Co-Application of the Diamide Insecticides in Processing Snap Beans

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Building Market Foundations for Sustainable Vegetable Production and Processing: A Consumer and Metrics-Based Approach


Goal. “Enhanced potential for improved efficiency, productivity, and profitability for the vegetable production and processing industry based on an improved understanding of the role of consumer markets”

Approach. “Beginning with the market, work with growers, processors, and distributors to explore how to generate market rewards through science-based sustainability that is measurable and profitable”
Project Objectives

**Objective 1.** Identify consumer preferences and willingness to pay for sustainably produced and processed vegetables and quantify market segments.

**Objective 2:** Create and test sustainability assessment tools and sustainability metrics for commercial vegetable growers.

**Objective 3:** Validate and improve the relationship between practice-based sustainability assessments and environmental and economic outcomes at the farm scale in each region.

- Implement sustainable practices to identify opportunities for improved water, nitrogen, and pesticide use efficiency at the field and farm level (Bland, Colquhoun, Mitchell, Ruark).
- Refine sustainable production practices to reduce environmental and economic risk (Bland, Colquhoun, Hutchison, Groves, Gevens, Nault, Ruark).

**Objective 4:** Build critical mass of support for sustainably grown and processed vegetables.
Factors Influencing Insect Pest Management

‘Food Safety and Residues’

– 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 & bio-pesticides).
Neonicotinoid Insecticides in the News

**Neonicotinoid Insecticides in the News**

Neonicotinoids are a relatively new class of chemistry to control pests. They are now widely adopted because they are persistent and systemic in plant tissues. Most field crops in Iowa have a neonicotinoid seed treatment. Common examples of neonicotinoids include clothianidin (Poyno), thiacloprid (Cruiser), and acetamiprid (Gaucho). Active ingredient rates range from 25-120 milligrams per hectare (applied as 251-1250 X 10^-3)

Neonicotinoids are extremely toxic to bees. Lethal LD50 rates the rate at which half of the exposed population dies for clothianidin at 22-44 nanograms per bee for direct contact and 2-9.3 nanograms per bee for oral ingestion. In other words, a single corn kernel with a 1,200 rate of neonics is enough to harm a colony. There has been increased public awareness of pollinator health and the decline of bees in North America. Researchers have identified multiple contributing factors for honey bee decline, including VARV mites, disease causing pathogens, habitat loss, malnutrition, the intensity of migratory pollination services and pesticides (Fig 1).

**Insecticidal Seed Treatments can Harm Honey Bees**

Erik Hodgson, Department of Entomology (ISU) and Christian Knupke, Department of Entomology (Purdue)

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Rich Hatfield, a biologist with the Xerces Society, estimates that over 50,000 bumble bees were killed, likely representing more than 300 wild colonies. “Each of those colonies could have produced multiple new queens that would have gone on to establish new colonies next year. This makes the event particularly catastrophic.”
Annual Changes in Crop Uses in the U.S.


Annual Changes in Crop Uses in the U.S.


Key findings include:

**Parasites and Disease Present Risks to Honey Bees:**
The parasitic Varroa mite and new virus species have been found in the U.S. and several of these have been associated with Colony Collapse Disorder (CCD).

**Increased Genetic Diversity is Needed:**
Genetic variation improves bees thermoregulation, disease resistance and worker productivity.

**Poor Nutrition Among Honey Bee Colonies:**
Bees need better forage and a variety of plants to support colony health.

**Need for Improved Collaboration and Information Sharing:**
Best Management Practices associated with bees and pesticide use, exist, but are not widely or systematically followed by members of the crop-producing industry.

**Additional Research is Needed to Determine Risks Presented by Pesticides:**
The most pressing pesticide research questions relate to determining actual pesticide exposures and effects of pesticides to bees in the field.
Major Snap Bean Pests in Midwest

Seedcorn Maggot (SCM)

Potato Leafhopper (PLH)

European corn borer (ECB)
Processing Snap Bean:
European Corn Borer, Pest Phenology

Redrawn with permission, Brian Flood Del Monte Foods
Insecticides for Managing Snap Bean Pests

Recently Labeled in Wisconsin:

- Radiant SC (spinetoram)
- Coragen 1.67 SC (chlorantraniliprole) – foliar
- Blackhawk (spinosad) – foliar
- Beseige (chlorantraniliprole + lambda-cyhalothrin) (aka. Voliam Xpress)
- Belt SC (flubendiamide) – foliar
- Entrust SC (spinosad) – foliar
- Movento (spirotetramat) – foliar
- Transform WG (sulfoxaflor) – foliar

In the Pipeline or in Review:

- Exirel, Verimark (cyantraniliprole) – 2015/16
European Corn Borer Lifecycle

**Eggs**
- Laid in masses (20-50)
- Black dots at hatch, 5-7 days

**Larva**
- Overwinter in corn stalks
- 5 instars (2-4 weeks) \(1^{st}\) and \(2^{nd}\) external.

**Adult**
- 2 normal flight peaks June-Aug (1400 DD\(_{50}\) and 1733 DD\(_{50}\))

**Pupa**
- Inside stems 10-14 days

ECB SEASONAL LIFECYCLE
European Corn Borer: Snap bean damage

- Small larvae external
- Damage marginal
- Pods preferred if present
- Serious problem
- Later instars bore into stems
- Plants easily compensate
- Rejection threshold 1/1000
European Corn Borer Management

1. Predict flight with degree days:
   - $1^{st} = 375\ DD_{50}$, $2^{nd} 1400\ DD_{50}$
   - and $3^{rd} 1733\ DD_{50}$

2. Monitor flights:
   - Network of blacklight traps (DATCP)

3. Treat plants @ early bloom / pin bean stage:
   - $15 \& 100$ moths/night, $1^{st}$ and $2^{nd}$ generation
Objectives

• Compared ECB control with chlorantraniliprole, cyantraniliprole, and bifenthrin at three different phenological stages of snap bean development (i.e., bud, bloom, pod formation) to determine the duration of residual activity for each insecticide under field conditions in snap bean.

• Co-applied cyantraniliprole and bifenthrin insecticides with either herbicides or fungicides at similar crop stages to determine if tank mixing cyantraniliprole and bifenthrin with common agrochemicals would reduce ECB control.
Anthranillic Diamide Insecticides

• **Active ingredients**: rynaxypyr (aka chlorantraniliprole) and cyazypyr (aka cyantraniliprole).

• **Class**: anthranilic diamide (IRAC MoA Class 28)

• **Mode of action**: ryanodine receptor modulator
  - Systemic activity
  - Most effective through ingestion
  - Insects stop feeding, become paralyzed and die within 1 to 3 days
  - Applied to soil at planting, drip chemigation and foliar spray (seed treatment)
  - Exceptionally long residual control – xylem mobile
  - Active against Lepidoptera, Coleoptera, and Hemiptera
Can Timing of Insecticide Application be Improved for ECB Control

Current Recommendations for ECB Control

Alternative Timing for ECB Control?
Can Timing of Insecticide Application be Improved for ECB Control

Planting (May 31)  →  Spray (July 16)  →  Harvest (Aug. 3)

Current Recommendations for ECB Control

Planting (May 31)  →  Co-apply with fungicide (July 10)?  →  Harvest (Aug. 3)

Alternative Timing for ECB Control?
Can Timing of Insecticide Application be Improved for ECB Control

**Current Recommendations for ECB Control**

- **Planting** (May 31)
- **Spray** (July 16)
- **Harvest** (Aug. 3)
- **Bud**
- **Bloom**
- **Pin**

**Alternative Timing for ECB Control?**

- **Planting (co-application) side-dress** (May 31)
- **Harvest** (Aug. 3)
- **Bud**
- **Bloom**
- **Pin**
<table>
<thead>
<tr>
<th>Type</th>
<th>Study years&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Application timing&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Trade name</th>
<th>Active ingredient (AI)</th>
<th>Chemical group</th>
<th>Rate (ac&lt;sup&gt;-1&lt;/sup&gt;)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insecticides</td>
<td>2012, 2013, 2014</td>
<td>bud (R5), bloom (R6), pod formation (R7)</td>
<td>Brigade® 2EC</td>
<td>bifenthrin</td>
<td>pyrethroid</td>
<td>6.4 fl oz</td>
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<tr>
<td></td>
<td>2012</td>
<td>bud (R5), bloom (R6), pod formation (R7)</td>
<td>Coragen®</td>
<td>chlorantraniliprole rynaxypyr</td>
<td>diamide</td>
<td>5.0 fl oz</td>
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<tr>
<td></td>
<td>2012, 2013, 2014</td>
<td>bud (R5), bloom (R6), pod formation (R7)</td>
<td>Exirel®</td>
<td>cyantraniliprole cyazypyr</td>
<td>diamide</td>
<td>10.2 fl oz</td>
</tr>
<tr>
<td></td>
<td>2012, 2013, 2014</td>
<td>bud (R5), bloom (R6), pod formation (R7)</td>
<td>Exirel®</td>
<td>cyantraniliprole</td>
<td>diamide</td>
<td>13.5 fl oz</td>
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<tr>
<td>Herbicides</td>
<td>2013, 2014</td>
<td>bud (R5)</td>
<td>Basagran®</td>
<td>bentazon</td>
<td>benzo thiadiazinone</td>
<td>1.5 pts</td>
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<tr>
<td></td>
<td>2013, 2014</td>
<td>bud (R5)</td>
<td>Reflex®</td>
<td>fomesafen</td>
<td>diphenylether</td>
<td>1.0 pt</td>
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<tr>
<td>Fungicides</td>
<td>2013, 2014</td>
<td>bloom (R6)</td>
<td>Topsin® M WSB</td>
<td>thiophanate- methyl</td>
<td>thiophanate</td>
<td>1.5 lb</td>
</tr>
<tr>
<td></td>
<td>2013, 2014</td>
<td>pod formation (R7)</td>
<td>Bravo Weather Stik®</td>
<td>chlorothalonil</td>
<td>chloronitrile</td>
<td>2.5 pt</td>
</tr>
</tbody>
</table>

<sup>a</sup> Chlorantraniliprole was only included in the 2012 small plot study. Co-applications were only tested in 2013 and 2014.

<sup>b</sup> Applications were timed at specific phenological stages of bean maturation.
Infested 10 plant row with ~ 500 ECB larvae
# Mean Percent Plant and Pod Damage, 2012

Treated at 3 crop development stages, Plover, WI

<table>
<thead>
<tr>
<th>Phenological stage</th>
<th>Insecticide</th>
<th>Plant damage</th>
<th>Pod damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>untreated</td>
<td>-</td>
<td>18.5±5.2 a</td>
<td>8.7±2.5a</td>
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<tr>
<td><strong>bud</strong></td>
<td>bifenthrin (6.4 fl oz/ac)</td>
<td>9.0±6.4 b</td>
<td>2.6±1.2 bc</td>
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<tr>
<td></td>
<td>chlorantraniliprole (5.0 fl oz/ac) (aka. rynaxypyr) - Coragen 1.67SC</td>
<td>4.1±3.3 bc</td>
<td>1.9±1.1 bc</td>
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<tr>
<td></td>
<td>cyantraniliprole (10.2 fl oz/ac) (aka. cyazypyr) – Exirel 10OD</td>
<td>1.0±0.7 c</td>
<td>0.7±0.3 bc</td>
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<tr>
<td></td>
<td>cyantraniliprole (13.5 fl oz/ac) (aka. cyazypyr) – Exirel 10 OD</td>
<td>0.8±0.5 c</td>
<td>0.6±0.2 c</td>
</tr>
<tr>
<td><strong>bloom</strong></td>
<td>bifenthrin (6.4 fl oz/ac)</td>
<td>0.7±0.4 c</td>
<td>1.4±0.4 bc</td>
</tr>
<tr>
<td></td>
<td>chlorantraniliprole (5.0 fl oz/ac) (aka. rynaxypyr) - Coragen 1.67SC</td>
<td>0.0±0.0 c</td>
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<tr>
<td></td>
<td>cyantraniliprole (10.2 fl oz/ac) (aka. cyazypyr) – Exirel 10OD</td>
<td>0.1±0.1 c</td>
<td>0.2±0.1 c</td>
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<tr>
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<td>cyantraniliprole (13.5 fl oz/ac) (aka. cyazypyr) – Exirel 10 OD</td>
<td>0.0±0.0 c</td>
<td>0.1±0.1 c</td>
</tr>
<tr>
<td><strong>pod formation</strong></td>
<td>bifenthrin (6.4 fl oz/ac)</td>
<td>0.0±0.0 c</td>
<td>0.0±0.0 c</td>
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<td>chlorantraniliprole (5.0 fl oz/ac) (aka. rynaxypyr) - Coragen 1.67SC</td>
<td>0.0±0.0 c</td>
<td>0.3±0.1 c</td>
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<td>0.0±0.0 c</td>
<td>0.0±0.0 c</td>
</tr>
<tr>
<td>Vegetative stage</td>
<td>Insecticide</td>
<td>Plant damage</td>
<td>Pod damage</td>
</tr>
<tr>
<td>------------------</td>
<td>-------------</td>
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<td>------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2013&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2014&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>untreated&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-</td>
<td>63.5±9.8 a</td>
<td>13.3±3.8 a</td>
</tr>
<tr>
<td><strong>bud</strong></td>
<td>bifenthrin (6.4 fl oz/ac)</td>
<td>22.1±10.1 ab</td>
<td>11.3±3.5 a</td>
</tr>
<tr>
<td>(herbicide)</td>
<td>cyantraniliprole (10.2 fl oz/ac) (aka. cyazypyr) – Exirel 10OD</td>
<td>19.4±7.5 ab</td>
<td>6.9±2.2 ab</td>
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<tr>
<td></td>
<td>cyantraniliprole (13.5 fl oz/ac) (aka. cyazypyr) – Exirel 10 OD</td>
<td>20.5±2.0 ab</td>
<td>9.6±6.4 a</td>
</tr>
<tr>
<td><strong>bloom</strong></td>
<td>bifenthrin (6.4 fl oz/ac)</td>
<td>12.5±3.9 bc</td>
<td>1.2±1.2 bc</td>
</tr>
<tr>
<td>(fungicide)</td>
<td>cyantraniliprole (10.2 fl oz/ac) (aka. cyazypyr) – Exirel 10OD</td>
<td>1.5±1.1 c</td>
<td>1.4±0.7 bc</td>
</tr>
<tr>
<td></td>
<td>cyantraniliprole (13.5 fl oz/ac) (aka. cyazypyr) – Exirel 10 OD</td>
<td>1.7±1.3 c</td>
<td>1.0±0.7 bc</td>
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<tr>
<td><strong>pod formation</strong></td>
<td>bifenthrin (6.4 fl oz/ac)</td>
<td>7.7±3.4 bc</td>
<td>0.0±0.0 c</td>
</tr>
<tr>
<td>(insecticide)</td>
<td>cyantraniliprole (10.2 fl oz/ac) (aka. cyazypyr) – Exirel 10OD</td>
<td>0.8±0.8 c</td>
<td>3.8±2.2 b</td>
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<td>0.5±0.5c</td>
<td>1.1±1.1 bc</td>
</tr>
</tbody>
</table>
Percent Snap Bean Stems Damaged by European Corn Borer

Plover, WI 2013

Mean percent ECB damaged stems

In-furrow

Liq Fert Pre-Mix

Foliar

Treatments

- Untreated
- Verimark 6.5
- Verimark 10
- Verimark 6.5
- Verimark 10
- Brigade 5

P = 0.032  N=4

(a)
Percent Snap Bean Pods Damaged by European Corn Borer

Plover, WI 2013

Mean percent ECB damaged pods

In-furrow

Liq Fert Pre-Mix

Foliar

P < 0.001  N=4
Advantages of Reduced Risk Technologies

• Limit impacts on pollinators

• Reduced risk to environment and farm workers
  – Drift to non-target areas is eliminated
  – Farm workers do not come into contact with residues on exterior of plant
  – Beneficial organisms not directly exposed

• Longer residual activity
  – Not subject to loss from rain and UV light
  – Not subject to plant growth dilution effects

• More cost-effective??
Summary

• Diamide insecticides (e.g. Coragen & Exirel) appear to have very good activity against ECB when applied as a foliar.

• Co-application of diamides with fungicides (bloom) had no antagonistic effects and were similar in performance to current foliar recommendations (pod-formation).

• Cyantraniliprole (aka. cyazypyr) was effective against ECB when applied as a in-furrow and as a liquid fertilizer pre-mix applications.
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