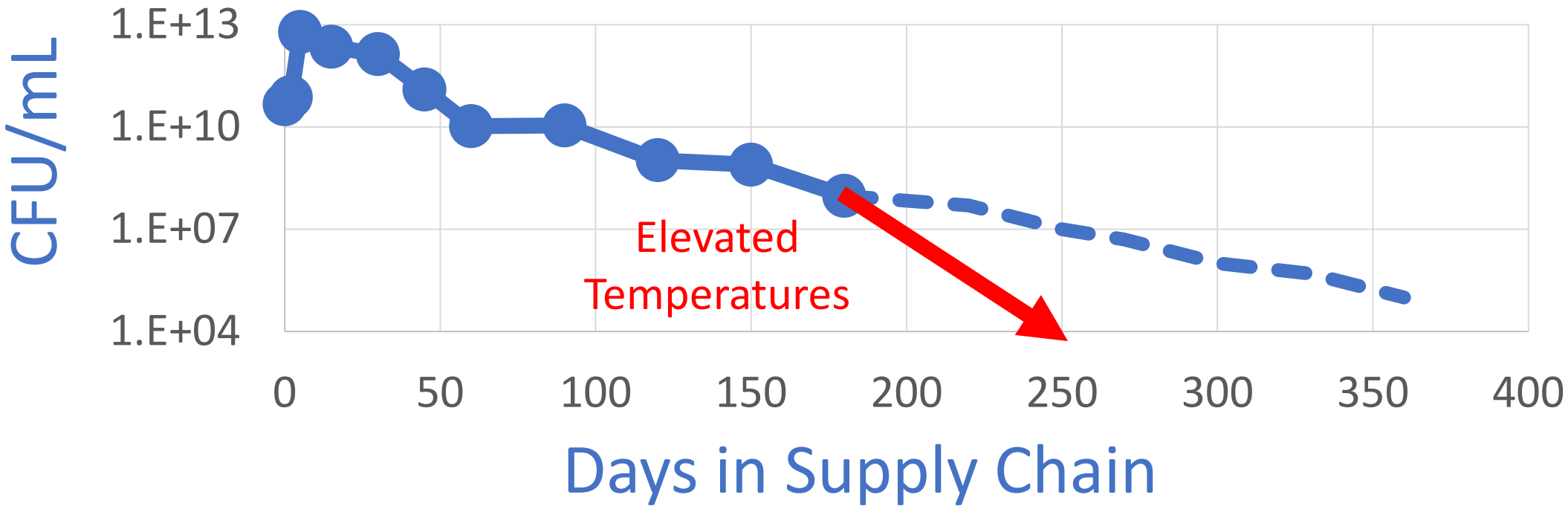
Liquid In-furrow + AgBio markets increasing

- Currently, 25-30% US Corn acres use liquid in-furrow
- Expected to grow to >50% by 2020
- AgChem introducing new in-furrow fungicide and insecticide products
- Innovation of in-furrow equipment
  - AMVAC SIMPAS
  - FMC 3RIVE 3D
  - Liquid Systems
  - Precision Planting FurrowJet
  - Raven Sidekick Pro

- AgBio Market $6.75B, CAGR 13.8%
- AgBio: biopesticides, biostimulants, biofertilizers
- Microbials colonize roots, providing extended effects beyond chemistry
- Discovery innovation of new microbials

Source: Adam Cairns/Columbus Dispatch

Microbes decline in supply chain



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Deliver 100% viable microbes to the field

Novel Delivery Approach

- Product activated on-site by farmer
- On-site growth, closed system
- Microbes added to liquid in-furrow tank

Tank mix compatibility varies by strain

- Low salt index fertilizer
  - Avoid using fertilizer with salt index >20
- Micronutrients
  - Check physical stability
- Fungicides and/or insecticides
  - Check physical stability
- Biologicals
  - **Check compatibility with chemicals**

Fertilizer	Salt Index	In-furrow Use
2-20-20	7.2	Check compatibility
3-18-18	8.5	
6-24-6	11.5	
6-30-30	13.8	
9-18-9	16.7	
10-34-0	20.0	Use with Caution
7-21-7	7-21-7	Do not use
4-10-10	4-10-10	
28% UAN	63.0	

Biostimulants require LOTS of yield data

Challenges:

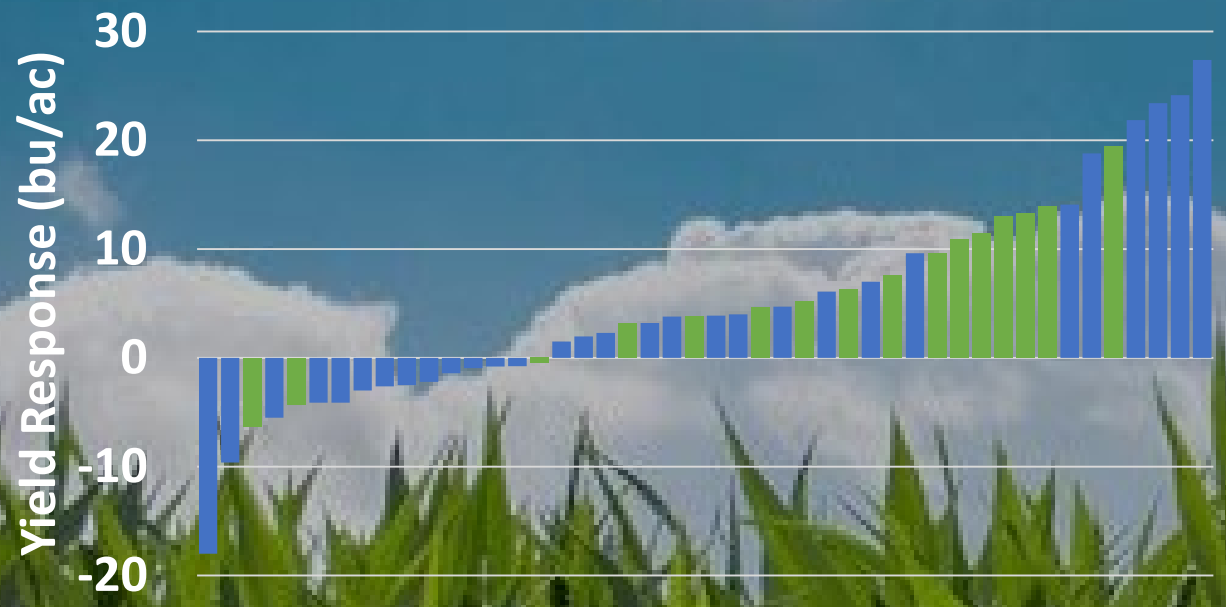
- Variable soil conditions
  - soil type
  - soil temperature
  - soil moisture
  - microbial population
- Variable weather conditions
  - at planting / throughout season
  - site to site / year to year
- Variable delivery methods
- **Statistically significant results hard to achieve**

Strategies:

- University trials: replicated, small plots
- Contract research: replicated, larger plots, closer to production fields
- Direct to grower: production fields
- Region specific – focused testing geographically, multiple years
- Global – multiple strains, regions, years
- **Alternative metrics to yield**

Bio-YIELD®: Corn Yield Increase Averaging 5+ Bu/Ac

Ohio Corn Field Trials
(2014-2018)



	Seed Treatment	In-furrow w/ starter
AVG Yield Response	4.1	7.0
Number trials	30	16
Check (bu/ac)	238.5	197.5
Bio-YIELD® (bu/ac)	242.6	204.1
% increase	1.7%	3.5%

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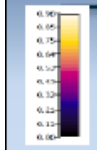
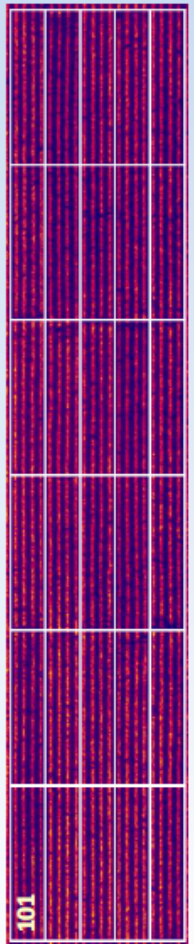
HIGH-RESOLUTION IMAGING – 3BAR BIOLOGICS – IN FURROW



URB

IMAGE DATE: 5/21/18

MULTISPECTRAL IMAGE



AERIAL NDVI				
46.5	36.6	44.0	44.7	42.3
46.8	37.8	38.9	41.2	41.8
49.2	47.1	42.6	37.5	45.5
52.0	45.8	41.9	39.7	44.5
43.9	53.5	49.7	50.2	50.3
44.9	56.5	52.3	52.2	48.0

TREAMENT MAP				
5	1	2	3	4
5	1	2	3	4
3	4	5	1	2
3	4	5	1	2
1	2	3	4	5
1	2	3	4	5

PHL

IMAGE DATE: 6/14/18

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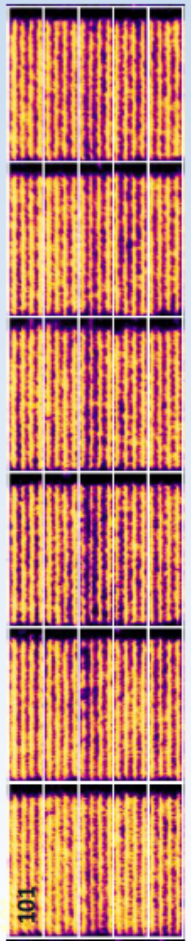


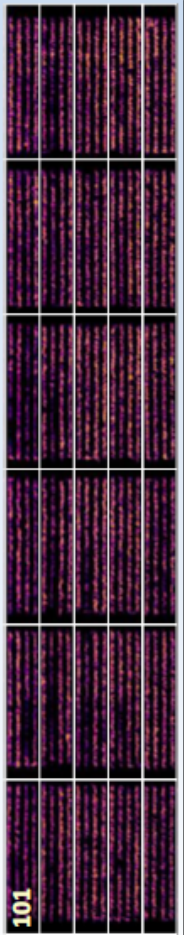
AERIAL NDVI				
136.6	131.0	128.8	124.9	141.7
151.8	150.7	142.6	127.9	140.4
154.5	150.7	131.8	148.3	145.0
129.8	133.2	117.4	140.2	139.2
133.7	137.4	140.8	160.7	139.6
152.5	161.6	146.2	171.7	147.8

TREAMENT MAP				
2	4	5	1	3
2	4	5	1	3
3	5	1	2	4
3	5	1	2	4
1	2	3	4	5
1	2	3	4	5

PEM

IMAGE DATE: 6/6/18

MULTISPECTRAL IMAGE



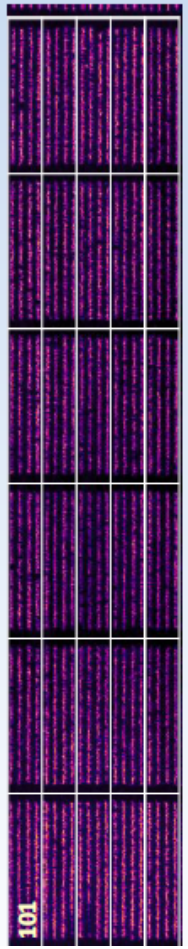
AERIAL NDVI				
49.9	33.7	49.1	48.8	45.7
44.3	32.6	36.3	41.2	50.2
23.7	32.8	48.4	45.1	45.2
43.3	31.3	40.2	47.2	27.6
35.6	26.7	29.6	39.1	44.9
28.1	39.7	43.8	40.6	38.9

TREAMENT MAP				
3	2	5	4	1
2	3	1	5	4
1	5	4	3	2
4	3	2	5	1
5	4	1	2	3
1	2	3	4	5

STM

IMAGE DATE: 6/22/18

MULTISPECTRAL IMAGE



AERIAL NDVI				
28.2	28.6	30.9	35.0	26.0
27.6	28.1	30.5	29.0	21.9
25.5	27.0	23.1	24.0	24.1
24.3	25.2	18.1	24.2	21.7
27.0	32.2	30.1	28.0	23.9
34.4	37.8	37.5	43.6	38.1

TREAMENT MAP				
2	5	4	3	1
2	5	4	3	1
3	4	1	5	2
3	4	1	5	2
1	2	3	4	5
1	2	3	4	5

Courtesy: Dr. Jeremiah Roeth, Buckeye Ag Testing

Early emergence data provide insights

2018 Corn Field Trial Data (Ohio)

In furrow Treatment	No. Sites	Yield	Yield Response	NDVI	NDVI Response
Bio-YIELD (No Starter)	4	233.0	-3.2	57.1	-6.7
Bio-YIELD (+ Starter)	4	236.8	0.6	65.5	1.7
2X Bio-YIELD (+ Starter)	4	234.4	-1.8	65.5	1.7
Development Strain (+ Starter)	4	243.3	7.0	67.5	3.8
Check (+ Starter)	4	236.2		63.8	

Summary

- Use of in-furrow delivery and biologicals is increasing
- In-furrow effective mode of delivery for liquid biological products, particularly non-spore forming microbes
- Compatibility with starter fertilizers is critical evaluation step
- More consistent field performance possible, with ‘fresh’ microbes and just-in-time delivery
- Early emergence data of biostimulants supports better understanding of field performance