The Diversity of „Biorationals“ – learning from Biocontrol Agents

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The Concept of IPM

- Fire Brigade = Intervention
- Chemical Plant Protection
- Biological Plant Protection
- Biostimulants
- Mechanical, Physical Culturing Techniques, Breeding
- Non-chemical Plant Protection
- Fire Safety = Prevention
Neglection of Fire Safety in Plant Protection

• Application of IPM is mandatory in Europe since 2014: 
  Directive 2009/128/EC

• Despite 30 years of IPM in German Plant Protection Law: Plant protection mainly based on chemicals
  • Unintended non-target effects
  • Residues and (unrealistic) consumer expectations
  • Rapid development of resistance

• „Disease spread is like a forest fire“: because of lack of fire safety

• 90-98 % of sprays do not reach target: Damage caused by fire fighting

• Decline of biodiversity: Agricultural intensification is also the consequence of low prizes and food waste
Loss of Foodstuff

Pre-harvest and Harvest
Transportation and Storage

Cereals: 30% loss worldwide
- Europe
- Subsahara-Africa
- South-east Asia
- Latin America

Fruits: 45% loss worldwide
- Europe
- Subsahara-Africa
- South-east Asia
- Latin America

Meat: 20% loss worldwide
- Europe
- Subsahara-Africa
- South-east Asia
- Latin America

Modified from BMEL/Gustavsson et al. 2011
The Bounty of Biological Tools

Classical Biocontrol

Biocontrol Products

Biopesticides

Biochemicals

Semio-chem.

Organic Acids

Plant extract.

Microbials

Bacteria

Viruses

Protozoa

Fungi

Yeast Others

Macro-organisms

Pred. Insects

Pred. Mites

Parasitoids

EPN

Conservation Biocontrol

Breeding

Biostimulants

Biofertilizers

New Technologies

Modified from Dunham & Trimmer as presented on ABIM 2015
The Registration Process of Microbial Biological Control Agents (MBCAs)

<table>
<thead>
<tr>
<th>Period</th>
<th>Details</th>
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</table>
| Before 1993  | • Many national registration  
• Individual registration in each country  
• No common legal framework |
| 1993 – 2011  | • Uniform rules on the evaluation, authorisation, placing on the market  
• Control of plant protection products and the active substances they contain |
| Since 2011   | • Harmonization of plant protection registration  
• Reduce risk for human and animal health  
• Reduce risk for environment  
• Safeguarding the competitiveness of European Agriculture |
414/91 based harmonization caused loss of MBCAs

- **Pre-91/414**: 22 species of micro-organisms in Europe registered

- **91/414 Transition**: only 16 MOs defended as pre-existing, thereof 8 Entomopathogens
  
  6 MOs got lost (e.g. *Beauveria brongniartii*, three baculoviruses and others)

- **91/414**: Initially only 8 MBCAs included into Annex I, several were pending for seven and more years

Source: Hauschild, 2011
Registered Microbial Biocontrol Agents in Germany

**Viruses**
- Adoxophyes orana GV
- Cydia pomonella GV-Mexican strain
- Cydia pomonella GV-006
- Cydia pomonella GV-R5

**Bacteria**
- Bacillus subtilis QST 713
- Pseudomonas chlororaphis MA 342
- Bacillus thuringiensis tenebr. NB 176
- Bacillus thuringiensis aizawai GC-91
- B. thuringiensis aizawai ABTS-1857
- B. thuring. kurstaki ABTS-351 (HD1)

**Fungi**
- Ampelomyces quisqualis AQ10
- Coniothyrium mimitans M91-08
- Gliocladium catenulatum J1446
- Trichoderma asperellum ICC 012
- Trichoderma gamsii ICC 080
- Metarhizium anisopliae F52
- Beauveria bassiana ATCC 74040

**Disease control**
- Capex 2
- Madex 3, Carpovirusine
- Madex Max
- Carpovirusine EVO 2
- Serenade, Serenade Max
- Cedomon, Cerall
- Novodor
- Agree
- XenTari
- Bactospeine, Dipel
- AQ 10
- Contans
- PreStop, PreStop Mix
- Bioten
- Bioten
- MET Granulat
- Naturalis

**Insect control**
- Madex Max
- Carpovirusine EVO 2
- Serenade, Serenade Max
- Cedomon, Cerall
- Novodor
- Agree
- XenTari
- Bactospeine, Dipel
- AQ 10
- Contans
- PreStop, PreStop Mix
- Bioten
- Bioten
- MET Granulat
- Naturalis
Commercial Beneficials in Germany

Number of species over time from 1980 to 2010, showing the increase in the number of beneficial species. The categories include:
- Pollinators
- Other predators
- Predatory bugs
- Predatory beetles
- Predatory flies
- Predatory mites
- Parasitic wasps
- Nematodes
## Release area of Beneficials (ha/year)

Most important commercially available beneficials:

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td><em>Trichogramma brassicae</em></td>
<td>5900</td>
<td>5600</td>
<td>9443</td>
<td>19414</td>
<td>22484</td>
<td>Corn</td>
<td><em>Ostrinia</em></td>
</tr>
<tr>
<td><em>Encarsia formosa</em></td>
<td>196</td>
<td>403</td>
<td>273</td>
<td>198</td>
<td>1266</td>
<td>Veg &amp; Orn</td>
<td>White fly</td>
</tr>
<tr>
<td><em>Aphidius - species</em></td>
<td>65</td>
<td>174</td>
<td>174</td>
<td>203</td>
<td>1042</td>
<td>Veg &amp; Orn</td>
<td>aphids</td>
</tr>
<tr>
<td><em>Lysiphlebus testaceipes</em></td>
<td>0.5</td>
<td>7.8</td>
<td>20</td>
<td>315</td>
<td></td>
<td>Veg &amp; Orn</td>
<td>aphids</td>
</tr>
<tr>
<td><em>Diglyphus isaea</em></td>
<td>19</td>
<td>73</td>
<td>95</td>
<td>27</td>
<td>119</td>
<td>Veg &amp; Orn</td>
<td>Leaf miners</td>
</tr>
<tr>
<td><em>Aphidoletes aphidimyza</em></td>
<td>66</td>
<td>131</td>
<td>134</td>
<td>54</td>
<td>48</td>
<td>Veg &amp; Orn</td>
<td>aphids</td>
</tr>
<tr>
<td><em>Chrysoperla carnea</em></td>
<td>10</td>
<td>55</td>
<td>40</td>
<td>4</td>
<td>62</td>
<td>Veg &amp; Orn</td>
<td>aphids &amp; more</td>
</tr>
<tr>
<td><em>Phytoseiulus persimilis</em></td>
<td>123</td>
<td>125</td>
<td>126</td>
<td>85</td>
<td>332</td>
<td>Veg &amp; Orn</td>
<td>spider mites</td>
</tr>
<tr>
<td><em>Amblyseius sp.</em></td>
<td>104</td>
<td>174</td>
<td>201</td>
<td>25</td>
<td>1470</td>
<td>Veg &amp; Orn</td>
<td>mites &amp; thrips</td>
</tr>
<tr>
<td><em>Entomopath. Nematodes</em></td>
<td>47</td>
<td>413</td>
<td>200</td>
<td>1272</td>
<td>247</td>
<td>Veg &amp; Orn</td>
<td>various</td>
</tr>
</tbody>
</table>
IPM is a System!

- Multic-component system by definition!
- Components are not inter-changeable!
- Components need to work together!
- Prevention should prevail intervention!
- Systemic approach of differently efficacious tools!
- Clear development: Fewer chemicals a.i. will be available!
An Example from Practice

Tomato in Greenhouse in Niederrhein area:

▪ Control of insect pests only with biocontrol
▪ Use on ~98% of growing area

Source: LWK NW, Heike Scholz-Döbelin
Statusbericht Biolog. Pflanzenschutz 2013
Application of new Active Substances since 1996

Source: EU Comm. 2016
What are the consequences?

✓ Biological Control Agents
  • are highly specific,
  • have a narrow application segment,
  • application profile have an intrinsic reduced risk

✓ „Replacing“ a single chemical a.i. will require many biologicals
  • Registration of biological a.i. is strain-specific:
    Different strains have similar properties!

✓ Many potential biologicals not registered because of high registration costs compared to market volume (no ROI)

✓ Increasing gap of indications will require new approaches in the registration of biologicals

✓ Registration needs to be SMART and SLIM and RISK-RELATED
Example: Baculoviruses

- dsDNA-Virus,
- largest insect virus group,
- specific for Lepidoptera, Hymenoptera, Diptera
- Highly specific for few targets

- OECD Consensus document No. 20 (2002): „baculoviruses are safe for humans, animals and environment“
- REBECA Proposal to approve baculovirus a.i. on species level (2006)

CONSEQUENCE: fast registration of resistance-breaking CpGV isolates

Referring to QPS status (EFSA BIOHAZ panel) of baculoviruses, they are considered as low risk on family level (proposed amendment of (EC) No.1107/2009)
# Microbial Biocontrol Agents: Most will be Low Risk Substances

<table>
<thead>
<tr>
<th>Substance</th>
<th>Category</th>
<th>Status under Reg. (EC) No 1107/2009</th>
<th>Date of approval</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Bacillus amyloliquefaciens</em> strain FZB24</td>
<td>Fungicide</td>
<td>Approved</td>
<td>01/06/2017</td>
</tr>
<tr>
<td>Cerevisane</td>
<td>Plant activator</td>
<td>Approved</td>
<td>23/04/2015</td>
</tr>
<tr>
<td>COS-OGA</td>
<td>Elicit./Fung.</td>
<td>Approved</td>
<td>22/04/2015</td>
</tr>
<tr>
<td>Ferric phosphate</td>
<td>Molluscicide</td>
<td>Approved</td>
<td>01/01/2016</td>
</tr>
<tr>
<td><em>Isaria fumosorosea</em> Apopka strain 97 (formely <em>Paecilomyces fumosoroseus</em>)</td>
<td>Insecticide</td>
<td>Approved</td>
<td>01/01/2016</td>
</tr>
<tr>
<td><strong>Mild Pepino Mosaic Virus isolate VC 1</strong></td>
<td>Elicitor</td>
<td>Approved</td>
<td>29/03/2017</td>
</tr>
<tr>
<td><strong>Mild Pepino Mosaic Virus isolate VX 1</strong></td>
<td>Elicitor</td>
<td>Approved</td>
<td>29/03/2017</td>
</tr>
<tr>
<td>Pepino mosaic virus strain CH2 isolate 1906</td>
<td>Elicitor, Virus inoculation</td>
<td>Approved</td>
<td>07/08/2015</td>
</tr>
<tr>
<td><em>Saccharomyces cerevisiae</em> strain LAS02</td>
<td>Fungicide</td>
<td>Approved</td>
<td>06/07/2016</td>
</tr>
<tr>
<td><em>Trichoderma atroviride</em> strain SC1</td>
<td>Fungicide</td>
<td>Approved</td>
<td>06/07/2016</td>
</tr>
</tbody>
</table>
Lessons learned

✓ Not only fire fighting but improved fire safety is needed
✓ Re-thinking the paradigmas: IPM is not a tool box but a multicomponent system!
✓ Harmonization of registration should facilitate regulatory process in general BUT it caused loss of agents in the past (some never came back)
✓ Because of specificity, single biological solutions have inherent restrictions of applications (market)
✓ Be aware of strength and weakness of regulatory process
  • *Essential legal framework for producers farmers, and consumers*
  • *Regulatory process needs to be risk-related*
  • *Current conditions hampers registration of small products*
✓ New pathes needed, not running faster in the treadmill