## Wisconsin Vegetable Production Statistics (Wis. Ag. Stats. 2010)

<table>
<thead>
<tr>
<th>Crop</th>
<th>Nat. Rank</th>
<th>Acres</th>
<th>% of U.S.</th>
<th>$ Value (millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Major crops</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potatoes</td>
<td>3 or 4</td>
<td>63,500</td>
<td>8</td>
<td>$242</td>
</tr>
<tr>
<td>Sweet corn (Proc)</td>
<td>1</td>
<td>88,900</td>
<td>21</td>
<td>$97</td>
</tr>
<tr>
<td>Sweet corn (Fresh)</td>
<td>--</td>
<td>7,700</td>
<td>--</td>
<td>$21</td>
</tr>
<tr>
<td>Snap beans</td>
<td>1</td>
<td>82,300</td>
<td>38</td>
<td>$73</td>
</tr>
<tr>
<td>Peas</td>
<td>3</td>
<td>46,200</td>
<td>36</td>
<td>$32</td>
</tr>
<tr>
<td><strong>Minor crops</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cucumbers (pickles)</td>
<td>4</td>
<td>7,100</td>
<td>11</td>
<td>$13</td>
</tr>
<tr>
<td>Cabbage (fresh)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cabbage (kraut)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carrots</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Onions (storage)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beets (table)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Small-acreage fresh market production continues to expand. Anecdotal statistics estimate ca. 1,900 small-acreage producers that grow over 50 crops in Wisconsin.
Wisconsin Vegetable Pest Management

Options for Insect Pest Management – *More than ever before!*

- Cultural controls
- Host plant resistance
- Transgenic plants IR traits
- Natural enemies
- Reduced-Risk Chemical Insecticides
- Baits and baiting systems
- Population disruption
- Entomopathogens

Vegetable IPM
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).
Factors Influencing Insect Pest Management

‘Environmental Concerns’

– With increasing affluence reaching the developing world, there will be increasing concerns about pesticide usage and perceived environmental effects.

– This will accelerate the shift to “softer” products and technologies.
Systemic Neonicotinyl Insecticides

Beneficial Attributes

- Effective on pyrethroid resistant CPB’s
- Broad spectrum
  - CPB, leafhoppers, aphids
- Flexible
  - Row mark, furrow, seed, layby
- Long residual
  - Rate dependant
- Low toxicity
  - “Healthy Grown”

Disadvantages

- Same chemical class
- Resistance likely
Sustainable Potato IPM

- Detection and management of insecticide resistance
- Reduced – risk management alternatives
- New approaches to achieve sustainable insect pest management
Michigan, 2005 Imidacloprid Bioassays

Byrne and Graffius (2006): 15 populations, LC$_{50}$ range (0.03 – 4.06)

Note: * = significantly greater than LD$_{50}$ for susceptible population
Wisconsin, 2007 - 10 Imidacloprid Bioassays

Survey Sites:
- Adams County (11)
- Dane County (2)
- Iowa County (1)
- Langlade County (8)
- Oconto County (1)
- Portage County (15)
- Waushara County (13)

Total: (51)

CPB Populations:
- Over-wintered adult
- 2nd generation adult

Adult Topical Bioassays:
Topical Bioassays

• Collections of up to 300-600 adult beetles per site were obtained.

• Serial, 2X dilutions of imidacloprid were prepared in acetone and used for all adult CPB screens

• Topical applications of 1 µl insecticide solution/beetle.

• Preliminary screens used to choose five doses.
  – targeting >0% and <100% mortality.
Results
Assessment

- Beetle response assessed 7 days post treatment.
  - walking = able to walk forward normally
  - poisoned = legs extended and shaking, unable to walk forward in coordinated manner
  - dead = abdomen shrunken, elytra dark
Wisconsin, 2007
Imidacloprid Bioassays

Preliminary Assays (2007): 35 populations,
LC$_{50}$ range (0.021 – 1.355)
Wisconsin, 2008
Imidacloprid Bioassays

Preliminary Assays (2008): 31 populations, LC$_{50}$ range (0.018 – 1.33)

Reported field control
- **Good**
- **Fair**
- **Poor**

LD$_{50}$ (µg/beetle)

- 1.5
- 1.2
- 0.9
- 0.6
- 0.3
- 0.0

Location
Preliminary Assays (2009): 24 populations, 
$\text{LC}_{50}$ range (0.029 – 0.832)
<table>
<thead>
<tr>
<th>County</th>
<th>Site</th>
<th>( (P&lt;0.0001) ) ((\alpha=0.05))</th>
<th>Estimated slope</th>
<th>( \text{LD}_{50} ) ((\pm 95% \text{ CL}))</th>
<th>Resistance Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adams</td>
<td>A</td>
<td>((P=0.0008))</td>
<td>12.6% ± 1.7</td>
<td>0.616 (0.454–0.793)</td>
<td>0.616 / 0.024 (25.7)</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>((P=0.0451))</td>
<td>9.9% ± 2.5</td>
<td>0.437 (0.377–0.504)</td>
<td>0.437 / 0.024 (18.2)</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>((P=0.0103))</td>
<td>8.2% ± 2.8</td>
<td>0.347 (0.143–0.486)</td>
<td>0.347 / 0.024 (14.5)</td>
</tr>
<tr>
<td></td>
<td>D</td>
<td>((P=0.0284))</td>
<td>6.8% ± 1.2</td>
<td>0.071 (0.029–0.097)</td>
<td>0.071 / 0.024 (3.0)</td>
</tr>
<tr>
<td></td>
<td>E</td>
<td>((P=0.0095))</td>
<td>8.3% ± 2.7</td>
<td>0.059 (0.018–0.088)</td>
<td>0.059 / 0.024 (2.5)</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>((P=0.0128))</td>
<td>7.7% ± 1.8</td>
<td>0.146 (0.098–0.479)</td>
<td>0.146 / 0.024 (6.1)</td>
</tr>
<tr>
<td></td>
<td>G</td>
<td>((P&lt;0.0001))</td>
<td>10.8% ± 2.4</td>
<td>0.014 (0.001–0.021)</td>
<td>0.014 / 0.024 (0.6)</td>
</tr>
<tr>
<td></td>
<td>H</td>
<td>((P=0.0983))</td>
<td>5.9% ± 1.2</td>
<td>0.096 (0.038–0.176)</td>
<td>0.096 / 0.024 (4.0)</td>
</tr>
<tr>
<td></td>
<td>I</td>
<td>((P=0.0127))</td>
<td>9.1% ± 3.2</td>
<td>0.184 (0.083–0.273)</td>
<td>0.184 / 0.024 (7.7)</td>
</tr>
<tr>
<td></td>
<td>J</td>
<td>((P=0.0062))</td>
<td>7.1% ± 0.8</td>
<td>0.055 (0.016–0.339)</td>
<td>0.041 / 0.024 (1.7)</td>
</tr>
<tr>
<td></td>
<td>K</td>
<td>((P=0.0077))</td>
<td>9.4% ± 2.7</td>
<td>0.115 (0.089–0.150)</td>
<td>0.115 / 0.024 (4.8)</td>
</tr>
<tr>
<td></td>
<td>L</td>
<td>((P=0.0517))</td>
<td>11.2% ± 2.6</td>
<td>0.049 (0.040–0.059)</td>
<td>0.049 / 0.024 (2.0)</td>
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<tr>
<td></td>
<td>M</td>
<td>((P=0.0789))</td>
<td>4.9% ± 2.1</td>
<td>0.031 (0.009–0.113)</td>
<td>0.031 / 0.024 (1.3)</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>((P=0.0192))</td>
<td>6.1% ± 1.7</td>
<td>0.185 (0.082–0.371)</td>
<td>0.185 / 0.024 (7.7)</td>
</tr>
<tr>
<td></td>
<td>O</td>
<td>((P=0.0522))</td>
<td>7.9% ± 0.9</td>
<td>0.264 (0.102–0.417)</td>
<td>0.264 / 0.024 (11.0)</td>
</tr>
<tr>
<td></td>
<td>P</td>
<td>((P=0.0003))</td>
<td>8.1% ± 3.1</td>
<td>0.202 (0.135–0.308)</td>
<td>0.202 / 0.024 (8.4)</td>
</tr>
<tr>
<td></td>
<td>Q</td>
<td>((P=0.0803))</td>
<td>9.4% ± 2.5</td>
<td>0.358 (0.159–0.521)</td>
<td>0.358 / 0.024 (14.9)</td>
</tr>
<tr>
<td></td>
<td>R</td>
<td>((P=0.0104))</td>
<td>7.4% ± 2.1</td>
<td>0.310 (0.194–0.436)</td>
<td>0.310 / 0.024 (12.9)</td>
</tr>
</tbody>
</table>
Neonicotinoid Insensitivity: CPB Survivorship

Seasonal, in-plant [imidacloprid]

Days (post-application)

Imidacloprid [ppm]
Measuring Resistance

- LD$_{50}$ (or LC$_{50}$) = dose (or concentration) that is lethal to 50% of the test population under defined conditions.

- LD$_{90}$ = dose that is lethal to 90% of the test population.
Log dose vs. probit mortality plot

- Susceptible
- Intermediate
- Resistant

Log dose vs. Probit mortality

- LD$_{50}$
- LD$_{90}$

$\Delta$ susceptibility (slope)
Susceptibility continues in 2010

Δ

Dose (log ppm)

% Mortality (probit scale)

Sensitive

Developing Insensitivity

Resistant

NJ CPB LD$_{50}$ = 0.029
Insecticide Resistance Management (IRM): Nicotinyl Insecticides

The Challenge!

Maintaining the effectiveness of nicotinyl insecticides:

- Admire, Provado, Gaucho, Genesis, Leverage, Platinum, Actara, Cruiser, Belay
- All are in same MoA class = 4
- Represent the backbone of CPB management
- Resistance already reported in several Midwest and Eastern U.S. production areas
Insecticide Resistance Management (IRM): Principles

I. **Problem Identification**: If you suspect resistance, first eliminate other possible causes.

Lack of control can be attributed to application error, equipment failure, or less-than-optimal environmental conditions.

II. **Product Rotation**: Avoid the consecutive use of a single product, or multiple products with similar modes of action. Insecticide Resistance Action Committee (IRAC) has developed and updates a Mode of Action (MoA) classification system.

http://www.irac-online.org/


- rotate different modes of action across generations

- successive foliar applications
Mode of Action Classification

IRAC
Insecticide Resistance Action Committee

The Key to Resistance Management

More information on IRAC and the Mode of Action Classification is available from: www.irac-online.org or enquiries@irac-online.org

Group 1: Analytical class (AGIs) Inhibitors (a polyvalent representation of key active ingredients)

1A Carbamates

Group 2: GLyA-based chloroalkane anticholinesterases (SAs)

2A Organophosphates

Group 3: Glutathione-S-transferase (GSTs)

3A Pyrethroids

Group 4: Nicotinic acetylcholine receptor (nACHR) agonists

4A Neonicotinoids

Group 5: Aqueous non-specific methyl ester inhibitors

5A Carbamates

Group 6: Nicotinic acetylcholine receptor (nACHR) agonists

6A Organophosphates

Group 7: Juvenile hormone analogues

7A Juvenile hormone analogues

Group 8: Chloride channel activators

8A Pyrethroids

Group 9: Miscellaneous non-specific multi-site inhibitors

9A Allyl halides

Group 10: Mitochondrial complex I inhibitors

10A Chlorothalonil, Iprodione

Group 11: Mitochondrial complex II and III electron transport inhibitors

11A Nebenmycin, Spirothiazole

Group 12: Voltage-dependent sodium channel blockers

12A Ivermectin, Abamectin

Group 13: Mitochondrial complex IV electron transport inhibitors

13A Catecholamines, Dithiocarbamates

Group 14: Nicotinic acetylcholine receptor (nACHR) channel blockers

14B Organophosphates

Group 15: Other (various)

15B Pyrazole, Dinitroaniline, Pyridazone

Group 16: Mitochondrial complex V electron transport inhibitors

16A Benzimidazoles, Carbamates

Group 17: Resistance modifier modulators

17A Pyrimethanil, Thiamethoxam

Group 18: Inhibitors of cytochrome b5 monoxygenase

18A Phthalimide, Pyrimidines

Group 19: Miscellaneous (various)

19A Pyrazole, Dinitroaniline, Pyridazone

Group 20: Mitochondrial complex I electron transport inhibitors

20A Dithiocarbamates, Fungicides

Group 21: Miscellaneous (various)

21A Azaflavin, Dithiocarbamates

Group 22: Mitochondrial complex III electron transport inhibitors

22A Metamidophos, Tetramic acid derivatives

Group 23: Miscellaneous (various)

23A Pyrazole, Dinitroaniline, Pyridazone

Group 24: Mitochondrial complex II and III electron transport inhibitors

24A Dithiocarbamates, Fungicides

Group 25: Miscellaneous (various)

25A Pyrazole, Dinitroaniline, Pyridazone

Group 26: Mitochondrial complex IV and V electron transport inhibitors

26A Dithiocarbamates, Fungicides

Group 27: Resistance modifier modulators

27A Pyrazole, Dinitroaniline, Pyridazone

Group 28: Miscellaneous (various)

28A Pyrazole, Dinitroaniline, Pyridazone
Insecticide Resistance Management (IRM): Principles

III. *Rates and Spray Intervals:* Use insecticides at labeled rates and follow prescribed spray intervals. Do not reduce or increase rates from labeled recommendations as this can hasten resistance development. Use products at their full, recommended doses. Reduced (sub-lethal) doses quickly select populations with average levels of tolerance, whereas high doses impose excessive selection pressures.

IV. *Cultural Control(s):* Where possible, consider adopting all non-chemical techniques suppress pest populations, including crop rotation. Rotations > 400 m (¼ mile) away from previous potato crop.

V. *Pest Surveillance and Scouting:* Monitor the pest population and track stages of development. Reduced-risk foliar insecticides generally require accurate timing of applications against susceptible life stages.
Insecticide Resistance Management (IRM): Principles

VIII. Tank Mixes: Mixtures may offer a short-term solution to resistance problems, but it is essential to ensure that each component of a mixture belongs to a different insecticide mode of action class, and that each component is used at its full rate.

- Compounds should persist on the crop or surface for similar periods in order to avoid sub-lethal exposure

- Acute toxicity of each compound should be equal at full labeled rates

bifenthrin / imidacloprid

lambda-cyhalothrin / thiamethoxam

chlorantraniliprole / thiamethoxam
Sustainable Potato IPM

- Detection and management of insecticide resistance
- Reduced – risk management alternatives
- New approaches to achieve sustainable insect pest management
Reduced Risk Foliar Options (CPB)

- **Radiant™ (spinetoram)**
  - MoA group 5
  - Use rate 4.5 – 8 fl oz / a (CPB)
  - Control of CPB, early & late larvae and Leps

- **Rimon 0.83 EC (novaluron):**
  - Chitin biosynthesis inhibitors (MoA Group 15)
  - Use rate 9 – 12 fl oz / ac (foliar)
  - Control of CPB larvae only, and Leps
  - Timing critical (80% egg deposition - 20% egg hatch)

- **Agri-Mek 0.15EC (abamectin):**
  - Chloride channel activator (MoA Group 6)
  - Use rate 8 – 16 fl oz / ac (foliar)
  - Control of CPB larvae only
  - Temprano & Abba
Reduced Risk Foliar Options (CPB) 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

- **Voliam Xpress®** *(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, and aphids
Reduced Risk Foliar and In-Furrow Options (CPB) New Registrations

- **Coragen™ (rynaxypyr)**
  - Anthranillic diamide (MoA group 28)
  - Use rate 3.5 - 5 oz / ac (CPB)
  - Control of CPB adults and larvae and Leps

- **HGW86 (cyazypyr)**
  - Anthranillic diamide (MoA group 28)
  - Use rate 3.5 - 5 oz / ac (CPB)
  - Control of CPB adults and larvae, leafhoppers, aphids, and Leps

* Water soluble, systemically mobile insecticides
** Not currently registered
## Full Season Insect Control

**Hancock, WI (2009)**

### 5 – Systemic Based, Full-Season Management Programs

<table>
<thead>
<tr>
<th>1) Cruiser 5FS (0.16 fl oz/ cwt)</th>
<th>4) Belay 16 WSG (12.0 fl oz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voliam Xpress (8.0 fl oz)**</td>
<td>Coragen 1.67SC (3.5 fl oz)</td>
</tr>
<tr>
<td>Voliam Xpress (6.0 fl oz)</td>
<td>Coragen 1.67SC (3.5 fl oz)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2) AdmirePro (8.7 fl oz/A)</th>
<th>5) Belay (0.6 fl oz/cwt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regent 4SC (3.2 fl oz/A)</td>
<td>Alverde (4.5 fl oz/A)**</td>
</tr>
<tr>
<td>Alverde (4.5 fl oz/A)**</td>
<td>Alverde (4.5 fl oz/A)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3) Platinum 2SC (8.0 fl oz/A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coragen 1.67SC (3.5 fl oz)</td>
</tr>
<tr>
<td>Coragen 1.67SC (3.5 fl oz)</td>
</tr>
</tbody>
</table>
3 – Foliar Based, Full-Season Management Programs (without neonicotinoids)

- **Radiant SC (8.0 fl oz/A)**
- **Radiant SC (6.0 fl oz/A)**
- **Coragen 1.67SC (5.0 fl oz)**
- **Coragen 1.67SC (3.5 fl oz)**

- **Rimon 0.83EC (12.0 fl oz/A)**
- **Rimon 0.83EC (8.0 fl oz/A)**
- **Alverde (4.5 fl oz/A)**
- **Alverde (4.5 fl oz/A)**

- **Novodor FC (2.75 L/A)**
- **Novodor FC (2.0 L/A)**
- **Entrust 80WP (2.0 oz/A)**
- **Entrust 80WP (2.0 oz/A)**

Note: To date, no PLH sprays required with systemic-based programs
# Full Season Insect Control

## Hancock, WI (2009)

### 7 – Foliar Based, Full-Season Management Programs (with neonicotinoids)

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>8)</td>
<td><strong>Agri-Mek 0.15EC (12.0 fl oz/A)</strong></td>
<td><strong>Agri-Mek 0.15EC (8.0 fl oz/A)</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Endigo ZC (4.5 fl oz/A)</strong></td>
<td><strong>Endigo ZC (3.0 fl oz/A)</strong></td>
</tr>
<tr>
<td>9)</td>
<td><strong>Alverde (4.5 fl oz/A)</strong></td>
<td><strong>Alverde (4.5 fl oz/A)</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Assail 30SG (4.0 oz/A)</strong></td>
<td><strong>Assail 30SG (4.0 oz/A)</strong></td>
</tr>
<tr>
<td>10)</td>
<td><strong>Assail 30SG (4.0 oz/A)</strong></td>
<td><strong>Assail 30SG (4.0 oz/A)</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Coragen 1.67SC (5.0 fl oz)</strong></td>
<td><strong>Coragen 1.67SC (3.5 fl oz)</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Coragen 1.67SC (3.5 fl oz)</strong></td>
<td><strong>Coragen 1.67SC (3.5 fl oz)</strong></td>
</tr>
<tr>
<td>11)</td>
<td><strong>Assail 30SG (4.0 oz/A)</strong></td>
<td><strong>Bifenture 2EC (2.5 fl oz/A)</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Assail 30SG (4.0 oz/A)</strong></td>
<td><strong>Bifenture 2EC (2.5 fl oz/A)</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Coragen 1.67SC (3.5 fl oz)</strong></td>
<td><strong>Coragen 1.67SC (3.5 fl oz)</strong></td>
</tr>
<tr>
<td>12)</td>
<td><strong>Assail 30SG (4.0 oz/A)</strong></td>
<td><strong>KFD 47-01ME (3.5 fl oz/A)</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Assail 30SG (4.0 oz/A)</strong></td>
<td><strong>KFD 47-01ME (3.5 fl oz/A)</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Coragen 1.67SC (3.5 fl oz)</strong></td>
<td><strong>Coragen 1.67SC (3.5 fl oz)</strong></td>
</tr>
</tbody>
</table>

**Note: Not currently registered on potato**
7 – Foliar Based, Full-Season Management Programs (with neonicotinoids) – cont.

14) Actara 25WDG (3.0 oz/A)
   Actara 25WDG (1.5 oz/A)
   Voliam Xpress (8.0 fl oz/A)
   Voliam Xpress (6.0 fl oz/A)

15) Agri-Mek 0.15EC (12.0 fl oz/A)
   Agri-Mek 0.15EC (8.0 fl oz/A)
   Voliam Flexi (4.0 fl oz/A)
   Voliam Flexi (3.0 fl oz/A)
2009, Reduced Risk Full-Season Control Programs: Mean US #1’s

Mean cwt US #1 / acre

Treatment Combinations

CruiserMaxx / V. Xpress
AdmirePro / Alverde
Platinum / Coragen
Belay / Coragen
Endigo / Alverde
Actara / V. Xpress
Agri-Mek / Voliam Flexi
Actara / Agri-Mek
Brigadier / Coragen
Radiant / Alverde
Rimon / Coragen
Blackhawk / Coragen
Radiant / Coragen
Novodor / Entrust

At-plant neonicotinoid
Foliar neonicotinoid
Foliar Reduced-Risk

P = 0.0049
Factors Influencing Insect Pest Management
‘Water Quantity and Quality’

• Decreasing availability of water for agriculture

- Agriculture is the overwhelming user of fresh water.
- Increasing urban demand will drive irrigation efficiency.
Wisconsin groundwater quantity & quality

- Wisconsin Department of Agriculture, Trade and Consumer Protection (DATCP)

- Proposed amendments to NR-151 (July 2011), groundwater management and groundwater advisory areas

- Proposed amendments to NR-140 (Dec 2011), groundwater quality standards (carbaryl, chlorpyrifos, aldicarb, etc...)
### Wisconsin groundwater quality: Thiamethoxam detections 2008-09

<table>
<thead>
<tr>
<th>Well</th>
<th>Date(s)</th>
<th>Concentration Range (parts per billion)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private well near Lone Rock</td>
<td>6/23/09 &amp; 6/9/09</td>
<td>0.693-1.26</td>
</tr>
<tr>
<td>Private Well near Arena</td>
<td>6/23/08</td>
<td>0.656</td>
</tr>
<tr>
<td>Private well near Edgerton</td>
<td>11/2/09</td>
<td>1.61</td>
</tr>
<tr>
<td>Monitoring well Adams County</td>
<td>2008 and 2009*</td>
<td>0.82-8.93</td>
</tr>
<tr>
<td>Monitoring well Grant County</td>
<td>4/7/08</td>
<td>1.25</td>
</tr>
<tr>
<td>Monitoring well Iowa County</td>
<td>2008 and 2009*</td>
<td>0.784-2.04</td>
</tr>
<tr>
<td>Monitoring well Iowa County</td>
<td>2008 and 2009*</td>
<td>0.671-2.85</td>
</tr>
<tr>
<td>Monitoring well Sauk County</td>
<td>2008 and 2009*</td>
<td>1.47-3.66</td>
</tr>
<tr>
<td>Monitoring well Waushara County</td>
<td>8/19/08 &amp; 12/1/08</td>
<td>0.638-0.704</td>
</tr>
</tbody>
</table>

- All monitoring wells in the results table are in areas with sandy soil and shallow depth to groundwater
- The monitoring well sites in Grant, Iowa, and Sauk Counties are located in the Lower Wisconsin River Valley
- The monitoring wells listed in the table are screened at or near the water table and adjacent to agric. fields
- The level of detection for thiamethoxam at the DATCP lab is 0.50 µg/l (parts per billion)
- There is no groundwater enforcement standard for thiamethoxam in Wisconsin
Research Goals: Insect Pest Management in Potato

- Extend the interval of control of current, water-soluble insecticide registrations
- Reduce (eliminate) the need for subsequent foliar applications ($$)
- Reduce (optimize) the amount of active ingredient required for adequate control
- Limit the potential for leaching and ground-water contamination
- Promote resistance management “high dose strategy”
Sustainable Potato IPM

- Detection and management of insecticide resistance
- Reduced – risk management alternatives
- New approaches to achieve sustainable insect pest management
Increasing the Interval of Control - Minimizing Sub-lethal Effects

![Graph showing imidacloprid concentrations over time for different strains.](image)

- **Current, in-plant imidacloprid**
- **Hypothetical, in-plant imidacloprid**

**Laboratory susceptible LD₅₀** = 0.031

**Field Strain LD₅₀** = 1.691

Days (post-application)
Modified Use Patterns: Extending the Interval of Control

- **Insecticide Injections:** (anhydrous knives)
- **Side Dress, Hill-Spray Applications:** (2\textsuperscript{nd} hilling)
- **Split Applications:** (in-furrow and starter)
## Side Dress Treatments: Hilling

<table>
<thead>
<tr>
<th>Treatment</th>
<th>fl oz/A</th>
<th>Large Larvae/10 plants</th>
<th>% Defoliation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>7/1 70 dap</td>
<td>7/8 77 dap</td>
</tr>
<tr>
<td>Belay (side)</td>
<td>12.0</td>
<td>7.1 a</td>
<td>4.3 a</td>
</tr>
<tr>
<td>(in-furrow)</td>
<td>12.0</td>
<td>5.2 a</td>
<td>6.8 a</td>
</tr>
<tr>
<td>Platinum (side)</td>
<td>2.67</td>
<td>8.9 a</td>
<td>7.3 a</td>
</tr>
<tr>
<td>(in-furrow)</td>
<td>2.67</td>
<td>5.8 a</td>
<td>6.1 a</td>
</tr>
<tr>
<td>AdmirePro (side)</td>
<td>8.7</td>
<td>5.2 a</td>
<td>11.7 a</td>
</tr>
<tr>
<td>(in-furrow)</td>
<td>8.7</td>
<td>6.6 a</td>
<td>9.2 a</td>
</tr>
<tr>
<td>Control</td>
<td>---</td>
<td>68.8 b</td>
<td>77.3 b</td>
</tr>
</tbody>
</table>

Note: At-plant systemic treatments applied 21 April 2009
CPB, Side-Dress Treatments: Hilling

Untreated Control

Belay® 12.0 fl oz / A

AdmirePro®, 8.7 fl oz / A

Platinum® 75 SG, 2.67 oz / A
## Split Application Treatments: 2nd Hilling

<table>
<thead>
<tr>
<th>Treatment (Seed)</th>
<th>Fl oz/A</th>
<th>Trt</th>
<th>Large Larvae/10 plants</th>
<th>% Defoliation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>7/1 70 dap</td>
<td>7/8 77 dap</td>
</tr>
<tr>
<td>Belay 0.5% NIS</td>
<td>4.8 / 4.8</td>
<td>Split</td>
<td>6.8 a</td>
<td>5.1 a</td>
</tr>
<tr>
<td></td>
<td>9.6</td>
<td>In-furrow</td>
<td>5.2 a</td>
<td>6.8 a</td>
</tr>
<tr>
<td>Platinum 0.5% NIS</td>
<td>4.0 / 4.0</td>
<td>Split</td>
<td>7.1 a</td>
<td>16.3 ab</td>
</tr>
<tr>
<td></td>
<td>8.0</td>
<td>In-furrow</td>
<td>8.9 a</td>
<td>7.3 a</td>
</tr>
<tr>
<td>AdmirePro 0.5% NIS</td>
<td>4.0 / 4.7</td>
<td>Split</td>
<td>18.2 b</td>
<td>22.7 b</td>
</tr>
<tr>
<td></td>
<td>8.7</td>
<td>In-furrow</td>
<td>5.2 a</td>
<td>11.7 a</td>
</tr>
<tr>
<td>Control</td>
<td>---</td>
<td>---</td>
<td>68.8 c</td>
<td>77.3 c</td>
</tr>
</tbody>
</table>

Note: At-plant systemic treatments applied 21 April 2009
Split Application Treatments: 2\textsuperscript{nd} Hilling

Belay\textsuperscript{®} 12.0 fl oz / A

Belay\textsuperscript{®} Split Appl. 6.0 fl oz / A
# Knife Injection Treatments: 2\textsuperscript{nd} Hilling

<table>
<thead>
<tr>
<th>Treatment (Seed)</th>
<th>fi oz/ A</th>
<th>Large Larvae/10 plants</th>
<th>% Defoliation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>7/1 70 dap</td>
<td>7/8 77 dap</td>
</tr>
<tr>
<td>Belay 2.13 SC</td>
<td>12.0</td>
<td>7.1 a</td>
<td>6.8 a</td>
</tr>
<tr>
<td>(knife)</td>
<td>12.0</td>
<td>3.4 a</td>
<td>5.9 a</td>
</tr>
<tr>
<td>Platinum 75SG</td>
<td>2.67</td>
<td>8.9 a</td>
<td>7.3 a</td>
</tr>
<tr>
<td>(knife)</td>
<td>2.67</td>
<td>6.2 a</td>
<td>4.5 a</td>
</tr>
<tr>
<td>AdmirePro</td>
<td>8.7</td>
<td>5.2 a</td>
<td>11.7 b</td>
</tr>
<tr>
<td>(knife)</td>
<td>8.7</td>
<td>2.7 a</td>
<td>3.9 a</td>
</tr>
<tr>
<td>Control</td>
<td>---</td>
<td>68.8 b</td>
<td>77.3 c</td>
</tr>
</tbody>
</table>

**Note:** At-plant systemic treatments applied 21 April 2008
Pesticide - Polyacrylate Impregnation

Polymers Inc.

Sand Suppression Polymers

Hydro-seeding polymers

Horticultural Polyacrylate
Neonicotinoid - Polyacrylate Impregnation Trials: HAES, 2008 - 2010

Insecticide Impregnated Polyacrylate (vacuum-dried)

Vacuum Oven
Neonicotinoid - Polyacrylate Impregnation Trials
HAES, 2008 - 2010

In-furrow Application
Vacuum Dried

Impregnated Polyacrylamide (in-furrow)
<table>
<thead>
<tr>
<th>Treatment Number</th>
<th>Product</th>
<th>Active Ingredient</th>
<th>Rate</th>
<th>Application Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Belay 2.13 SC</td>
<td>clothianadin</td>
<td>9.6 fl oz / A</td>
<td>In-furrow</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td>9.6 fl oz / A</td>
<td>Impregnated</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td>4.8 fl oz / A</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>AdmirePro</td>
<td>imidacloprid</td>
<td>8.7 fl oz / A</td>
<td>In-furrow</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td>8.7 fl oz / A</td>
<td>Impregnated</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td>4.4 fl oz / A</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Platinum 2SC</td>
<td>thiamethoxam</td>
<td>8.0 fl oz / A</td>
<td>In-furrow</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td>8.0 fl oz / A</td>
<td>Impregnated</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
<td>4.0 fl oz / A</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Coragen</td>
<td>rynaxypyr</td>
<td>5.0 fl oz / A</td>
<td>In-furrow</td>
</tr>
<tr>
<td>11</td>
<td></td>
<td></td>
<td>5.0 fl oz / A</td>
<td>Impregnated</td>
</tr>
<tr>
<td>12</td>
<td></td>
<td></td>
<td>2.5 fl oz / A</td>
<td></td>
</tr>
<tr>
<td>Treatment (No)</td>
<td>Appl. Type</td>
<td>Rate fl oz/A</td>
<td>Large Larvae/10 plants 7/3 7/10 7/17 7/17</td>
<td>% Defoliation 7/17</td>
</tr>
<tr>
<td>----------------</td>
<td>------------</td>
<td>--------------</td>
<td>-------------------------------------------</td>
<td>------------------</td>
</tr>
<tr>
<td>1. Belay</td>
<td>IF</td>
<td>9.6</td>
<td>3.8 a 9.8 a 16.3 a 17.9 a</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>IMP</td>
<td>9.6</td>
<td>0.4 b 0.1 b 2.1 b 0.8 b</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td></td>
<td>4.8</td>
<td>0.5 b 2.5 b 7.5 b 3.5 b</td>
<td></td>
</tr>
<tr>
<td>4. Admire</td>
<td>IF</td>
<td>8.7</td>
<td>10 a 23.3 a 29.5 a 16.5 a</td>
<td></td>
</tr>
<tr>
<td>Pro</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>IMP</td>
<td>8.7</td>
<td>1.1 c 0.6 c 1.8 c 0.4 b</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td></td>
<td>4.4</td>
<td>4.9 b 3.2 b 6.9 b 4.9 b</td>
<td></td>
</tr>
</tbody>
</table>

Note: At-plant treatments applied 29 April 2010
Application Type: IF = In-furrow; IMP = polyacrylate impregnated
### CPB, In-Furrow and Impregnations
HAES (2010)

<table>
<thead>
<tr>
<th>Treatment (No)</th>
<th>Appl. Type</th>
<th>Rate fl oz/A</th>
<th>Large Larvae/10 plants</th>
<th>% Defoliation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>7/3 73 dap</td>
<td>7/10 80 dap</td>
</tr>
<tr>
<td>7. Platinum</td>
<td>IF</td>
<td>8.0</td>
<td>2.2 a</td>
<td>6.9 a</td>
</tr>
<tr>
<td>8.</td>
<td>IMP</td>
<td>8.0</td>
<td>0.2 b</td>
<td>0.0 b</td>
</tr>
<tr>
<td>9.</td>
<td></td>
<td>4.0</td>
<td>1.9 ab</td>
<td>4.2 a</td>
</tr>
<tr>
<td>10. Coragen</td>
<td>IF</td>
<td>5.0 a</td>
<td>0.7 a</td>
<td>2.3 a</td>
</tr>
<tr>
<td>11.</td>
<td>IMP</td>
<td>5.0 a</td>
<td>0.0 a</td>
<td>0.4 b</td>
</tr>
<tr>
<td>12.</td>
<td></td>
<td>2.5 a</td>
<td>0.5 a</td>
<td>1.3 ab</td>
</tr>
</tbody>
</table>

Note: At-plant treatments applied 29 April 2010
Application Type: IF = In-furrow; IMP = polyacrylate impregnated
CPB, In-Furrow and Impregnations
HAES (2010): Mean US #1’s

<table>
<thead>
<tr>
<th>Treatments</th>
<th>IF (9.6 oz)</th>
<th>IMP (9.6 oz)</th>
<th>IMP (4.8 oz)</th>
<th>IF (8.7 oz)</th>
<th>IMP (8.7 oz)</th>
<th>IMP (4.4 oz)</th>
<th>IF (8.0 oz)</th>
<th>IMP (8.0 oz)</th>
<th>IMP (4.0 oz)</th>
<th>IF (5.0 oz)</th>
<th>IMP (5.0 oz)</th>
<th>IMP (2.5 oz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belay 2.13SC (P &lt; 0.0001)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AdmirePro (P = 0.0042)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Platinum 75SG (P &lt; 0.0001)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coragen 2SC (P = 0.0231)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Future Plans

- Investigate additional alternatives to extend the interval of control of water-soluble insecticides.

- Map in-plant concentrations of water soluble insecticides
Acknowledgements

Technical Support
Scott Chapman
Anders Huseth
Jolyn Rasmussen

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Wisconsin Potato and Vegetable Growers Assoc
DuPont Crop Protection
Bayer Crop Science
Syngenta Crop Protection
Gowan Company

QUESTIONS ??