Microbial Herbicides

IR-4 Western Regional Workshop
Numerous fungal and bacterial plant pathogens have been researched and developed as herbicides as live infective agents:

**Collego®, LockDown®** - *Colletotrichum gloeosporioides* for control of northern jointvetch in soybeans and rice

**DeVine®** - *Phytophthtora palmivora* for control of stranglevine

*Alternaria cassiae* for control of sicklepod in soybean/peanuts (Mycogen®)

**Phoma** (Karen Bailey and Susan Boyetchko – AAFC)

*Xanthomonas* sp. and *Pseudomonas* sp.
Success has been difficult to achieve:

1. Often too target specific, limits market opportunities
2. Limited shelf-life, have to be viable to function as pathogens
3. Limited market opportunity prevents efficiencies gained through fermentation scale
4. Require specific environmental conditions for good efficacy
Marrone Bio Innovations

**Opportune® (MBI-005)** - 17% killed, non-viable *Streptomyces acidiscabies* strain RL-110\(^T\) cells and spent fermentation media. Also registered in Canada. Pre-emergent activity against grass species and post-emergent activity against certain broadleaf plants.

**MBI-012** - 94.46% heat-killed *Burkholderia rinojensis* strain A396 cells and spent fermentation media, aqueous-based formulation sold as Venerate or Venerate XC.
MBI-005 – Selective Rice and Turf Bioherbicide

- Broad spectrum control of broadleaves and sedges
- Bacterial compound (thaxtomin A) produced by fermentation; nontoxic to rats, fish, birds, Daphnia
- No phytotoxicity on rice or turf grass
Cellulose Synthesis Inhibitor

Lambsquarter – 7DAT

Dandelion – 7DAT

Velvetleaf – 14DAT

Sunflower – 7DAT
Excellent (smallflower umbrella) sedge control post
## Post Control of Turf Weeds

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Stunting to turf</th>
<th>Rose Clover % control</th>
<th>Oxalis % Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>UTC</td>
<td>0 a</td>
<td>0 c</td>
<td>0 b</td>
</tr>
<tr>
<td>MBI-005 (2 gal/acre)</td>
<td>0 a</td>
<td>45 b</td>
<td>100 b</td>
</tr>
<tr>
<td>MBI-005 (4 gal/acre)</td>
<td>0 a</td>
<td>50 b</td>
<td>100 b</td>
</tr>
<tr>
<td>Battleship (4pt/a)</td>
<td>0 a</td>
<td>62.5 a</td>
<td>100 b</td>
</tr>
<tr>
<td>Speed Zone (6pt/a)</td>
<td>0 a</td>
<td>67.5 a</td>
<td>100 b</td>
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</tbody>
</table>

- *Oxalis pes-caprae* (Bermuda buttercup) highly controlled
Pre-Emergent Spectrum in Field Trials – *Poa annua*
So what’s the problem? Cost of goods
Marrone Bio Innovations

**MBI-012** - heat-killed *Burkholderia rinojensis* strain A396 cells and spent fermentation media, aqueous-based and WDG formulations in development. The WDG appears the to be the best route to a commercially viable formulation.
Herbicide Screening
Basta - Glufosinate ammonium

- Phosphinothricin (a breakdown product of bialaphos) discovered from *Streptomyces viridochromogenes* and *S. hygroscopicus*

- Inhibits the activity of the glutamine synthetase enzyme, which causes ammonia build-up in the cell.
Screening for Systemic Mode of Action

- Used glufosinate (Basta®) as a model – molecule originally found from a *Streptomyces*
- Purified glutamine synthetase enzyme – the main enzyme involved with glufosinate
- Screened thousands of extracts against this enzyme
- We selected several candidates for further testing – A396 (=MBI 010/012) showed herbicidal activity in the in vivo test as well (new species of *Burkholderia*)
<table>
<thead>
<tr>
<th>Compounds</th>
<th>Grass Seedlings (% Mortality)</th>
<th>Lettuce Seedlings (% Mortality)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Templamide A (1)</td>
<td>100</td>
<td>88</td>
</tr>
<tr>
<td>Templamide B (2)</td>
<td>0</td>
<td>75</td>
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<tr>
<td>FR901465 (3)</td>
<td>88</td>
<td>100</td>
</tr>
<tr>
<td>FR901228 (4)</td>
<td>100</td>
<td>88</td>
</tr>
<tr>
<td>Templazole A</td>
<td>ND</td>
<td>63</td>
</tr>
<tr>
<td>Templazole B</td>
<td>ND</td>
<td>77</td>
</tr>
<tr>
<td>Control (Water)</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

New

Templamide A (1)

Templamide B (2)

FR901465 (3)

FR901228 (4)

Templazole A

Templazole B
New Herbicide in Our Pipeline (MBI-010/012)

Treating **one** petiole/plant kills leaf quickly and subsequently stunts entire plant

- Kills several glyphosate resistant weeds
- New mode of action
- Xylem-mobile

Water

3 DAT  MBI-010/012  14 DAT
Next Steps in Development of MBI-012

- Finalize production and formulation parameters
- Conduct broad level crop safety studies on field and specialty crops (IR-4)
- Conduct broad level efficacy studies against weed species (IR-4)
- Evaluate effects of different classes of adjuvants
- Evaluate MBI-012 in combination with other herbicides
- Confirm shelf-life under various conditions
- If all is good, write label, complete toxicology studies and submit to EPA
Questions?

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