BASF – a chemical company mastering the challenges of biologicals

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White Biotechnology Research – Lab Team Leader Microbiology
BASF Group - 115,500 employees create chemistry for a sustainable future
Sales and EBIT by segment 2017

€ million

- **Chemicals**
  - Sales 16,331
  - EBIT* 4,233
- **Functional Materials & Solutions**
  - Sales 20,745
  - EBIT* 1,617
- **Other**
  - Sales 2,242
  - EBIT* (-764)
- **BASF Group**
  - Sales 64,475
  - EBIT* 8,328
- **Oil & Gas**
  - Sales 3,244
  - EBIT* 793
- **Agricultural Solutions**
  - Sales 5,696
  - EBIT* 1,033
- **Performance Products**
  - Sales 16,217
  - EBIT* 1,416

* Before special items

- In 6 research divisions 10,000 employees are running ~3,000 projects worldwide
- Expenditures for R&D: €1,888 million, world leader in chemical industry (23% of EBIT)
BASF Agricultural Solutions
More than 12000 employees create solutions for sustainable farming

- Agricultural Solutions is one of the world’s leading research-based companies in crop protection
- €507 million invested in R&D in 2017 (27% of the company’s research investment)
- Continued investments in innovation to expand portfolio in and beyond crop protection, such as biological solutions and digital tools and devices

(Agricultural Center founded in 1914 by Carl Bosch for research on fertilizers)
Why Biologicals?
Biologicals offer new tools for the grower

Growers need new solutions
- Political pressure to reduce chemical input
- Consumer demand for lower residues
- Diseases and pests developing resistance
- Yield increase

Biologicals can provide solutions
- Different modes of action versus chemistries
- No chemistry-like residues
- Low likelihood of resistance
- Yield effects beyond disease & pest control
Biologicals in Agricultural Solutions
Important technology for crop protection that complements chemistry-based solutions over the full cropping cycle

Products for soil, seed and foliar application to meet today’s and tomorrow’s agricultural challenges
Challenges
Many challenges to be mastered when working with biologicals …
Selected biologicals of our growing portfolio for foliar or seed application
A natural complement to chemistry

**Bradyrhizobium japonicum**
Inoculant, Biofertilizer (Vault®, Nodulator®, HiStick®)
- Nitrogen-fixing rhizobia stimulate root nodulation improving nutrient uptake
- More consistent overall performance, reducing uncertainty

**Steinernema spec**
Bioinsecticide (Nemasys®)
- Entomopathogenic nematode
- Excellent compatibility and performance with chemistry as part of an IPM program

**Bacillus amyloliquefaciens**
Biofungicide
- Mode of action via biofilm formation, secondary metabolites, stimulation of plant’s natural defenses...
- Usable in combination with chemical treatments

**Bacillus subtilis**
Biofungicide (Velondis®)

**Beauveria bassiana PPRI5339**
Bioinsecticide (Velifer®)
- Fungal spores applied to insect attach to cuticle and initiate infection
- Low likelihood of resistance due to complex interaction with host
## Product profile: Serifel®
BASF’s first proprietary biological fungicide based on *Bacillus amyloliquefaciens* strain MBI600

<table>
<thead>
<tr>
<th><strong>Active ingredient</strong></th>
<th><em>Bacillus amyloliquefaciens</em> strain MBI 600</th>
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<tbody>
<tr>
<td><strong>Formulation</strong></td>
<td>Min. $5.5 \times 10^{10}$ CFU/g WP formulation</td>
</tr>
<tr>
<td><strong>Key markets</strong></td>
<td>Specialty crops including leafy vegetables, fruiting vegetables, potatoes, grapes, strawberries; tobacco, hops</td>
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<td><strong>Disease targets</strong></td>
<td>Foliar and soil diseases including <em>Fusarium</em> species, <em>Alternaria solani</em>, <em>Botrytis cinerea</em>, <em>Rhizoctonia solani</em>, powdery mildew, sour rot</td>
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</table>
| **Modes of action**   | - Physical exclusion of disease pathogens via biofilm formation  
- Production of fungicidal metabolites  
- Competition for resources |
| **Unique value proposition** | Pure spore formulation works more efficiently than the competition:  
- More rainfast  
- Productive over a wider range of temperatures  
- Lower application rate  
- Serifel® creates a synergistic effect when used with chemistry-based solutions |
Spotlight: Serifel® - Broadening disease spectrum
Complementary tank mixes broaden the disease control spectrum

Tomato inoculated with *Fusarium oxysporum*

### Bar Chart

- Untreated control
- Serifel
- Zampro
- Serifel + Zampro

<table>
<thead>
<tr>
<th>Treatment</th>
<th>% Dead plants</th>
</tr>
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<tbody>
<tr>
<td>Untreated control</td>
<td>70</td>
</tr>
<tr>
<td>Serifel</td>
<td>20</td>
</tr>
<tr>
<td>Zampro</td>
<td>60</td>
</tr>
<tr>
<td>Serifel + Zampro</td>
<td>10</td>
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Insight into one of our discovery strategies for biocontrol biologicals
Computational discovery strategy – a differentiating approach to detect novel biologicals

- Controlled inoculation field experiments with selected resistant and susceptible genotypes
- Sampling of plants & soil

Microbiome sequencing

Diverse plant lines

Disease tolerance

Microbes in diseased plants

Microbes in tolerant plants

Differential microbiome analysis

OTUs of interest

“Functional collection” of selectively isolated microorganisms

Microbiology

Validation screens
1) Lab
2) Greenhouse
3) Field
First validation of the approach via functional assays
Prioritized microbes more likely to be active than random ones

- Functional assays are only a first evidence showing the benefit of the computational approach to identify microbes for biocontrol
- Upcoming greenhouse and field trials will investigate their biocontrol potential *in planta*
White biotechnology

Expertise in microbiology, fermentation and downstream processing is essential for production of biologicals

**Pilot plant**
- Upscaling: Shake flask → 5m³ bioreactor
- Supply of small amounts of new product candidates for initial application tests
- Development of new bioprocesses
- Optimization of fermentation and purification processes
- Process transfer to production plants
Key takeaways

- BASF is investing heavily in crop protection research with a growing portfolio of biological products.
- Benefit of our computational discovery pipeline shown in functional assays, but *in planta* potential still needs to be investigated.
- Biologicals are challenging from R&D and market perspective.
- New product launches will strengthen BASF’s position to tackle these challenges.

Thank you!
BASF
We create chemistry