Evolution of the biocontrol industry

Willem Ravensberg
President IBMA

IBMA and Copa-Cogeca Workshop to explore the implications of Bacillus cereus relating to the recent EFSA opinion on the safety microbial pesticides - March 28, 2017
Evolution of microbial biopesticides
focus on micro-insecticides

Introduction
• History
• Research
• Product development
• Registration
• Use of microbial biopesticides
• Developments over time
• Sales and use
• Future outlook
Early history on microbial control

- In late 1800’s start of research on fungi killing insects in silk worm industry
- Researchers: Bassi, Pasteur, Leconte, Hagen
- Hagen (in 1879): 1\textsuperscript{st} to suggest: mass produce and spray on infested plants and wait for disease development
- Bacteria found against insects in 1\textsuperscript{st} decade of 20\textsuperscript{th} century:
  - Bacillus thuringiensis and B. popilliae
  - First product registered in 1948 in USA, first in 1961 in Europe (Bt)
- Fungi research in 1870 in Russia and USA. First product in USSR in 1965
- Baculoviruses discovered in 1940’s. First product developed in 1970’s
  - Protozoa and Microsporidia: common insect pathogens, but hard to produce, hence hardly product development; one product ever.
- Insect-pathogenic nematodes: discovered in 1930’s and used since then
Research

- Academic Research
- > 150 years
- Details on pathogenicity, mode of action, host range, environmental fate, safety
- Public-private research
  - Product development
  - Registration
  - Use of biopesticides
Product development

• Screening for virulent strains
• Production
• Formulation
• Packaging
• Process and Product Quality control
  • microbial contaminants
• Efficacy testing (application, dose, etc)
Registration

- Identity
  - taxonomy
  - mode of action
  - biological properties
- Toxicology
- Eco-toxicology
- Fate and behaviour in the environment
- Efficacy and crop safety
Microbial biopesticides today

- Producers: >100
- Products: active substances > 200 *
- Formulated products > 400
- Uses in agriculture, forestry, vector control, animal husbandry, pests, external parasites, amenities, public green
- Agriculture: protected crops, field vegetables, soft fruit, orchard, vineyard
Microbial biopesticides today

- Producers: >100
- Products: active substances > 200
- Formulated products > 400
- Uses in agriculture, forestry, vector control, animal husbandry, pests, external parasites, amenities, public green
- Agriculture: protected crops, field vegetables, soft fruit, orchard, vineyard, row crops, cereals
Microbial product use

- Mainly North America, Europe
- Also in other continents
- Uses as insecticides, acaricides, fungicides, bactericides, nematicides, herbicides, post harvest pests and diseases
- Sales: approx. 2% of world wide pesticide sales
- Growth rate: approx. 15% p.a.
Bacteria used in biopesticides

- Agrobacterium
- Bacillus
- Burkholderia
- Chromobacterium
- Erwinia
- Lactobacillus
- Pantoea
- Pseudomonas
- Serratia
- Streptomyces
Bacillus species used in biopesticides

- amyloliquefaciens
- cereus
- firmus
- licheniformis
- mycoides
- popilliae
- pumilus
- subtilis
- thuringiensis
  - subsp. aizawai
  - subsp. galleriae
  - subsp. israelensis
  - subsp. tenebrionis
<table>
<thead>
<tr>
<th>Strain Description</th>
<th>Country/Region</th>
<th>Application/Pathogens</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bacillus amyloliquefaciens (formerly B. subtilis) MBI 600</td>
<td>CA, J, EU*, NZ (2009, 2012), USA</td>
<td>seed treatment, soilborne diseases</td>
</tr>
<tr>
<td>Bacillus amyloliquefaciens AH2</td>
<td>EU *</td>
<td>fungal soil diseases</td>
</tr>
<tr>
<td>Bacillus amyloliquefaciens AT-332</td>
<td>J</td>
<td>Botrytis, powdery mildew</td>
</tr>
<tr>
<td>Bacillus amyloliquefaciens bs1b</td>
<td>NZ (2010)</td>
<td>foliar diseases</td>
</tr>
<tr>
<td>Bacillus amyloliquefaciens PTA-4838</td>
<td>USA</td>
<td>nematodes</td>
</tr>
<tr>
<td>Bacillus cereus BP01</td>
<td>USA</td>
<td>foliar plant growth regulator</td>
</tr>
<tr>
<td>Bacillus firmus i-1582</td>
<td>CA, EU, NZ (2016)</td>
<td>nematodes</td>
</tr>
<tr>
<td>Bacillus licheniformis SB3086</td>
<td>USA</td>
<td>fungal foliar diseases</td>
</tr>
<tr>
<td>Bacillus mycoides JCX-10244</td>
<td>CA, USA</td>
<td>Cercospora Leaf Spot on sugar beet</td>
</tr>
<tr>
<td>Bacillus popilliae</td>
<td>USA</td>
<td>Japanese beetle</td>
</tr>
<tr>
<td>Bacillus pumilus GB34</td>
<td>USA</td>
<td>root diseases of soy beans</td>
</tr>
<tr>
<td>Bacillus pumilus QST 2808</td>
<td>BR, EU, USA</td>
<td>fungal foliar diseases</td>
</tr>
<tr>
<td>Bacillus subtilis ATCC 6051</td>
<td>NZ (2012)</td>
<td>fungal foliar diseases</td>
</tr>
<tr>
<td>Bacillus subtilis GB03</td>
<td>CA, USA</td>
<td>fungal diseases</td>
</tr>
<tr>
<td>Bacillus subtilis HAI-0404</td>
<td>J</td>
<td>foliar diseases</td>
</tr>
<tr>
<td>Bacillus subtilis IAB/BS03</td>
<td>EU *</td>
<td>foliar fungal and bacterial diseases</td>
</tr>
<tr>
<td>Bacillus subtilis KTSB</td>
<td>NZ (2008)</td>
<td>foliar diseases</td>
</tr>
<tr>
<td>Bacillus subtilis QST 713</td>
<td>BR, CA, EU, J, NZ (2001), USA</td>
<td>fungal foliar diseases</td>
</tr>
<tr>
<td>Bacillus subtilis var. amyloliquefaciens FZB24</td>
<td>CA, EU*, USA</td>
<td>fungal foliar diseases</td>
</tr>
<tr>
<td>Bacillus subtilis Y 1336</td>
<td>J</td>
<td>Botrytis, powdery mildew</td>
</tr>
<tr>
<td>Bacillus thuringiensis EG-7826</td>
<td>BR</td>
<td>lepidopteran caterpillars</td>
</tr>
<tr>
<td>Bacillus thuringiensis BMP 123</td>
<td>BR</td>
<td>lepidopteran caterpillars</td>
</tr>
<tr>
<td>Bacillus thuringiensis CryC encapsulated in killed Pseudomonas fluorescens</td>
<td>USA</td>
<td>lepidopteran caterpillars</td>
</tr>
<tr>
<td>Bacillus thuringiensis CrylA(c) and CrylC in killed pseudomonas fluorescens</td>
<td>USA</td>
<td>lepidopteran caterpillars</td>
</tr>
<tr>
<td>Bacillus thuringiensis EG 2348</td>
<td>BR, EU</td>
<td>lepidopteran caterpillars</td>
</tr>
</tbody>
</table>
Developments over time

• Biocontrol industry matured
• Public Research activities large scale
• Product quality from variable to high standard
• Increased efficacy and reliability
• Knowledge-based recommendations on applications
• Regulatory authorities evolved with increasing number of product applications
• Regulatory requirements evolved and aligned with science
Sales and use

• Approx. 1 billion US$ sales of microbial pesticides world wide
• Bt.- 40-50%
• Most used biopesticide over the last 50 years
• Formed the basis of biocontrol with microbes
• Cornerstone of IPM programmes
• Bt. genes have large scale uses in GMO crops
Future outlook

• Increase of bacterium-based products, mainly for disease control
• Increase for vector control
• Expansion of use world wide
  • As biopesticide
  • As biostimulant
  • As biofertilizer
  • In many other applications
Thank you for your attention