Biostimulants, biofungicides and biofertilizers

a.k.a. Agricultural Biologicals

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Agricultural Biologicals

- Long history of use in agriculture
  - Aristotle (384-322 BCE)
    Humus theory: need regular additions of organic matter to the soil to maintain fertility and crop yield
Agricultural Biologicals

**Rhizobia**: fix atmosphere nitrogen in legumes
- discovered in 1888

Martinus Beijerinck
Total market value of agricultural biologicals estimated at $5.1B in 2015 and expected to reach $10B by 2020
Questions????

• What are these products?
• What do they do?
• Why are there so many all of a sudden?
• Do they really work?
• Where do they fit in my production system?
What they are?

- Microorganisms (*bacteria, fungi, viruses*) isolated from soil and plants for their beneficial activities
- Microbes that were developed in the lab
- Microbial products (metabolites)

Photos courtesy: S. Abdelrazek

https://biocontrol.entomology.cornell.edu/pathogens/trichoderma.php
What are they?

• Compounds derived from plants
• Byproducts from other industries
• Reformulated plant compounds & byproducts

Neem Oil

https://downtoearthph.com/tag/fish-emulsion/

Hydrolysis
What are they reported to do?

- **Biopesticides** (a.k.a. biocontrol products)
  - Applications:
    - Disease, insect & pathogen control
  - Derived from:
    - Microbes (bacteria, fungi, viruses)
    - Plant extracts (botanicals)
    - Plant growth regulators
    - Semiochemicals (pheromones)
  - Tightly regulated by USDA

Mechanisms of Action (MoA)

- Antibiosis
- Parasitism
- Antibiotic production
- Induced systemic resistance
- Competitive exclusion
What are they reported to do?

• **Biofertilizers** *(no legal definitions)*
  
  - Enhance nutrient status by:
    - replacing soil nutrients
    - making them more availability to plants
    - increasing plant access to nutrients
  
  - Derived from:
    - plant and animal wastes
    - microbes and their products

**Mechanisms of Action (MoA)**

- Plant nutrients
- Microbes that:
  - Fix atmospheric N
  - Solubilize P
  - Produce phytohormones
What are they reported to do?

• **Biostimulants** (a.k.a. bioyield enhancers)

**Definition in the European Union**

“A material that, when applied to a plant, seed, soil or growing media - in conjunction with established fertilization plans, enhances the plant's nutrient use efficiency, or provides other direct or indirect benefits to plant development or stress response.”

*Do not contain nutrients*

**Definition in the United States**

“Products derived from natural or biological sources..”
**Applications:**
- Increase germination
- Improve nutrient uptake
- Improve nutrient-use efficiency
- Increase tolerance to and recovery from abiotic stresses (*salt, water, heat, heavy metals*)

**Potential Mechanisms of Action (MoA)**

*Biostimulant Action of Protein Hydrolysates: Unraveling Their Effects on Plant Physiology and Microbiome*

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OPEN ACCESS
Why are these products growing so rapidly?

- Development of new scientific tools and technologies
- Demand for organic and more “environmentally-friendly” agricultural systems
- Agricultural intensification *(how do we close the yield gap?)*
Closing the yield gap: an opportunity for biologicals

<table>
<thead>
<tr>
<th>Crop</th>
<th>Average yield</th>
<th>World record</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>5.8</td>
<td>35.0</td>
</tr>
<tr>
<td>Soybean</td>
<td>2.9</td>
<td>11.5</td>
</tr>
<tr>
<td>Wheat</td>
<td>3.4</td>
<td>16.8</td>
</tr>
<tr>
<td>Rice</td>
<td>5.8</td>
<td>22.4</td>
</tr>
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Yield in metric tonnes per hectare
Source: FAS/USDA/3rd International Biostimulant Conference
Do they really work and where do they fit in my production system?

**Ideal developmental pipeline**
- Product development
- Internal testing
- On-farm tests & recommendations

**Actual developmental pipeline**
- Product development
- Internal testing
- On-farm tests & recommendations

Matt Kleinhenz (OSU)
Questions:

1) How do I choose the right product?

2) When and how can I achieve the most benefits from these products?

3) How do I know if they are working?
Look for specific modes of action (MoA)

- Beware of products with no discernable MoA other than “increases plant growth”
- The more details the better and even stronger if linked to scientific literature to back up claims
Look for reliable, independent research trials

- Trials conducted by companies selling the products or farmers who have received products free of charge are fine as indicators of how to use the products, but do not hold much scientific rigor

- Trials conducted by an organization or institute you know to be of high integrity and with no declared financial interests
Look for specific recommendations

• Are they tank mix compatible with co-applied agrochemicals or other biologicals?
• Do they contain specific adjuvants to maximize action (ie. surfactants, wetters, antifoaming agents)?
• Are they approved for use under organic certification guidelines?
• Are they preserved in a way that maximizes shelf life and how should they be stored?
• How should they be applied and what is the optimal rate and frequency of application needed to achieve benefits?
Understanding where these products fit in your production system
Where do these products have a role?

• Alternatives for some synthetic products (ie. pesticides for organic farming)
  
  *Caveat - preventative NOT curative*

• Supplement fertility programs (ie. mycorrhiza aid in phosphorous acquisition)
  
  *Caveat - not likely to replace need for fertilizers*

*Part of an integrated management system*
Where do these products have a role?

- When plants are under stress
  - Cold
  - Waterlogging
  - Drought
  - Salinity
  - Heavy metals
  - Heat
  - Nutrient immobilization

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Study conducted at Purdue in collaboration with Bioworks

- **Rootshield**: contains *Trichoderma harzianum* strain T22 and *Trichoderma virens* strain G-41

- **Objective**: Evaluate efficacy in reducing transplant stress in Indiana and identify best product formulation
Increased tomato transplant size in the greenhouse

Increased transplant survival and RS+WP1 increased biomass

Tomato Stem Diameter at Transplant (7/19)

Biomass After 57 Days in Field

RS+ WP1 = treated with RootShield Plus WP at 4 oz/100 gallon rate
RS+ WP2 = treated with RootShield Plus WP at 6 oz/100 gallon rate
RS+ Granules = treated with RootShield Plus Granules at 1.5 lb/cu yd

*Above ground biomass
Evaluation: how do you know they are working?
Conducting objective research trials

- Include an untreated control
- Ensure that study site is as uniform as possible
- Replicate and randomize
- Use codes to mark treatments
- Collect and record standard and unusual growth parameters
- Use statistics to evaluate results
- Repeat
Resources for conducting on-farm trials

- County Extension educator
- SARE Technical Bulletin

Consider sharing your experiences

- Microbial-based biofertilizers in vegetable production List-serve (Ohio State University)

http://u.osu.edu/vegprolab/microbial_inoculants_in_vegpro/

http://www.sare.org/Learning-Center/Bulletins/How-to-Conduct-Research-on-Your-Farm-or-Ranch
Additional resources:

- **Ohio State University – “Bugs in a Jug” Webpage**
  
  [https://u.osu.edu/vegprolab/research-areas/vegebiostimsferts/](https://u.osu.edu/vegprolab/research-areas/vegebiostimsferts/)
  - Publications, bioproduct database, list-serve

- **Agricultural Biologicals Workshop at the upcoming Indiana HORTCongress**

The Indiana Horticultural Congress is an educational meeting designed to meet the needs of fruit, vegetable, wine, organics, specialty crop growers, greenhouse growers and marketers. All interested individuals are invited to attend. Check the website for the latest details! [inhortcongress.org](http://inhortcongress.org)
Summary and conclusions
Is this the future of agriculture?
Take-home message

• Provide opportunities to help close the yield gap, when plants are under stress
• Benefits likely to depend on site-specific conditions
• Part of an integrated management program
• Look for products that explain the MoA, conduct independent 3rd party research trials, and clearly explain when and how to use their products