Delivery of Biological Products: Meeting the Challenge

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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.
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

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

Days in Supply Chain

Manufacturing → Storage → Distribution → On-farm Storage → In-field Use

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

<table>
<thead>
<tr>
<th>Fertilizer</th>
<th>Salt Index</th>
<th>In-furrow Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-20-20</td>
<td>7.2</td>
<td></td>
</tr>
<tr>
<td>3-18-18</td>
<td>8.5</td>
<td>Check compatibility</td>
</tr>
<tr>
<td>6-24-6</td>
<td>11.5</td>
<td></td>
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<tr>
<td>6-30-30</td>
<td>13.8</td>
<td></td>
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<tr>
<td>9-18-9</td>
<td>16.7</td>
<td></td>
</tr>
<tr>
<td>10-34-0</td>
<td>20.0</td>
<td>Use with Caution</td>
</tr>
<tr>
<td>7-21-7</td>
<td>7-21-7</td>
<td></td>
</tr>
<tr>
<td>4-10-10</td>
<td>4-10-10</td>
<td>Do not use</td>
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<tr>
<td>28% UAN</td>
<td>63.0</td>
<td></td>
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</table>
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)

<table>
<thead>
<tr>
<th>Seed Treatment</th>
<th>AVG Yield Response</th>
<th>Number of Trials</th>
<th>Check (bu/ac)</th>
<th>Bio-YIELD® (bu/ac)</th>
<th>% Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-furrow w/ starter</td>
<td>4.1</td>
<td>30</td>
<td>238.5</td>
<td>242.6</td>
<td>1.7%</td>
</tr>
<tr>
<td></td>
<td>7.0</td>
<td>16</td>
<td>197.5</td>
<td>204.1</td>
<td>3.5%</td>
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</table>
Early emergence data provide insights

2018 Corn Field Trial Data (Ohio)

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