Rotating New Chemistries in Potato Pest Management

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Potato production in Wisconsin

- ca. 63,500 acres annually, estimated 267 million dollars
- fresh, processed (chips/frozen/dehydrated), or seed potatoes

**Major commercial varieties**
- Russet Burbank
- Yukon Gold
- Dark Red Norland
- Atlantic
Key pests of Wisconsin Potato

- **Potato leafhopper** (*Empoasca fabae*)
- **Colonizing Aphids** (*Myzus persicae* & *Macrosiphium euphorbiae*)
- **Colorado potato beetle** (*Leptinotarsa decemlineata*)
Dormancy & crop colonization

- Overwinter in non-crop habitats
- Dormancy habitats close to previous year potato
- Diapause 20-60cm in the soil
- Duff layers and snow cover lessens mortality
- Colonize crop by walking
Colonization and egg deposition

- Field edges colonized first
- Minimal adult feeding
- Yellow/orange egg masses
- 20-40 eggs/mass
- Adults lay eggs on underside of leaves
Larvae and Associated Damage

- Egg hatch in 1-2 weeks depending on temperature
- Small larvae move to leaf terminals
- 4 instars, 5-7 days per instar
- Large larvae (3 & 4) feed extensively
- 4th instars leave plant and pupate in soil for 2-3 weeks
Summer Generation Adults

- 2-3 generations per summer
- 1st summer generation emerges in July
- Very active and hungry
- Rapid defoliation
- Second generation adults leave to overwinter
- Can be partial 3rd generation
IPM and Methods of Control
US Insecticide Market

- $48 million spent in potatoes for insect control in 2010.
- Key pests by expenditure in $millions include:

<table>
<thead>
<tr>
<th>Pest</th>
<th>Expenditure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colorado potato beetle</td>
<td>$25.3</td>
</tr>
<tr>
<td>Green peach aphid</td>
<td>$12.4</td>
</tr>
<tr>
<td>Lepidoptera (BAW, looper, ECB)</td>
<td>$4.1</td>
</tr>
<tr>
<td>Potato aphid</td>
<td>$3.5</td>
</tr>
<tr>
<td>Potato leafhopper</td>
<td>$2.3</td>
</tr>
<tr>
<td>Potato psyllid</td>
<td>$1.5</td>
</tr>
</tbody>
</table>
Almost half of the insecticide expenditure ($23.6MM) is on two active ingredients, imidacloprid (Admire, Gaucho) and thiamethoxam (Cruiser, Platinum).

Both are in the same class of chemistry.

Length of control is getting shorter.

Resistance is growing to this class of chemistry (neonicotinoids – ‘neonics’).
<table>
<thead>
<tr>
<th>Insecticide</th>
<th>1&lt;sup&gt;st&lt;/sup&gt; Introduced</th>
<th>1&lt;sup&gt;st&lt;/sup&gt; Failed</th>
<th>Chemical Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbaryl</td>
<td>1957</td>
<td>1958</td>
<td>Carbamate</td>
</tr>
<tr>
<td>Azinphosmethyl</td>
<td>1959</td>
<td>1964</td>
<td>OP</td>
</tr>
<tr>
<td>Phosmet</td>
<td>1973</td>
<td>1973</td>
<td>OP</td>
</tr>
<tr>
<td>Phorate</td>
<td>1973</td>
<td>1974</td>
<td>OP</td>
</tr>
<tr>
<td>Carbofuran</td>
<td>1974</td>
<td>1976</td>
<td>Carbamate</td>
</tr>
<tr>
<td>Oxamyl</td>
<td>1978</td>
<td>1978</td>
<td>Carbamate`</td>
</tr>
<tr>
<td>Fenvalerate</td>
<td>1979</td>
<td>1981</td>
<td>Pyrethroid</td>
</tr>
<tr>
<td>Permethrin</td>
<td>1979</td>
<td>1981</td>
<td>Pyrethroid</td>
</tr>
<tr>
<td>Fenvalerate + PBO</td>
<td>1982</td>
<td>1983</td>
<td>Pyrethroid +</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>synergist</td>
</tr>
<tr>
<td>Esfenvalerate + PBO</td>
<td>1983</td>
<td>1984</td>
<td>Pyrethroid +</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>synergist</td>
</tr>
<tr>
<td>Imidacloprid</td>
<td>1995</td>
<td>2000</td>
<td>Nicotinyl</td>
</tr>
</tbody>
</table>
Systemic Neonicotinyl Insecticides

Beneficial Attributes

- **Broad spectrum**
  - CPB, leafhoppers, aphids

- **Flexible**
  - Row mark, furrow, seed, layby

- **Long residual**
  - Rate dependent

- **Low toxicity**

Disadvantages

- **Same chemical class**
- **Resistance likely**
Wisconsin, 2011 Imidacloprid Bioassays

- Topical Assays (2007-11)
- 6 populations
  \( \text{LC}_{50} \) range (0.02 – 4.46)
**Rate of CPB Development**

<table>
<thead>
<tr>
<th>Life stage</th>
<th>DD52</th>
<th>Accum DD</th>
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</thead>
<tbody>
<tr>
<td>Egg</td>
<td>120</td>
<td>120</td>
</tr>
<tr>
<td>1(^{st}) instar</td>
<td>65</td>
<td>185</td>
</tr>
<tr>
<td>2(^{nd}) instar</td>
<td>55</td>
<td>240</td>
</tr>
<tr>
<td>3(^{rd}) instar</td>
<td>60</td>
<td>300</td>
</tr>
<tr>
<td>4(^{th}) instar</td>
<td>100</td>
<td>400</td>
</tr>
<tr>
<td>Pupa</td>
<td>275</td>
<td>675</td>
</tr>
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</table>
Colorado Potato Beetle Management
Development and Defoliation Thresholds

- 20% Defoliation (pre-flower) and < 10-15% (post-flower)
- Population Development Thresholds (eggs, larvae)

<table>
<thead>
<tr>
<th>Month</th>
<th>1st Gen CPB</th>
<th>2nd Gen CPB</th>
</tr>
</thead>
<tbody>
<tr>
<td>15-Mar</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14-Apr</td>
<td></td>
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<tr>
<td>14-May</td>
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<tr>
<td>13-Jun</td>
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<td>13-Jul</td>
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<td>12-Aug</td>
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<td>11-Sep</td>
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<tr>
<td>11-Oct</td>
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</tbody>
</table>

At-plant systemic

Potato Crop
Colorado Potato Beetle Management Development and Defoliation Thresholds

- 20% Defoliation (pre-flower) and < 10-15% (post-flower)

- Population Development Thresholds (eggs, larvae)

![Diagram showing Colorado Potato Beetle life cycle and management strategies](image)
Factors Influencing Insect Pest Management

‘Food Safety’

– Major food retailers are setting acceptable residue levels below those set by government regulatory agencies.

“No detectable residues” will be a competitive advantage for food retailers.

– Older insecticides that do not meet these requirements are not being re-registered, resulting in increased use of novel insecticides (reduced-risk or bio-pesticides).
Reduced Risk Foliar Options

- **Radiant® (spinetoram) & Blackhawk® (spinosad)**
  - MoA group 5
    - Use rate 4.5 – 8 fl oz / ac
    - Control of nymphal psyllids and CPB

- **Rimon® 0.83 EC (novaluron)**:
  - Chitin biosynthesis inhibitors (MoA Group 15)
    - Use rate 9 – 12 fl oz / ac (foliar) – control of CPB eggs and larvae
    - Currently not registered for psyllids

- **Agri-Mek® 0.15EC & 0.7SC (abamectin)**:
  - Chloride channel activator (MoA Group 6)
    - Use rate 8 – 16 fl oz / ac (foliar)
    - Control of adult & nymphal psyllids, CPB larvae
    - Abba, Epi-Mek, Athena, Raptor, etc…
Reduced Risk Foliar Options - New Registrations

- **Voliam Flexi® (chlorantraniliprole + thiamethoxam)**
  - MoA groups 28 + 4A
  - Use rate 4 oz / ac (CPB)
  - Control of CPB adults and larvae, PLH, aphids, and Leps

- **Besiege® (lambda-cyhalothrin + chlorantraniliprole)**
  - MoA groups 3 + 28
  - Use rate 6 – 9 fl oz / ac (CPB)
  - Control of CPB adults and larvae, PLH, aphids, and Leps

- **Endigo® ZC (lambda-cyhalothrin + thiamethoxam)**
  - MoA groups 3 + 4A
  - Use rate 2.5 – 4.5 fl oz / ac (CPB)
  - Control of CPB, adults and larvae, PLH, aphids, and Leps
Reduced Risk Foliar and In-Furrow Options - New Registrations

- **Coragen™ (rynaxypyr)**
  - Anthranillic diamide (MoA group 28)
  - Use rate 3.5 - 5 oz / ac (CPB)
  - Control of CPB adults and larvae – no effect on psyllids

- **Benevia™ / Verimark™ (cyazypyr)**
  - Anthranillic diamide (MoA group 28)
  - Use rate 3.5 - 5 oz / ac (CPB)
  - Control of CPB adults and larvae, Leps, and psyllids

* Water soluble, systemically mobile insecticides
** Not currently registered
Colorado Potato Beetle Management Hypothetical Program (No systemic)

- No at-plant neonicotinoid – 1st generation RR-foliar (Rimon® 0.83EC)

- 2nd generation foliar (neonicotinoid)

![Image of Colorado Potato Beetle](image)

- **Rimon® 0.83EC** (9.0, 8.0, 7.0 fl oz)
- **Actara® 25WG** (@ 3.0 & 2.5 fl oz)

**Potato Crop**

- 15-Mar
- 14-Apr
- 14-May
- 13-Jun
- 13-Jul
- 12-Aug
- 11-Sep
- 11-Oct
Colorado Potato Beetle Management Hypothetical Program (At-Plant)

- At-plant neonicotinoid plus RR-foliar (Agri-Mek® 0.7SC)
- 2nd generation foliar (Coragen® 1.67SC)

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Need to protect potato crop from CPB for 6-8 weeks

Development threshold = 1st and 2nd instar stadia

1st Gen CPB
Coragen 1.67SC (@ 5.0 & 3.5 oz)

2nd Gen CPB
Platinum 75SG (@ 2.67 oz)

Agri-Mek 0.7SC (@ 2.6 & 2.3 oz)
Colorado Potato Beetle Management Hypothetical Program (Not Advised!!)

- At-plant neonicotinoid plus RR-foliar (Coragen® 1.67SC)
- 2nd generation foliar (Besiege®)

**Hypothetical Program**

15-Mar
14-Apr
14-May
13-Jun
13-Jul
12-Aug
11-Sep
11-Oct

- Vine Kill
- 1st Gen CPB
- Potato Crop
- 2nd Gen CPB

**Crop Protection**

- **1st Gen CPB**
  - Platinum® 75SG (@ 2.67 oz)

- **2nd Gen CPB**
  - Coragen® 1.67SC (@ 5.0 & 3.5 oz)
  - Besiege® (@ 9.0 & 6.5 oz)

**Need to protect potato crop from CPB for 6-8 weeks**

**Development threshold**

- 1st and 2nd instar stadia

**Not Advised!!**
General Positioning Guidelines

IRM guidelines below show least to best product rotation recommendations

Maintaining insect susceptibility greatly depends on rotation of Diamide insecticides with effective products with a different MOA that eliminate Diamide-resistant individuals. Rotation with products that provide poor control of the target pest increases the risk of developing Diamide resistance.

<table>
<thead>
<tr>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Gen</td>
<td>2nd Gen</td>
<td>1st Gen</td>
<td>2nd Gen</td>
</tr>
<tr>
<td>1st Gen</td>
<td>2nd Gen</td>
<td>1st Gen</td>
<td>2nd Gen</td>
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<tr>
<td>1st Gen</td>
<td>2nd Gen</td>
<td>1st Gen</td>
<td>2nd Gen</td>
</tr>
</tbody>
</table>

- **No alternation/rotation**
  - High selection pressure
  - No recovery of sensitive population.

- **Rotation within generation**
  - Consecutive generations exposed to same MoA. Selection pressure doesn’t change between generations. Risk of resistance development for both ai’s.

- **Rotation among generations**
  - Following generations are not exposed to same MoA. Selection pressure doesn’t increase within the generation. Recovery of susceptible population.

- **Rotation within and between**
  - Ideal situation (very low risk) Not always applicable with good efficacy.

Guidance for Diamide Country Groups, August 2010
Potato Psyllid Life History

The nymph stage usually lasts from 14 to 22 days.

Newly emerged adults remain green for a day or so before turning darker.

There are three generations annually in mid-latitudes, with larvae present in July, August, and September.
Potato Psyllid Sampling

Sweep net sampling

Mid-canopy, leaf sampling

Yellow sticky cards
**Potato Psyllid**

3-4 Generations / Year

- At-plant, in-furrow insecticides can be effective
- Ineffectiveness may result from arrival time of adult psyllids
- Full-season control achieved with well-timed, foliar applications

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Diagram:

- **1st Gen**: At-plant, in-furrow insecticides can be effective.
- **2nd Gen**:
  - Ineffectiveness may result from arrival time of adult psyllids.
- **3rd Gen**:
  - Full-season control achieved with well-timed, foliar applications.
- **4th Gen**:
  - Year-round control possible with proper insecticide application.

**Potato Crop**

- 1-Mar
  - 31-Mar
  - 30-Apr
  - 30-May
  - 29-Jun
  - 29-Jul
  - 28-Aug
  - 27-Sep
  - 27-Oct
  - 26-Nov
Complete canopy coverage

Perimeter applications during early colonization

Product selection based upon predominant stadia

Resistance management essential – rotation of insecticides as a series of successive applications

Avoid the use of synthetic pyrethroids
Full-Season Control
MoA Classes

- **Neonicotinoids – Group 4A**: AdmirePro, Platinum, Belay, Scorpion, Assail, Actara, Provado, Endigo, etc..

- **Spinosyns – Group 5**: Blackhawk, SpinTor, Radiant

- **Avermectins – Group 6**: Agri-Mek, Epi-Mek, Abba

- **Selective Feeding Blockers - Group 9**: Fulfill, Beleaf

- **Lipid Biosynthesis Inhibitors – Group 23**: Oberon, Movento

- **Anthranilic diamides - Group 28**: Benevia**, Verimark**

**Not currently registered in potato**
Potato Psyllid - Seasonal Control Program

- At-plant, in-furrow insecticides can be effective
- Ineffectiveness may result from arrival time of adult psyllids
- Full-season control achieved with well-timed, foliar applications

**Not currently registered for use in potato**

Need to protect potato crop from potato psyllid for 8-10 weeks

- **1st Gen**
  - Platinum® 75SG (2.67 oz)
  - Admire® Pro (8.7 fl oz)
  - Belay® (12 fl oz)
  - **Verimark™ 20SC**

- **2nd Gen**
  - Movento® (5 fl oz)
  - Agri-Mek® SC (3.5 fl oz)

- **3rd Gen**
  - Fulfill® 50WDG (5.5 fl oz)

- **4th Gen**
  - Radiant® SC (8.0 fl oz)

Potato Crop

http://www.entomology.wisc.edu/vegento/

Questions??