Biologically-Based, Insect Pest Management in Solanaceous Crops

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## Wisconsin Vegetable Production Statistics (Wis. Ag. Stats. 2008)

<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</td>
<td>64,500</td>
<td>6</td>
<td>$242</td>
</tr>
<tr>
<td>Sweet corn (Proc)</td>
<td>1</td>
<td>88,900</td>
<td>21</td>
<td>$81</td>
</tr>
<tr>
<td>Sweet corn (Fresh)</td>
<td>--</td>
<td>7,700</td>
<td>--</td>
<td>$14</td>
</tr>
<tr>
<td>Snap beans</td>
<td>1</td>
<td>82,300</td>
<td>38</td>
<td>$62</td>
</tr>
<tr>
<td>Peas</td>
<td>3</td>
<td>40,200</td>
<td>21</td>
<td>$20</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>8</td>
<td>$9</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>
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</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.
National Vegetable Production Acres (NASS 2002)
Macro-Factors Influencing Insect Pest Management

- Increasing population and changing demographics
- Changes in food consumption
- Decreasing arable land
- Decreasing availability of water
- Food safety
- Concern for the environment
- Global agricultural trade
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
Insect Management Trends on Vegetables

Present and Future

Targeted insecticide use

Integration of non-chemical alternatives

Reduced risk, ecologically-based IPM
Potato Production in Wisconsin

- 65,000 Acres, value $365 million, 3rd Nationally
- Most grown in Central Wisconsin
- Several varieties grown for seed, processing, and tablestock

Russet Burbank
Yukon Gold
Atlantic
Dark Red Norland
Insect Management in Potatoes
- Key Pests -

- Colorado potato beetle
- Green peach aphid
- Potato leafhopper
Colorado potato beetle adult
Overwintering site
Close to last crop
Adults 6” to 12” deep
Protected by mulch
Adults walk to crop

Damage depends on temperature

May - June
Adults lay eggs on underside of leaves

- Yellow / orange

- 20-40 eggs/mass
Larvae hatch 5-7 days

1st instar move to plant terminals

Little damage
Small larvae feed in terminals

4 instars, 5-7 days/stage

Large larvae (3+4) feed extensively
4th instar larva
Larval feeding

4th instars leave plant and pupate in soil
Pupae in soil

2-3 weeks

Summer adults emerge (July)
Summer adults emerge in July

- Very active

- Very hungry
- Rapid defoliation
- Partial second generation
- Adults leave to overwinter or...
- Can be partial 3rd gen.
Finding crop
• Crop rotation
• Cover crops
• Disrupt dispersal

Infesting crop
• Trap crops
• Trenches
• Physical control

Management on crop
• Prediction
• Timing
• Resistance

Colorado potato beetle ecology

Leaving crop
• Trap crops
• Physical control

Adult diapause
• Habitat disruption
• Cold shock
Colorado Potato Beetle Dispersal / Crop Colonization
Crop Rotation; avoid planting adjacent to previous potato

- Rotate > 400 m (¼ mile)
- Delays infestation
- Reduces infestation size
  - effect increased if small grain separates field from source of overwintered beetles
- Causes infestation to proceed from field edge
  - facilitates scouting
  - allows spot or perimeter applications of insecticide

Sexson and Wyman (2005)
Perimeter Insecticide / Edge Treatments
Trap adults moving into crop

Beetle Trench

Walking Beetles

Overwintering Site
CPB Trenching / Edge Treatments

- Trapping overwintered, adult CPB walking into fields.
Predators, parasites exist but rarely effective
Must control 1\textsuperscript{st} generation in June

Ignore overwintered adults unless severe feeding

Target young larvae, 1\textsuperscript{st} and 2\textsuperscript{nd} instar

Look for egg hatch

5 to 10 days, depending on temperature
** Problem: beetle has developed resistance to many insecticides e.g. carbamates, organophosphates,

** Tools available:**  *Biological (specific)*

- **Kaolin Clay (Surround)**
  - Target 1\(^{st}\), 2\(^{nd}\) instar (suppression)
  - Multiple applications
  - Good coverage (7-25 lb/A)

- **Beauvaria bassiana (Mycotrol O)**
  - Target 1\(^{st}\), 2\(^{nd}\) instar (suppression)
  - Multiple applications
  - Good coverage (0.25 – 1 qt/A)

- **Spinosad (Entrust)**
  - Target 1\(^{st}\), 2\(^{nd}\) generations
  - 1-2 applications (1-2 oz / A)
Bio-Based, Potato Pest Management ‘Healthy Grown Potato’

➔ IPM Success story
➔ Heavy pesticide reliance
➔ Major problems
  • Environmental; groundwater, drift
  • Resistance to pesticides: potato beetle
➔ Industry partnership with University, WWF, and ICF to reduce pesticide reliance
➔ New standards developed with independently certified eco-label
➔ Healthy Grown label launched in 2001
Potato leafhopper

Appearance
- Adults, small (1/8”) wedge-shaped, bright green
- Rapid movement
- Nymphs, yellow-green, lack wings

Occurrence
- Does not overwinter in Wisconsin
- Adults migrate from gulf states
- Arrive June, 2-3 generations/year
- Very broad host range includes potatoes, beans, alfalfa
- Can infest quickly
Potato leafhopper – damage in snap beans

- Both adults and nymphs feed
- Sucking mouthparts
- Saliva clogs plant, causes yellowing, leaf necrosis
- Can kill young plants quickly
- May only cause stunting

Treated with insecticides

Untreated
Potato Leafhopper – damage in potato
PLH – ‘hopperburn’

First signs of ‘hopperburn’

Later stages of ‘hopperburn’
PLH Management

**Cultural**
- Plant early to avoid

**Biological**
- No effective biologicals

**Chemical**
- Monitor often (June 1)
- Treat only when threshold exceeded (1/sweep)
- Do not let nymphs build up
- Control is effective if needed:
  - Pyrethrins = Pyganic (4.5 – 18 fl oz / A)
  - Kaolin clay = Surround WP (7-25 lb / A)
Special Note:
Tank conditions, pH, & evening applications

Personal Protective Equipment (PPE)
European corn borer (ECB)

**Appearance**
- Adults, gray / brown (1/2”)
- Nocturnal

**Occurrence**
- Native to Wisconsin, overwinters as larvae in corn
- Broad host range
- Beans, sweet corn, field corn, potatoes, peppers
- 2-3 generations/year
ECB Lifecycle

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

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

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

**Pupae**
- Inside stems 10-14 days
ECB: Potato damage

- Small larvae external
- Damage marginal

- Later instars bore into stems
- Plants easily compensate
1. Predict flight with degree days:
   - 1st = 375 DD$_{50}$, 2nd 1400 DD$_{50}$
   - 3rd generation possible in warm years (1733 DD$_{50}$)

2. Monitor flights:
   - State network of flight traps
   - DATCP survey

3. Treat plants @ early bloom
   - Blacklight traps:
     (15 & 100 moths/night, 1st and 2nd generation)
Degree Day Calculation and Insect Phenology (X1087)

I. Avg Daily Temp = (Daily High – Daily Low) / 2

II. Daily DD<sub>50</sub> = Avg Daily Temp – Base Temp

Adult ECB Flight

http://pestbulletin.wi.gov/

ECB Development
Pepper Insect Control

- Processing and fresh in Wisconsin
- Bell and hot peppers have similar problems
- Insects are usually only of minor importance

Key insect pests
- European corn borer
- Green peach aphid
European corn borer

**Occurrence**
- Overwinters as larva in corn
- Only 2\textsuperscript{nd} generation infest peppers
- August / September

**Damage**
- Egg masses laid on leaves
- Small larvae bore into fruit
- Often near stalk
- Larvae develop internally
- Fruit rot is secondary
European Corn Borer Control

Cultural
- Plant early to avoid 2nd generation
- Do not plant adjacent to sweet corn
- Discard infested fruit

Biological
- None effective

Chemical
- Only use for 2nd generation protection
- Only use if adult pressure is high
- Pyrethrum’s are effective
Green Peach Aphid

Occurrence
- Winged aphids infest July/August
- Multiple generations of wingless forms

Damage
- Heavy infestation can wilt plants
- Honeydew contaminates fruit – may be sooty mold
- Rarely a yield problem
- Nonpersistent virus diseases (CMV)
Aphid Monitoring

- Check as many plants as possible
- Look at terminal buds and lower leaf surfaces
- Cast skins, honeydew, & sooty mold are indications of aphid infestation.
- Yellow sticky traps can monitor winged aphids
Green Peach Aphid Control

**Cultural**
- Early planting
- Limit quick release fertilizers

**Biological**
- Effective
- Predators and parasites

**Chemical**
- Avoid use if possible to preserve natural control
- Azadirachtin (Aza-Direct, Azatin)
- Insecticidal soaps
Insect Management in Tomato
## Varied Tomato Insect Pests

### Common Pests
- Tomato fruitworm
- Tomato hornworm
- Potato aphid
- Cutworms - armyworms
- Thrips

### Intermittent Pests
- Flea beetles
- Whiteflies
- Two-spotted spider mites
- Colorado potato beetle
- Vegetable leafminer

![Tomato hornworm](image1)

![Tomato fruitworm](image2)
<table>
<thead>
<tr>
<th>April</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>Aug</th>
<th>Sept</th>
<th>Oct</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spider mites</td>
<td>Tobacco thrips</td>
<td>Potato and Green Peach Aphids</td>
<td>Western flower thrips</td>
<td>Stink bugs</td>
<td>Whiteflies</td>
<td>Flea beetles</td>
</tr>
<tr>
<td>Cutworms</td>
<td>Tomato hornworm</td>
<td>Tomato fruitworm</td>
<td>Armyworms</td>
<td>Leafminers</td>
<td>Colorado potato beetle</td>
<td></td>
</tr>
</tbody>
</table>
Phenology of Insect Infestations

- **Early season – planting to 1st flower**
  - Flea beetles
  - Tobacco thrips
  - Potato aphids
Flea Beetles as Tomato Pests

- Flea beetle (several species)

**Appearance**
- Small, shiny black beetles
- Hind legs enlarged for jumping
- Overwinter as adults
- 2 generations per year

**Damage**
- Adults chew small circular holes
- Can kill small plants
- Larvae in soil are not damaging
Flea Beetle Management

Cultural
- Exclude adults with row cover
- Attract adults to alternate trap crop (Indian mustard)
- Avoid early planting

Biological
- No effective controls

Chemical
- Spray to control adults (Entrust 2ee Product Bulletin)
- Aza-Direct (azadirachtin)
- DO NOT disrupt biological controls of other pests (aphids)
Aphids

- Soft-bodied insects
- Wings present or absent
- Cornicles (tail pipes)
- Honeydew
  - Sooty mold
- May transmit viruses
- Reduces plant vigor, stunting, malformation
Aphid Parasitoids
Aphid IPM

- **Sanitation**
  - Remove alternate hosts (weeds)
- **Limit the use of quick-release fertilizer**
- **Plant health / vigor**
  - (adequate irrigation)
- **Beneficial Insects**
  - Green lacewings
  - Ladybeetles
  - Parasitic wasps
Aphid Chemical Control

- Rotate chemicals every 2-3 applications to prevent insecticide resistance
- Organophosphate resistance common

Azatin, Aza-Direct, 
*Beauvaria bassiana* (*Botanigard*)
Insecticidal Soap(s)
Tomato Fruitworm (corn earworm, cotton bollworm)

**Adult**
- Does not overwinter
- Adults migrate from the south
- 2 generations / year

**Eggs**
- Laid singly on leaves
- Hatch in 5-7 days
- Feed externally on leaf and then bore into fruit

**Larvae**
- Develop inside fruit
- Brownish or green in color (morphs)
Tomato Fruitworm Damage

Occurrence

- 2nd generation only – Aug/Sept

Damage

- Small larvae feed on leaves
- Larger bore into fruit
- Develop internally
- Infested fruit may color early or rot
- Major pest in CA and FL
Tomato Fruitworm Control

**Cultural**
- Plant early: avoidance in time
- Discard infested fruit

**Biological**
- Effective parasites
- But will not prevent damage

**Chemical**
- Rarely necessary
- Bacillus thuringiensis (kurstaki) (e.g. Dipel, Javelin, Biobit)
- Disrupts natural control of other pest (leaf miner, aphid)
** ONLY when the plants have green fruit and an average of 1 infested plant (larvae or fresh feeding damage) per 40 plants
** Monitor for damage carefully when trap catches exceed 7 moths per trap per week
Tomato Hornworm Life Cycle

**Adult**
- Large Hawk moth
- Resembles hummingbird
- Sips flower nectar

**Eggs**
- Eggs large, round
- Laid on leaves
- Parasites and predators common

**Larvae**
- Green with ‘reddish’ horn
- Up to 2-3”

**Pupae**
- Brown with a “handle”
- In soil
Tomato hornworm: Damage & Control

Occurrence
- Overwinters as pupa
- Large hawk moths emerge
- 2 generations per year

Damage
- Larvae consume lots of foliage
- Occasional fruit feeding

Control

Cultural: Remove larvae and squash!

Biological: Usually very effective
- Both predators (eggs) and parasites (larvae)

Chemical
- Avoid use if possible
- *Bacillus thuringiensis* is effective