Environmental Fate of Neonicotinoids

UWEX & WPVGA Grower Education Conference

February 2, 2012

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Total Impact of Specialty Crop Production and Processing

(Economic activity in $ millions per year)

<table>
<thead>
<tr>
<th>Specialty Crop Production and Processing</th>
<th>Total Economic Activity</th>
<th>Total Jobs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetable &amp; Fruit Production</td>
<td>$1,092</td>
<td>9,900</td>
</tr>
<tr>
<td>Potatoes</td>
<td>$349</td>
<td>2,770</td>
</tr>
<tr>
<td>Cranberries</td>
<td>$300</td>
<td>3,400</td>
</tr>
<tr>
<td>Sweet Corn</td>
<td>$83</td>
<td>660</td>
</tr>
<tr>
<td>Green Beans</td>
<td>$63</td>
<td>490</td>
</tr>
<tr>
<td>Green Peas</td>
<td>$26</td>
<td>200</td>
</tr>
<tr>
<td>Carrots, Cucumbers &amp; Onions</td>
<td>$28</td>
<td>220</td>
</tr>
<tr>
<td>Ginseng</td>
<td>$16</td>
<td>130</td>
</tr>
<tr>
<td>Specialty Crop Processing</td>
<td>$5,268</td>
<td>24,800</td>
</tr>
<tr>
<td>Total Impact</td>
<td>$6,360</td>
<td>34,700</td>
</tr>
</tbody>
</table>

1Production estimates based on 2006-2008 average farmgate values; processing estimates based on 2007 Economic Census values. Note: Sum of impacts may not equal total impact due to rounding.

Keene and Mitchell, 2010
$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>
US Insecticide Market

- 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’)
Insecticide Resistance Management (IRM): Nicotinyl Insecticides

The Challenge!

Maintaining the effectiveness of nicotinyl insecticides:

- Admire, Provado, Gaucho, Genesis, Leverage, Platinum, Actara, Cruiser, Belay, several generics...
- 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
Wisconsin, 2011 Imidacloprid Bioassays

- Topical Assays (2007-11)
- 6 populations
  \( \text{LC}_{50} \) range (0.02 – 4.46)
Colorado Potato Beetle Management
Development and Defoliation Thresholds

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

Development threshold = 1<sup>st</sup> and 2<sup>nd</sup> instar stadia

Need to protect potato crop from CPB for 6-8 weeks
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, leafhoppers, Leps, and psyllids

* Water soluble, systemically mobile insecticides
** Not currently registered
Reduced Risk Foliar Options

- **Radiant™ (spinetoram) Blackhawk (spinosad)**
  - MoA group 5
  - Use rate 4.5 – 8 fl oz / ac
  - Control of larval CPB and ECB

- **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 (abamectin):**
  - Chloride channel activator (MoA Group 6)
  - Use rate 8 – 16 fl oz / ac (foliar)
  - Control of adult & nymphal psyllids, CPB larvae
  - Temprano, Abba, Epi-Mek
Reduced Risk Foliar Options - New Registrations

- **Voliam Flexi® (chlorantraniliprole + thiamethoxam)**
  - MoA groups 28 + 4A
  - Use rate 4 oz / ac (CPB)
  - Control of adult and nymphal psyllids

- **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
Colorado Potato Beetle Management Hypothetical Program (No systemic)

- No neonicotinoid – 1st generation RR-foliar
- 2nd generation foliar (neonicotinoid)

Development threshold = 1st and 2nd instar stadia

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

- Rimon (@ 10 & 8 oz)
- Actara (@ 3.0 & 1.5 oz)

1st Gen CPB 2nd Gen CPB Vine Kill

Potato Crop

Colorado Potato Beetle Management Hypothetical Program (At-Plant)

- At-plant neonicotinoid plus RR-foliar
- 2nd generation foliar (Coragen / Benevia)

Development threshold = 1st and 2nd instar stadia

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

1st Gen CPB

Vine Kill

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

2nd Gen CPB

Coragen (@ 5.0 & 3.5 oz)

Abba (@ 12 & 10 oz)

AdmirePro (@ 8.7 oz)
Colorado Potato Beetle Management Hypothetical Program (Not advised!!)

- At-plant neonicotinoid plus RR-foliar (Coragen)
- 2nd generation foliar (Voliam Xpress)

Development threshold = 1st and 2nd instar stadia

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

Potato Crop


Vine Kill

1st Gen CPB

2nd Gen CPB

Voliam Xpress (@ 9.0 & 6.5 oz)

Coragen (@ 50. & 3.5 oz)

Platinum (@ 2.67 oz)

Planting
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 Sampling

The table below has the 2010 results from the monitoring wells on your land. This year we sampled the shallowest of the three wells in the most that produced water.

If you have any questions, comments or suggestions on your results or the program, please call me at 608-224-8503. If you want the wells removed from your property, just call me.

### Table of Results for Site ADD
Sample Dates 3/3/10 and 11/15/10

<table>
<thead>
<tr>
<th>Compound</th>
<th>3/3/10 Results (parts per billion)</th>
<th>11/15/10 Results (parts per billion)</th>
<th>Groundwater Standard (parts per billion)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonia</td>
<td>no detect</td>
<td>no detect</td>
<td>no detect</td>
</tr>
<tr>
<td>Diethyl Ammine</td>
<td>no detect</td>
<td>no detect</td>
<td>no detect</td>
</tr>
<tr>
<td>Dimethyl Ammine</td>
<td>no detect</td>
<td>no detect</td>
<td>no detect</td>
</tr>
<tr>
<td>Dinitro Ammine</td>
<td>no detect</td>
<td>no detect</td>
<td>no detect</td>
</tr>
<tr>
<td>Total Ammonia</td>
<td>no detect</td>
<td>no detect</td>
<td>3</td>
</tr>
<tr>
<td>Manganese (Total)</td>
<td>no detect</td>
<td>no detect</td>
<td>100</td>
</tr>
<tr>
<td>Manganese ESA + OA</td>
<td>1.1</td>
<td>0.245</td>
<td>1,500</td>
</tr>
<tr>
<td>Manganese (Complex)</td>
<td>no detect</td>
<td>no detect</td>
<td>70</td>
</tr>
<tr>
<td>Nickel (Pring)</td>
<td>no detect</td>
<td>no detect</td>
<td>4</td>
</tr>
<tr>
<td>Cyanide (Blues)</td>
<td>no detect</td>
<td>no detect</td>
<td>1</td>
</tr>
<tr>
<td>Azoxyde (Aminooxy, Forms)</td>
<td>no detect</td>
<td>no detect</td>
<td>1</td>
</tr>
<tr>
<td>Azoxyde ESA + OA</td>
<td>no detect</td>
<td>no detect</td>
<td>250</td>
</tr>
<tr>
<td>Aldehyde (Lasso)</td>
<td>no detect</td>
<td>no detect</td>
<td>2</td>
</tr>
<tr>
<td>Aldehyde ESA</td>
<td>0.71</td>
<td>no detect</td>
<td>20</td>
</tr>
<tr>
<td>Aldehyde OA</td>
<td>no detect</td>
<td>no detect</td>
<td>1</td>
</tr>
<tr>
<td>Thiaminobut (Platinum)</td>
<td>2.25</td>
<td>5.28</td>
<td>33</td>
</tr>
<tr>
<td>Chloride</td>
<td>no test</td>
<td>3.43</td>
<td>10 parts per million</td>
</tr>
</tbody>
</table>

For more information, visit the Wisconsin Department of Natural Resources at www.dnr.wi.gov.
Wisconsin groundwater quality: Thiamethoxam detections 2008-09

<table>
<thead>
<tr>
<th>Well</th>
<th>Date(s)</th>
<th>Thiamethoxam 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 ug/l (parts per billion)
- There is no groundwater enforcement standard for thiamethoxam in Wisconsin
# Products Included in this Study

<table>
<thead>
<tr>
<th>Product</th>
<th>Active Ingredient</th>
<th>Class</th>
<th>Rate</th>
<th>Application*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated Control</td>
<td>N/A</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Platinum 75SG</td>
<td>thiamethoxam</td>
<td>neonicotinoid</td>
<td>2.67 oz / acre</td>
<td>POLY</td>
</tr>
<tr>
<td>thiamethoxam</td>
<td>neonicotinoid</td>
<td>2.67 oz / acre</td>
<td>IF</td>
<td></td>
</tr>
<tr>
<td>thiamethoxam</td>
<td>neonicotinoid</td>
<td>2.67 oz / acre</td>
<td>SD</td>
<td></td>
</tr>
<tr>
<td>Cruiser 5FS</td>
<td>thiamethoxam</td>
<td>neonicotinoid</td>
<td>0.16 fl oz/cwt</td>
<td>ST</td>
</tr>
</tbody>
</table>

* Application type = POLY (polymer impregnated), IF (in-furrow), SD (side dress), ST (seed treatment)
Neonicotinoid - Polyacrylate Impregnation Trials: 2011

Insecticide Impregnated Polyacrylate (vacuum-dried)

Vacuum Oven
Neonicotinoid - Polyacrylate Impregnation Trials, 2011

In-furrow Application
Vacuum Dried

Impregnated Polyacrylamide (in-furrow)
In-Plant Thiamethoxam Concentrations (ppb/mg) – Untreated Control

Date: P = 0.0024
Year: P = 0.6458
In-Plant Thiamethoxam Concentrations (ppb/mg) – Polyacrylamide (2.67 oz/acre)

Date: $P = 0.0249$
Year: $P = 0.2240$
In-Plant Thiamethoxam Concentrations (ppb/mg) – In-Furrow (2.67 oz/acre)

Date: P = 0.0249
Year: P = 0.0164
In-Plant Thiamethoxam Concentrations (ppb/mg) – Side Dress (2.67 oz/acre)

Date: $P = 0.0230$
In-Plant Thiamethoxam Concentrations (ppb/mg) – Seed Treatment (0.16 fl oz/cwt)

Date: $P = 0.0535$
In-Plant Thiamethoxam Concentrations
Delivery: P = 0.0488
LCMS Thiamethoxam Leachate Detection

- Untreated Control
- Polyacrylamide
- In-furrow
- Seed Treatment
- Foliar
WI DATCP – Bureau of Laboratory Services
LCMS Clothianadin Leachate Detection

[Graphs showing concentration of Clothianadin over Julian Days for different treatment methods: Untreated Control, Polyacrylamide, In-furrow, Seed Treatment, Foliar.]
Typical Monitoring Cluster Configuration (MI & GA)

Source: LFR
Soil-Pore Water Residues

- **Michigan**
  - Thiamethoxam residues ranged from 0.051 to 3.5 ppb, levels peaked at around 14 MAT and declined thereafter
  - Only 14 out of 32 lysimeters had thiamethoxam detects

- **Georgia**
  - Thiamethoxam residues were only found in two lysimeter samples: 9 ft. deep, 27 MAT, 1.3 ppb; and 6 ft. deep, 47 MAA, 0.24 ppb
# Mobility Summary - Thiamethoxam

## Time Dependent Sorption Studies

<table>
<thead>
<tr>
<th>Soil</th>
<th>Day 0 $K_d$</th>
<th>$K_{oc}$</th>
<th>Day 30 $K_d$</th>
<th>$K_{oc}$</th>
<th>$K_d$ Increased by Factor (X)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand</td>
<td>0.2939</td>
<td>84.5</td>
<td>1.4857</td>
<td>426.9</td>
<td>5.1</td>
</tr>
<tr>
<td>Sandy Loam</td>
<td>0.5674</td>
<td>51.5</td>
<td>1.5356</td>
<td>139.3</td>
<td>2.7</td>
</tr>
<tr>
<td>Loam</td>
<td>0.5635</td>
<td>108.0</td>
<td>1.1797</td>
<td>226.0</td>
<td>2.1</td>
</tr>
<tr>
<td>Silt Loam</td>
<td>1.0923</td>
<td>52.3</td>
<td>2.1193</td>
<td>101.5</td>
<td>1.9</td>
</tr>
<tr>
<td>Clay Loam</td>
<td>0.9337</td>
<td>81.2</td>
<td>1.8756</td>
<td>163.2</td>
<td>2.0</td>
</tr>
<tr>
<td>Muck</td>
<td>10.9193</td>
<td>38.7</td>
<td>16.7322</td>
<td>59.2</td>
<td>1.5</td>
</tr>
</tbody>
</table>
Summary: Neonicotinoid Fate

- All treatments were effective in controlling 1st generation CPB populations.

- Significant in-plant variability present within all delivery system treatments – spatial refugia for CPB’s and aphids.

- Highest initial peak concentrations (ppb/mg) of thiamethoxam in seed and in-furrow treatments.

- Polyacrylate impregnation resulted in greatest overall concentrations throughout the experiment.
Summary: Neonicotinoid Fate

- Significantly less thiamethoxam loss resulting from in-furrow and seed treatments – corresponding highest, in-plant concentrations.
- Greatest overall loss associated with polyacrylate impregnation (> 15 ppb) at 75 cm.
- Repeat experiments in 2012 (thiamethoxam & cyantraniliprole).