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Bio-Intensive IPM for Midwest Orchards

A Review of Common Pests and How to Manage Using low-Impact Strategies

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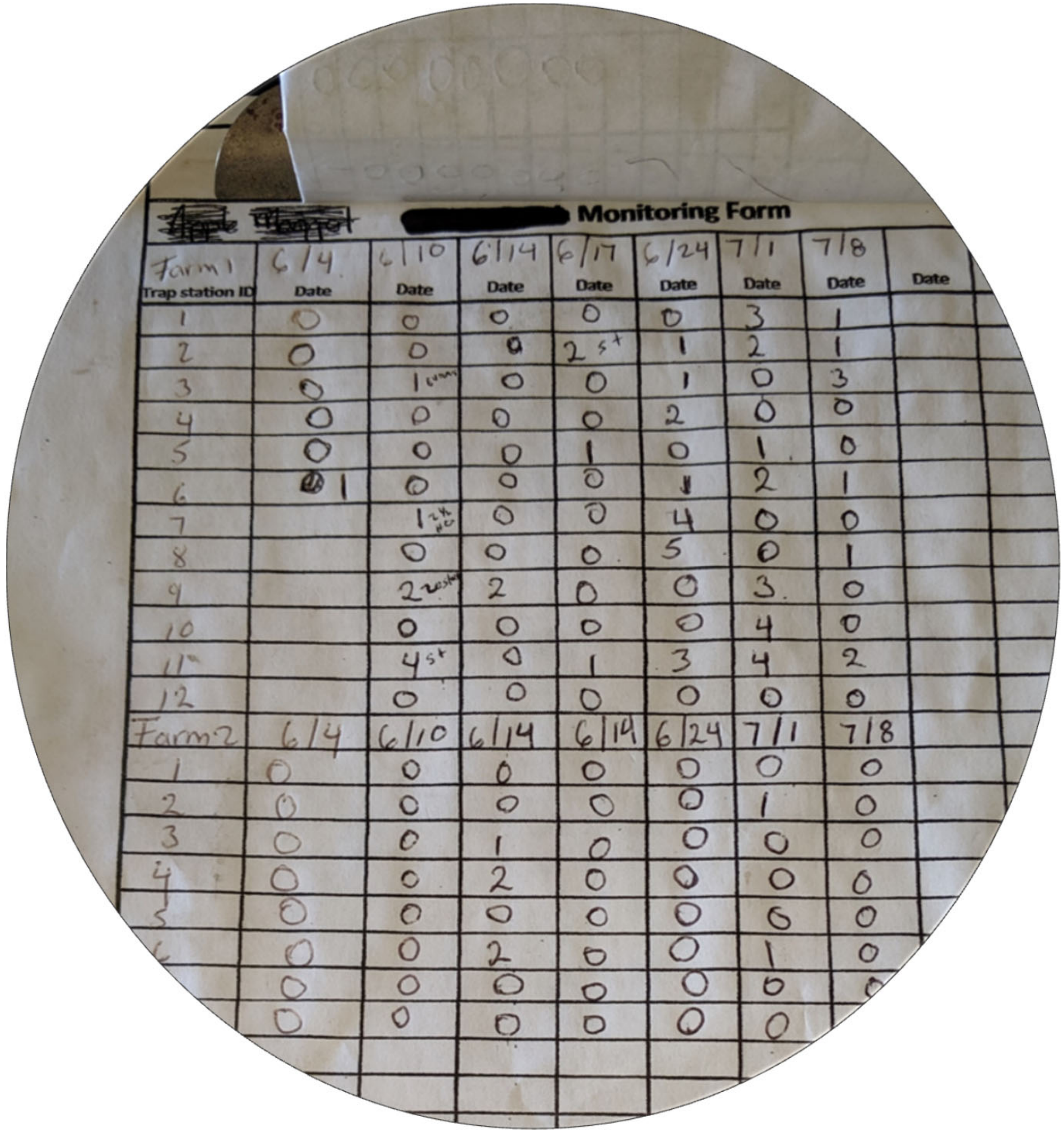
Supporting Pest Management with Data

"We cannot solve our problems with the same thinking we used when we created them."

– Albert Einstein



[redacted] [redacted] Monitoring Form

Farm 1 Trap station ID	6/4 Date	6/10 Date	6/14 Date	6/17 Date	6/24 Date	7/1 Date	7/8 Date	Date
1	0	0	0	0	0	3	1	
2	0	0	0	2 st	1	2	1	
3	0	1 [illegible]	0	0	1	0	3	
4	0	0	0	0	2	0	0	
5	0	0	0	1	0	1	0	
6	0 1	0	0	0	1	2	1	
7		1 [illegible]	0	0	4	0	0	
8		0	0	0	5	0	1	
9		2 [illegible]	2	0	0	3	0	
10		0	0	0	0	4	0	
11		4 st	0	1	3	4	2	
12		0	0	0	0	0	0	
Farm 2	6/4	6/10	6/14	6/14	6/24	7/1	7/8	
1	0	0	0	0	0	0	0	
2	0	0	0	0	0	1	0	
3	0	0	1	0	0	0	0	
4	0	0	2	0	0	0	0	
5	0	0	0	0	0	0	0	
6	0	0	2	0	0	1	0	
	0	0	0	0	0	0	0	
	0	0	0	0	0	0		

Agenda

- What we do and why
- IPPM: Integrated pest and pollinator management
- Plum curculio
- Codling moth
- Apple maggot
- Secondary pests
- Biological controls

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How We Make a Difference

Harnessing Marketplace Power to Improve Health, Environment, and Economics

- AppleTalk — Sharing Sustainable Orchard Management Solutions
- ARAY
- Basic American Foods™
- California Cut Flower Commission
- Canadian Horticultural Council
- Les Fermes Cavendish Farms
- Sustainably Grown Certified™ — SCS Global Services
- Bayer Crop Science
- eco certified — Local done right!
- efi™
- nea National Education Association nea.org — Education Support ESP Professionals
- Field to Market® — The Alliance for Sustainable Agriculture
- General Mills — Making Food People Love
- Green Shield Certified — Pest control. Peace of mind.
- Growing Wisconsin — Department of Agriculture, Trade and Consumer Protection — datcp.wi.gov
- Honeybear Brands

Specialty Crop Grower Services

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- Tree fruit scouting and consulting in Illinois, Iowa, Minnesota and Wisconsin.
- Technical services for IPM Weekly apple IPM conference call green tip to harvest.
- Frequent collaborations with state departments of Ag., land-grant universities and other non-profit organizations.
- **Midwest School for Beginning Apple Growers: January 19, 20 and 21, 2024**

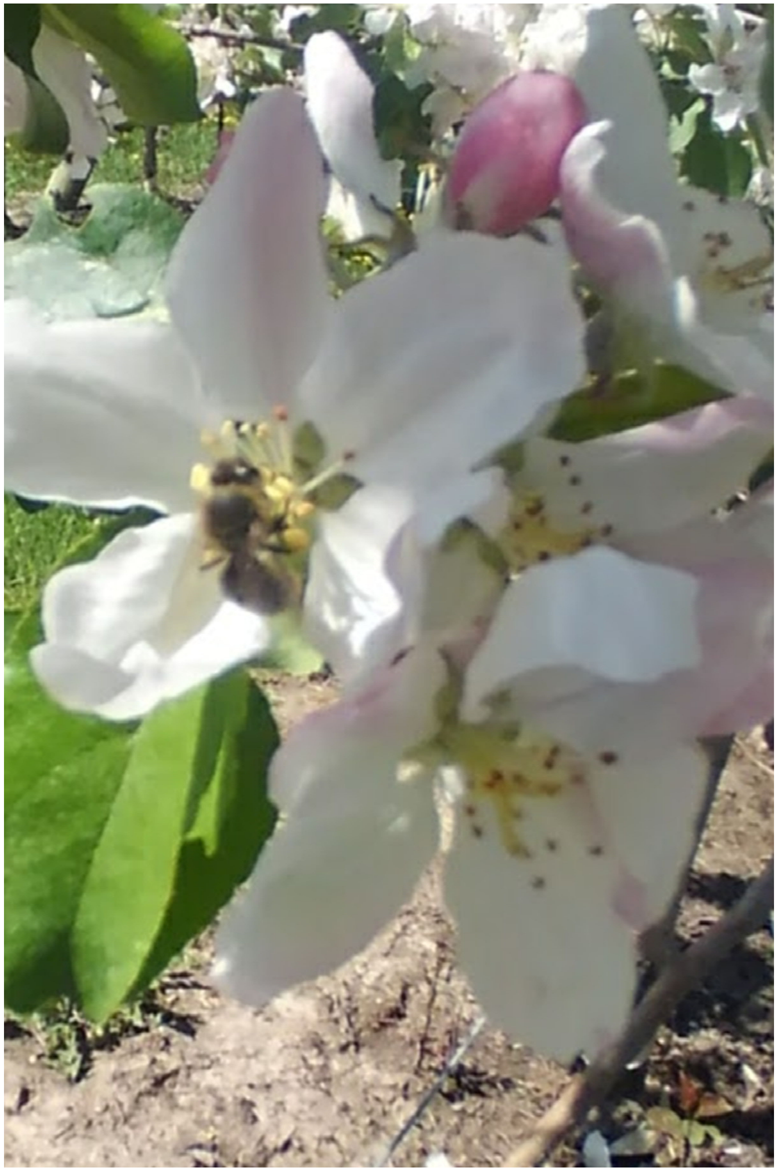
Harnessing Marketplace Power to Improve Health, Environment and Economics

Pest Management and Pollinators

- Integrated Pest and Pollinator Management (IPPM) recognizes the need for successful pest management while protecting and enhancing the health of pollinators and beneficial insects in an agricultural ecosystem.

- Special care should be taken to protect pollinators from pesticides during both "Petal Fall" and "First Cover".

- Risk to pollinators foraging and passing through an orchard remains season long.



Pesticide Synergies

- Combinations or "tank mixes" of two or more active ingredients that change the relative toxicity of a pesticide and its potential to impact pollinators.

- Pesticide synergies can include insecticides + fungicides, fungicides + fungicides and insecticides + insecticides.

- Pesticide synergies are not limited in their ability to impact acute contact or oral toxicity and tank mixtures have been found to cause a variety of effects on pollinators including:
  - Altering feeding behavior
  - Reducing queen emergence due to compromised immunity
  - Increased mortality
  - Negatively impacting nesting behavior

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Protecting Pollinators at petal fall

Active ingredients	Trade name	Effects on pollinators*	Known synergies (X)
Carbamates			
Carbaryl	Sevin XLR	Highly toxic to pollinators via oral and topical exposure. [70]* Impacts bees still visiting petal-less flowers.*	
Neonicotinoids			
Imidacloprid	Alias, Wrangler	Highly toxic to pollinators, may impact ground nesting bees.*	X
Thiamethoxam	Actara	Highly toxic to pollinators- bumble and solitary bees.*	X
Clothianidin	Belay	Highly toxic to pollinators	X
Organophosphates			
Phosmet	Imidan	Highly toxic to some solitary bees, often high residues on pollen samples*	
Pyrethroids			
Cyhalothrin, lambda	Warrior	Highly toxic to pollinators- bumble and solitary.*	X
Esfenvalerate	Asana	Topical exposure highly toxic to pollinators.*	X
Other			
Avermectin	Agri-Mek	Moderate to high toxicity to pollinators via topical and oral exposure.*	X
Emamectin, benzoate	Proclaim	High toxicity orally, toxicity increases over time.	

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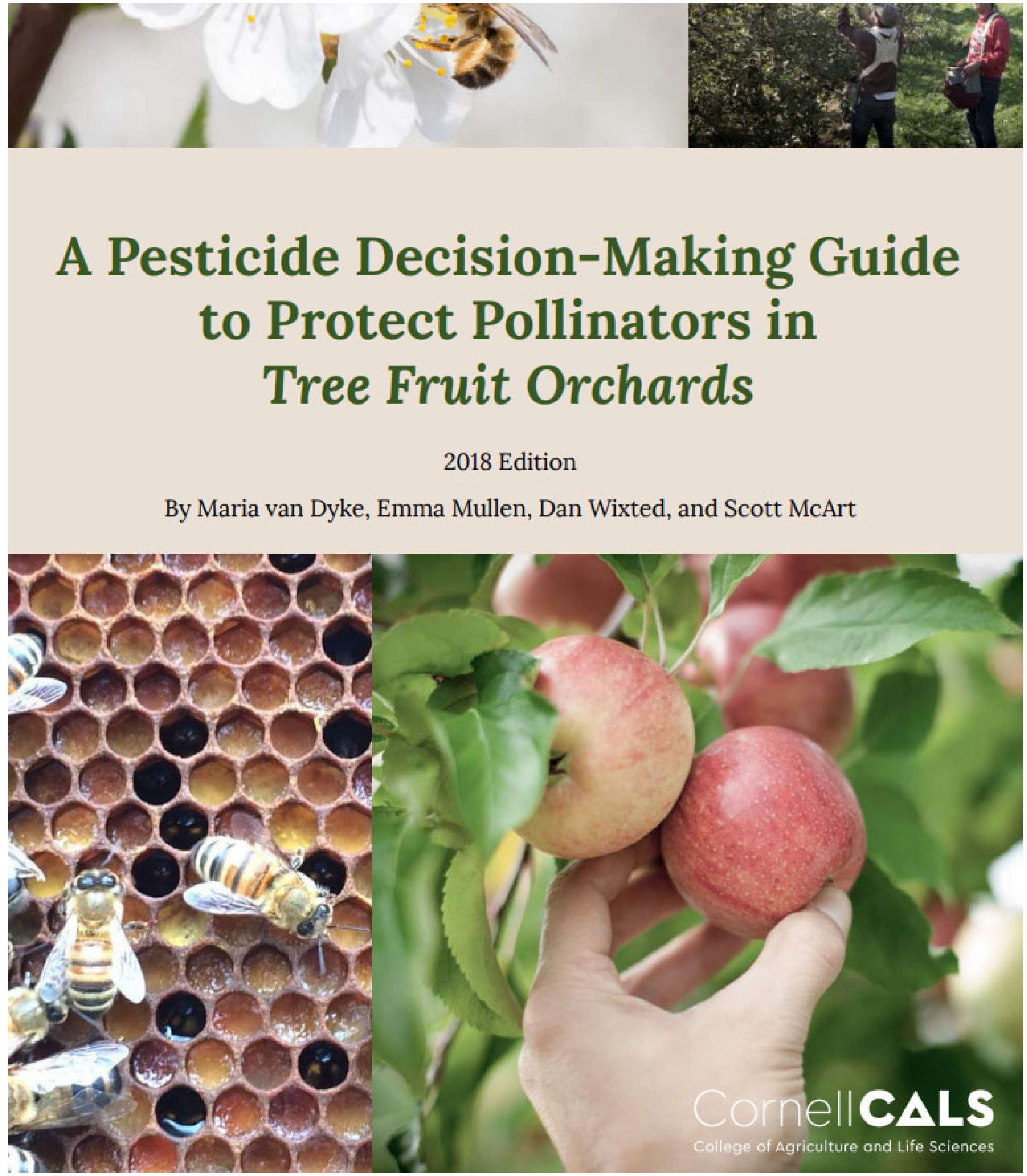
Pollinator Protection Resources

A comprehensive list of pesticide active ingredients, brand name of products and detailed descriptions of known pesticide synergies.

https://www.kyagr.com/statevet/documents/OSV_BEE_Pesticide-Decision-Making.pdf



How to calculate degree days

Use the following formula to calculate degree days for codling moth development

$$\left[\frac{(high\ temperature + low\ temperature)}{2}\right] - 50 = degree\ days$$

The upper and lower developmental parameters for CM are 86° and 50°F. If the daily high/low temperature is warmer or cooler than the upper or lower limits use the upper or lower developmental parameters (86° or 50°F) instead of the daily high/low temperature.

Example 1: May 21, high 56°, low 42°F

$$\left[\frac{56° + 50°F}{2}\right] - 50 = 3\ DD$$

Example 2: July 27, high 93°, low 72°F

$$\left[\frac{86° + 72°F}{2}\right] - 50 = 29\ DD$$

Example 3: August 18, high 78°, low 52°F

$$\left[\frac{78° + 52°F}{2}\right] - 50 = 15\ DD$$

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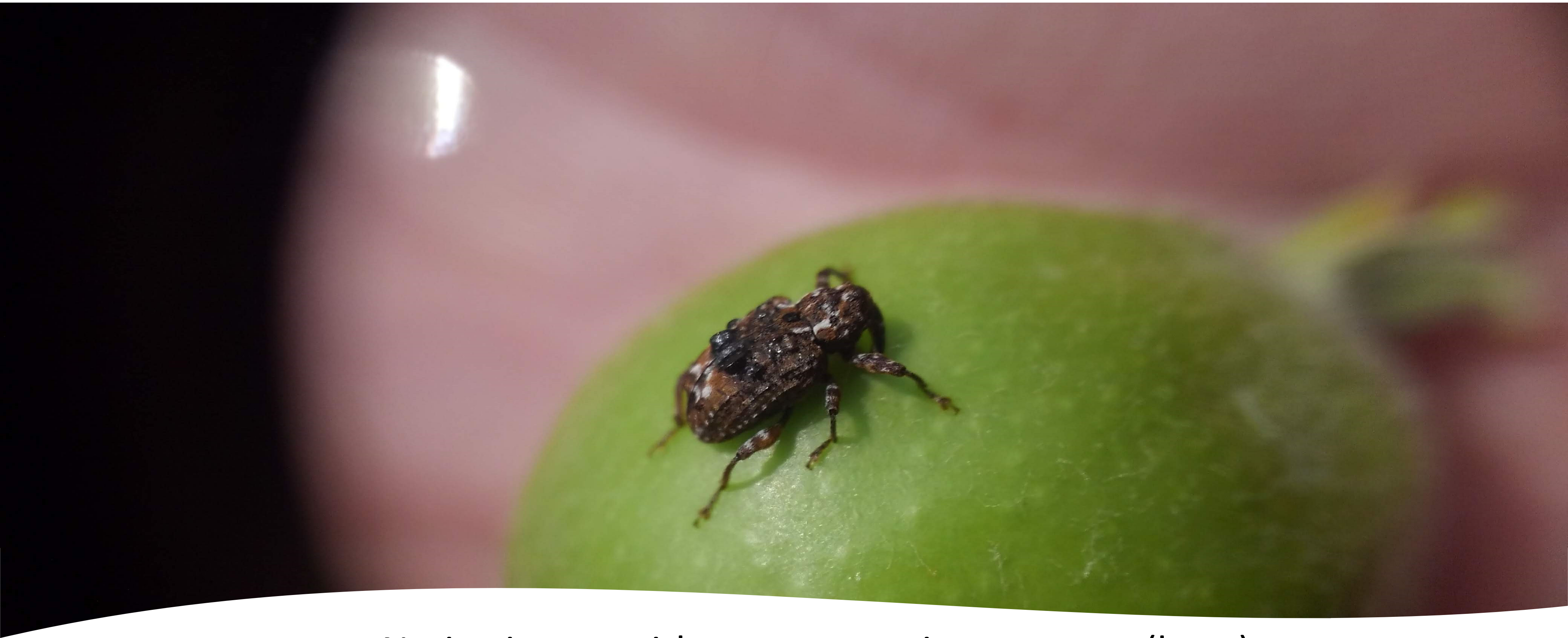
Active Ingredient Synergy Combinations

Fungicide A.I.	Fungicide Name	Insecticide A.I.	Insecticide Name
Difenoconazole	Inspire Super	Abamectin/avermectin	Agri-Mek, Reaper
Difenoconazole	Inspire Super	Thiamethoxam	Actara
Difenoconazole	Inspire Super	Imidacloprid	Admire Pro, Alias
Fenbuconazole	Indar	Acetamiprid	Assail 30SG
Boscalid + pyraclostrobin	Pristine Fungicide	Thiamethoxam	Actara
Myclobutanil	Rally 40 WSP	Imidacloprid	Admire Pro, Alias
Myclobutanil	Rally 40 WSP	Thiamethoxam	Actara
Myclobutanil	Rally 40 WSP	Lambda-cyhalothrin	Besiege, Cavalry, Warrior, Lamcap II
Pyraclostrobin	Merivon	Fenpyroximate	FujiMite/Portal
Thiophanate-methyl	Topsin-M	Imidacloprid	Admire Pro, Alias
Thiophanate-methyl	Topsin-M	Lambda-cyhalothrin	Besiege, Cavalry, Warrior, Lamcap II

Tank mixtures have been found to cause a variety of effects on pollinators including:

- Altering feeding behavior
- Reducing queen emergence due to compromised immunity
- Increased mortality
- Negatively impacting nesting behavior



Plum Curculio

- Native insect with one generation per year (here).
- Stone fruits are primary host.
- Overwinter as adults in protected areas, e.g., woods.
- Activity starts between bloom and petal fall.
- Begin scouting once fruit are >5mm diameter.
- PC move fast as temperatures warm >60F^{o} at night.
- Produce crescent-shaped egg-laying scars and misshapen fruit.
- Rarely larvae in fruit at harvest. Will develop in thinned fruit or June drops.

Photo credit: Peter Werts, IPM Institute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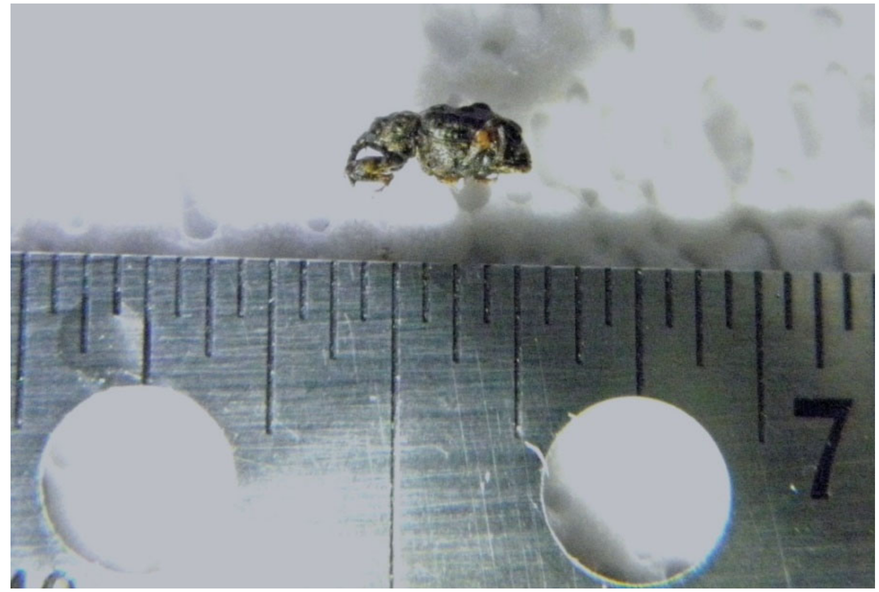
Oviposition injury appearance late in the season

Apple curculio

Plum Curculio: Monitoring

- Warm bloom: PC movement beyond the perimeter is likely.
- Cool bloom: PC probably still along the perimeter.
- Size and shape of block relative to location to woods.
- Record 95% McIntosh petal fall. PC emigration from wood lots ends after 308 DD from McIntosh petal fall.
- Perimeter is defined as first four rows or 60 – 80 ft. from edge of block.
- Early sizing fruit: Liberty, Zestar and Gingerold.



Plum Curculio: Habitat management

- Remove wild hosts (500-600 ft)
- Consider a trap crop as a buffer with overwintering sites.
    - 2-4 peripheral rows of an attractive cultivar such as Melba.
- Maintain perimeter so it is not conducive to migration to and from overwintering sites.
    - Bare ground or well-mowed (dry microclimate).
- Proper pruning for open canopy.
- Destroy PC infested apples when thinning
- Some or a lot of hand thinning is necessary in an organic orchard
- Destroy all thinned apples – don’t leave on the ground – including June drops.

Plum Curculio: Chemical Management

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Insecticide use in an IPM context

a. If PC is routinely distributed throughout block
   - Scout for first oviposition scars and treat.
   - Apply second treatment 10-14 days later.
   - If 308 DD_{50F} occur after 20 - 28 calendar days (petal fall biofix), scout for fresh scars and apply a third spray if necessary.

b. If PC is routinely distributed primarily at periphery, consider edge treatments.

c. High rates of NEEM and Kaolin Clay/ diatomaceous earth act as physical deterrents to PC activity
   a. Not rainfast and will wash off!

d. Organic: Grandevo shows some effect against PC and should be done at night.

e. Conventional products: Avaunt (indoxacarb) or Belay (clothianidin). Note: Both pose risks to pollinators.

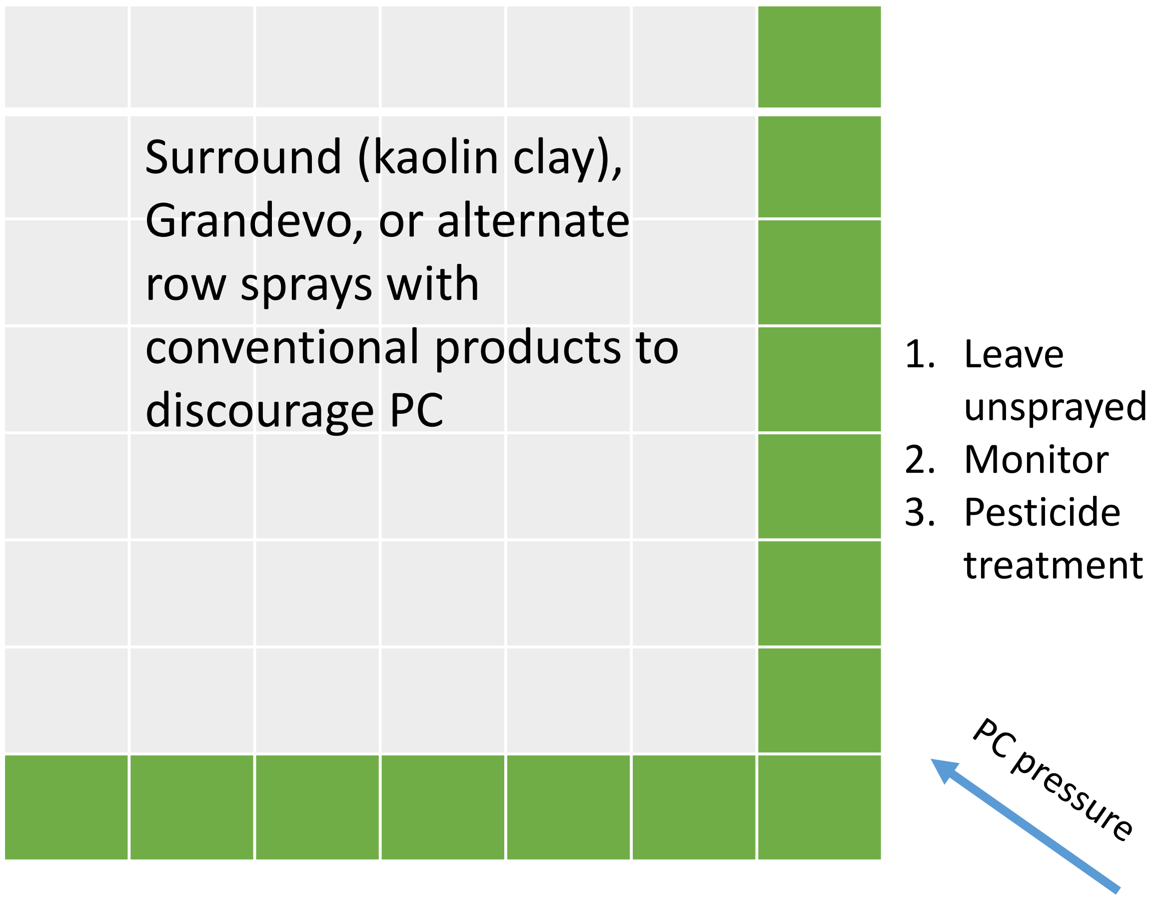
Plum Curculio: Behavioral Management

Push–Pull and trap cropping

1. Leave edge of orchard without Surround protection
2. Surround in interior of orchard, Alt-row sprays,
3. Monitor
4. When PC migrate, spray unprotected trees

Required conditions

1. PC coming from discrete location, not inside orchard
2. Orchard configuration
3. Fast spring warm-up



Codling moth

- Global pest and present in all apple growing regions.
- Two generations per year
- Classic "worm in apple"
- Organic management: Mating disruption, CM Virus, Entrust (spinosad). Bt not very effective.
- Conventional: Altacor, Exirel, Delegate, Assail, Avaunt

Photo credit: Peter Werts, IPM Institute

Codling Moth Biology

- Two generations span from shortly after petal fall to early September.
- Codling moths are very weak fliers:
  - More traps will improve accuracy of monitoring!
  - CM problems are often endemic to the orchard!
- One trap per five acres works on large and uniform blocks with level topography.
- One trap per 2.5 acres:
  - Irregular shaped blocks
  - Blocks with undulating topography, e.g., Driftless region, terminal moraines of SE Wisconsin
  - Using mating disruption
- Conditions that will inhibit flight:
  - Wind greater than 3 mph.
  - Rainy weather.
  - Flight between 6 – 11pm.

Codling Moth: Mating disruption

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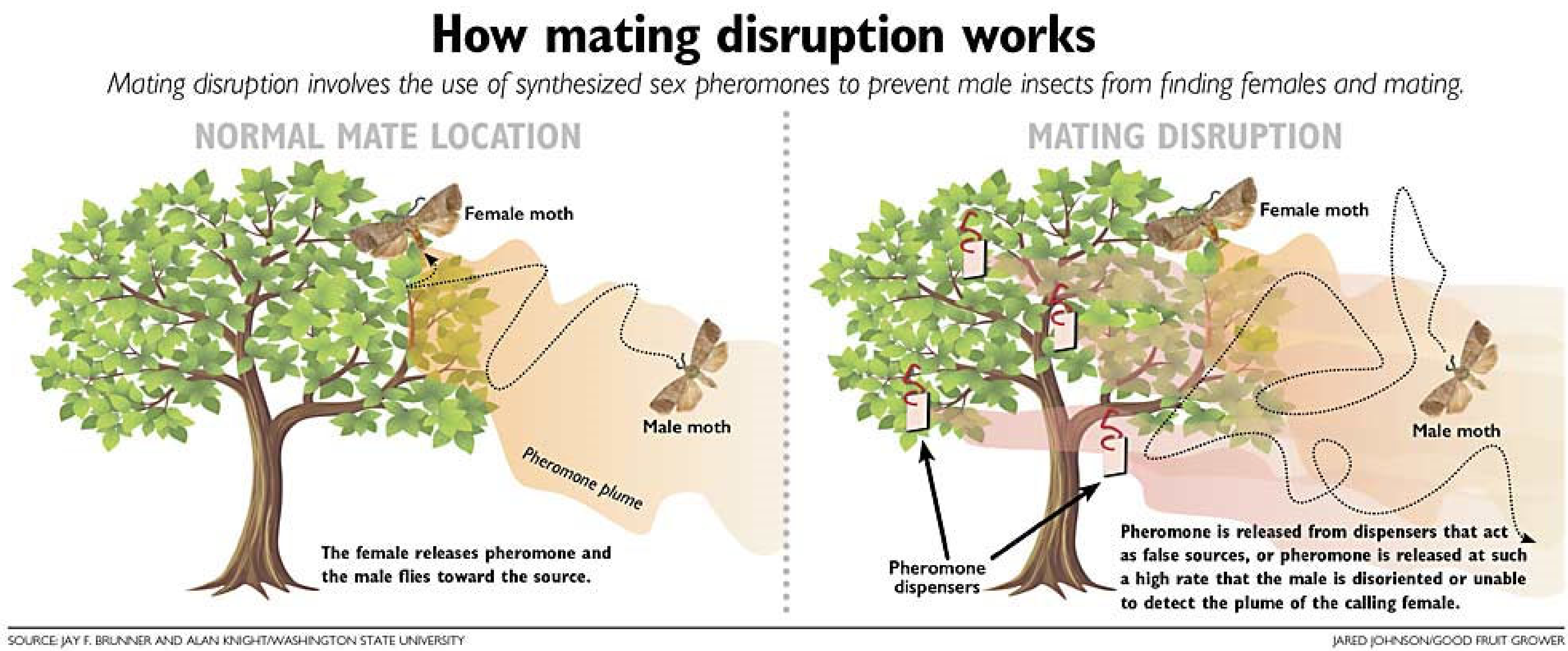
- Minimum of five acres.
- $45 - $125/acre
- Dispensers hung at 32 to 200/acre depending on formulation.
- Mating disruption allows growers to better allocate time and energy on other pests, e.g., plum curculio or apple maggot.



Codling moth oviposition (stings)

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First generation stings.

Second generation stings.

Advanced codling moth management

- One of the few pests where sufficient confidence exists in the established threshold that insecticidal controls can be eliminated or targeted simply by counting (enough) traps!
- A properly positioned and maintained trap will reflect the CM population from:

  No MD: Circle of ~235’ (approx one acre)

  With MD: Circle of ~75’ (approx one-tenth of an acre)

- Biofix: Start of the sustained codling moth flight.
- Tracking degree days from biofix tells us when eggs are hatching and what percent of eggs in the generation are hatching.
  - 250 DD from biofix – 3% egg hatch
  - 350 DD from biofix – 15% egg hatch
  - 450 – 600 DD from biofix – 50% egg hatch (Peak-egg hatch)
  - 700 – 900 DD from biofix – 15% egg hatch
  - 900 – 1000 DD from biofix – 3% egg hatch
  - 1000 – 1200 DD from biofix – Second-biofix (start model over again)

Codling moth biofix

Approx. 60% of larval hatch occurs between 350-650 DD from biofix

CM Bio-fix can be tricky to establish:

Three examples of early trap catches-

Day	1	3	5	7	9	11	13	15	17	19	21
Orchard											
A	18	24	0	0	6	35	39	18	0	0	0
B	2	1	0	0	0	4	1	7	0	0	3
C	2	0	0	1	1	2	3	1	0	0	0

Which orchard should apply larvicide @250 DD?

Which orchard could reset bio-fix, then apply larvicide @250 DD?

Which orchard could delay larvicide until 350 DD?

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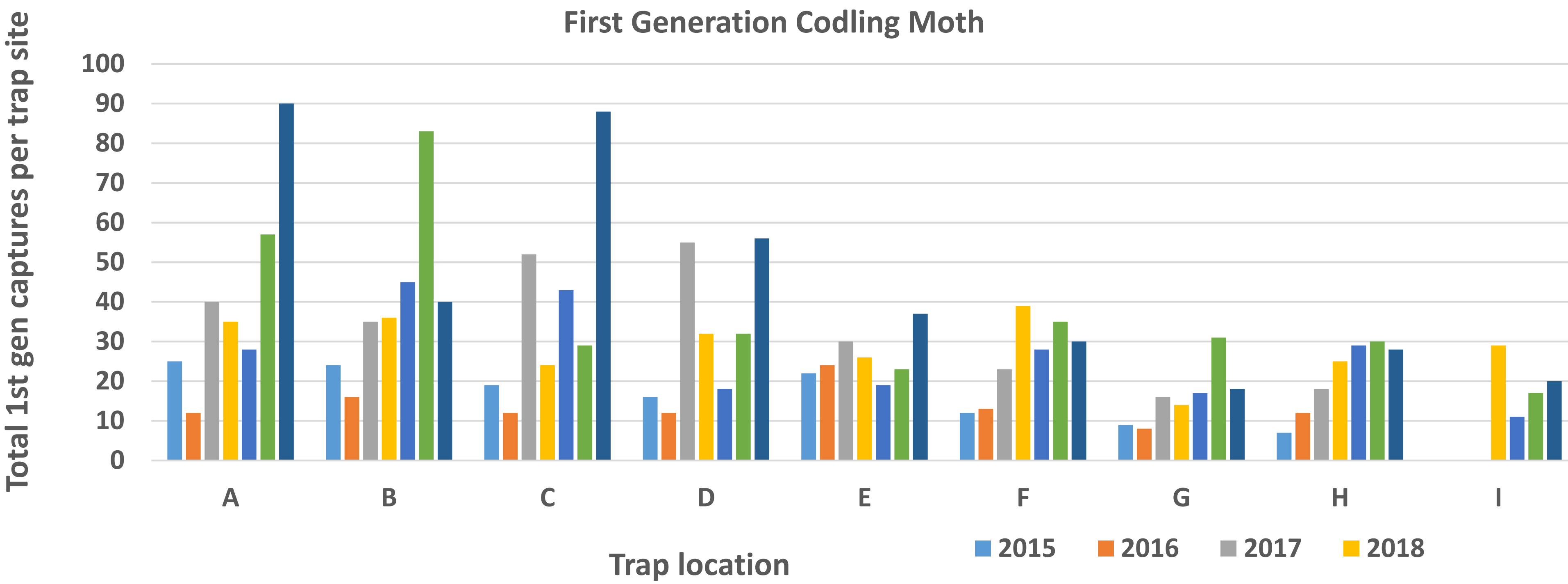
Codling Moth Population Dynamics



**First gen flight	DD from Jan 1 at time of biofix
5/26-7/8	252
5/26-7/12	239
5/18-7/10	220
5/24-7/11	266
5/30-7/10	253
5/27-7/6	228
5/18 - 7/7	218
AVG DD from January 1 for CM biofix	239

- One trap per 4.5 acres
- Most growers don't hang enough CM traps

Apple Maggot

- Native insect of North America: Hawthorn is natural host.
- One generation and overwinter as pupae in soil where apples fall.
- Adult feeding during 7-10-day preoviposition period.
- Summer into harvest.
  - Continuous emergence; not strictly tied to temperature.
  - Dependent on soil moisture and temperature.
- Significant varietal preferences but will attack all.
- Eggs laid directly in fruit.

Photo credit: Peter Werts, IPM Institute

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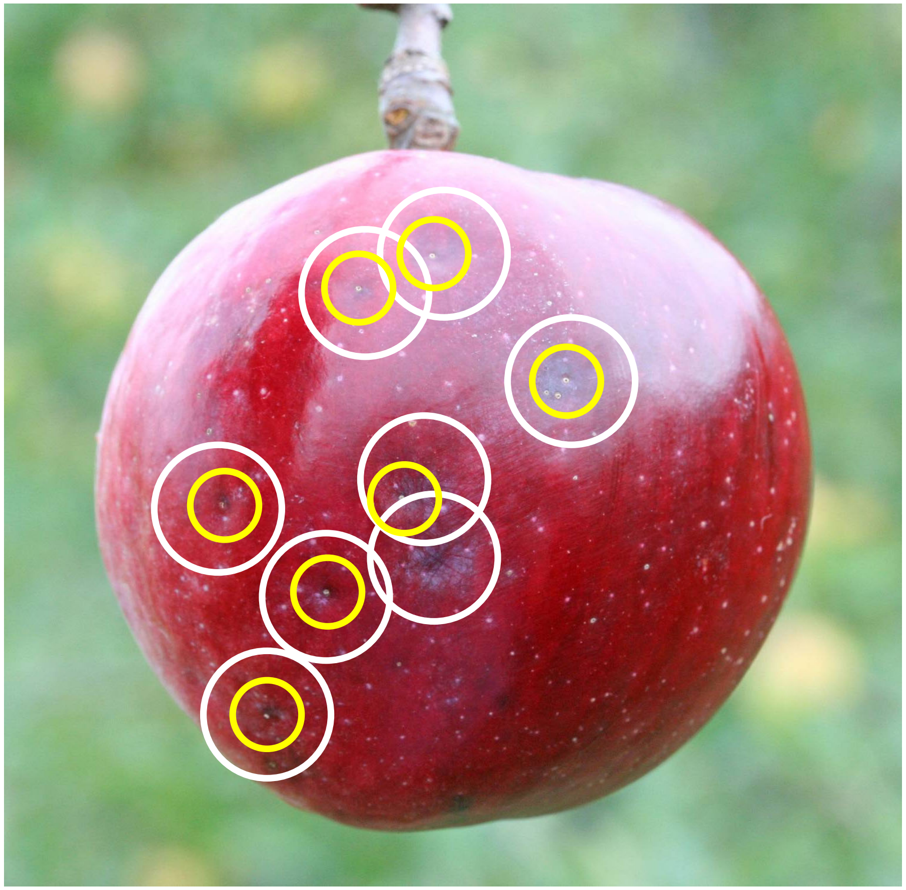
Apple maggot

Apple Maggot

- At minimum three traps per 10 acres.
- Preference to hang along perimeter every 50 yards, plus additional traps on interior.
- Baited traps:
  - Threshold is five.
  - Hang apple essence three feet from red sphere.
  - Good for assessing a population that is established in an orchard.
  - Post hailstorm.
  - Apples are ripe and essence needed to make trap more attractive.
- Unbaited traps:
  - No previous problems with AM.
  - Threshold is one.



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Apple maggot monitoring

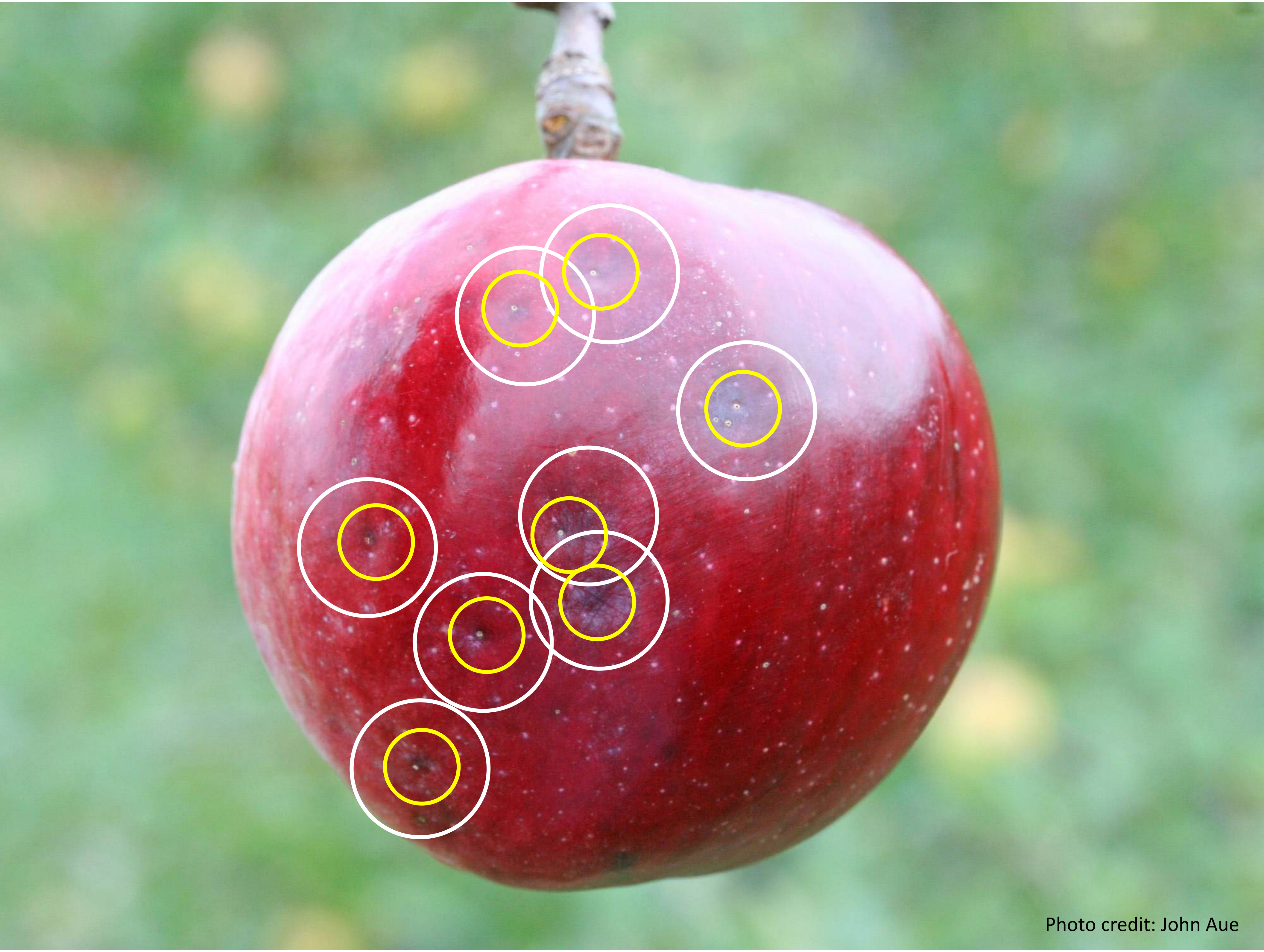

Photo credit: John Aue

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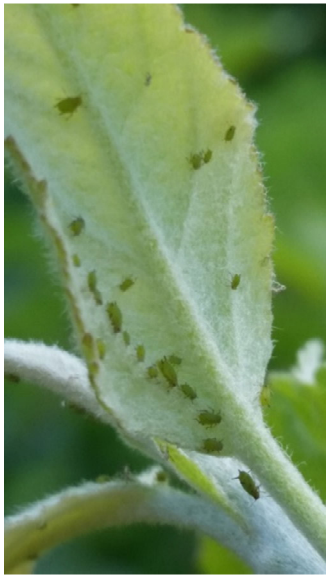
Secondary Pest Injury

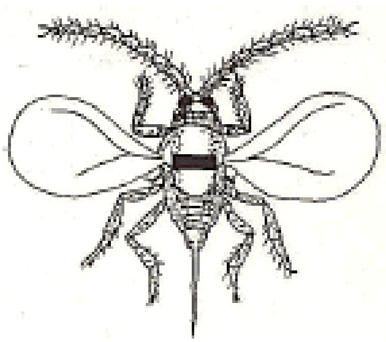







Leafrollers

San Jose scale



- **San Jose scale (SJS)** is an **endemic pest** of tree fruit. SJS infestations on the bark contribute to an overall decline in tree vigor, growth, and productivity. Loss of broad-spectrum post PF tools & increased tolerance from yearly exposure contribute to recent outbreaks.
- Feeding on the fruit induces local **red to purple discoloration** around feeding sites to decrease the cosmetic quality of the crop.
- **SJS produce 2 generations.** Crawlers are produced continuously over the season, fruit infestations are a constant threat once crawlers begin to emerge.
- Crawlers emerge from beneath the female scale cover, crawl or are **air-borne to new sites** of infestation on the bark, fruit, and leaves.
- **Develop waxy covering** within 48 hours of emergence (whitecap) that transitions to blackcap phase for 2^{nd} gen. or overwintering.

Source: Peter Jentsch, www.pomalab.org

San Jose scale

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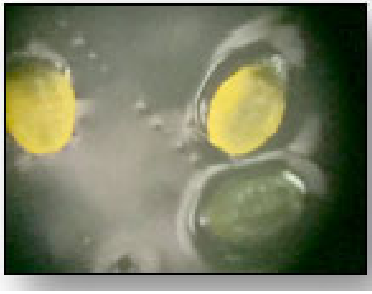
SJS Crawler Modeling:

- Pheromone trap for **adult male monitoring**.
- Black electrical tape with Vaseline to detect **first crawlers**



In 2018, the first SJS male flight in Highland occurred on the 19th May.

Model uses a 51°F lower threshold and 90°F upper threshold with 400 DD accumulations after the beginning of the male flight.

- **Emergence Model date:** June 15th, 2018.
- **Crawler emergence of nymphs on tape:** June 16th, 2018.
- **Fruit Injury on infested trees:** June 26th, 2018.

Source: Peter Jentsch, www.pomalab.org

Wooly Apple Aphid

- Injury: Forms large cotton candy colonies on branches by end of season.
- Considered a picking nuisance.
- Overwintering life stage feeds on tree roots, some NY growers suspect it is starting to overwinter on pruning cuts.
- Excellent example of a pest that can often be managed through biological control.
- Biological controls include:
  - Syrphid fly
  - Predatory Wasp *Aphelinus mali*
- Chemical controls: Movento, Beleaf applied several weeks after petal fall at early signs of infestation.

Pests on New Trees .....

....When secondary pests become direct pests

- Oblique and redbanded leafroller, aphids, thrips, potato leafhopper.
- Thresholds are nominal:
  - Consider size and age of tree.
  - 1 – 10% could be used.
  - Sample five terminals from 20 trees = 100 terminals, and determine percent infestation.
- Leafrollers:
  - Manage with Bt: UV breakdown, about four days of activity
  - Use before cloudy and warm period, >50F^{o}
- Aphids and leafhoppers:
  - No established thresholds
  - PyGanic, 1% oil solutions (non-bearing only)

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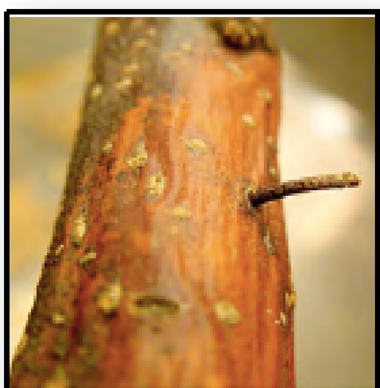
Black stem borer

- Black Stem Borer, 2mm in length, is a species of ambrosia beetle native to eastern Asia, but is an invasive species in Europe and North America.
- It carries an associated ambrosia fungus, *Ambrosiella hartigi and Fusarium solanii*. Females bore holes 1 mm in diameter to form reproductive galleries into the wood of trunks or limbs of **stressed trees that appear healthy and those that are dying.**
- **Ethanol-baited traps are used to monitor female flight. Entry sites found in wood from early July through early August in NYS.**



- Female BSB preferentially lands on and attacks physiologically stressed hosts emitting ethanol.
- Upon infesting the tree, the mycelium growth that the insects feed on, signals the tree that it is under attack, walling off its vascular system in response, symptoms develop including wilting, dieback, tree decline and death.

Source: Peter Jentsch, www.pomalab.org

Low Risk (Sorta) for Secondary Pests

Leafrollers	Plant bugs	Aphids/thrips	Japanese beetle	SJS
Bt products (Agree, Dipel)	Beleaf	Belay, Assail	Assail	Movento
Altacor, Exirel	Closer	Delegate	Neem (Maybe?)	Esteem
Delegate	Avaunt	Esteem	Exclusion on young trees	Centaur
Assail		Sivanto		Grandevo
Intrepid, Esteem		Beleaf, Movento (Especially for WAA)		Dormant oil

- Very few lower-risk pesticides have contact efficacy and require ingestion.
- Pests that eat lots of plant material are generally easier to kill, e.g., leafrollers.
- Pests that don't eat much, that have piercing and sucking mouth parts are harder to manage, e.g., thrips, aphids, plant bugs.
- Japanese beetle is in a class of its own.

Biocontrol Basics

Three types of classical biological control

- Conservation
  - Pesticide selection and formulation
  - Timing of applications, e.g., delay application to allow bio-controls to work.
- Augmentation
  - Habitat improvements and preservation
- Importation
  - Introduction of native or non-native biological controls to a production area.
  - Most common in closed systems, e.g., green houses

Types of biological control agents

- Parasitoids (specialists)
- Predators (specialists and generalists)
- Pathogens
  - Bacillus, viruses, etc.
  - Nematodes (Housed in pathology or entomology departments)

Scouting for Biological Controls

Black hunter thrips nymph (left) and adult (below).

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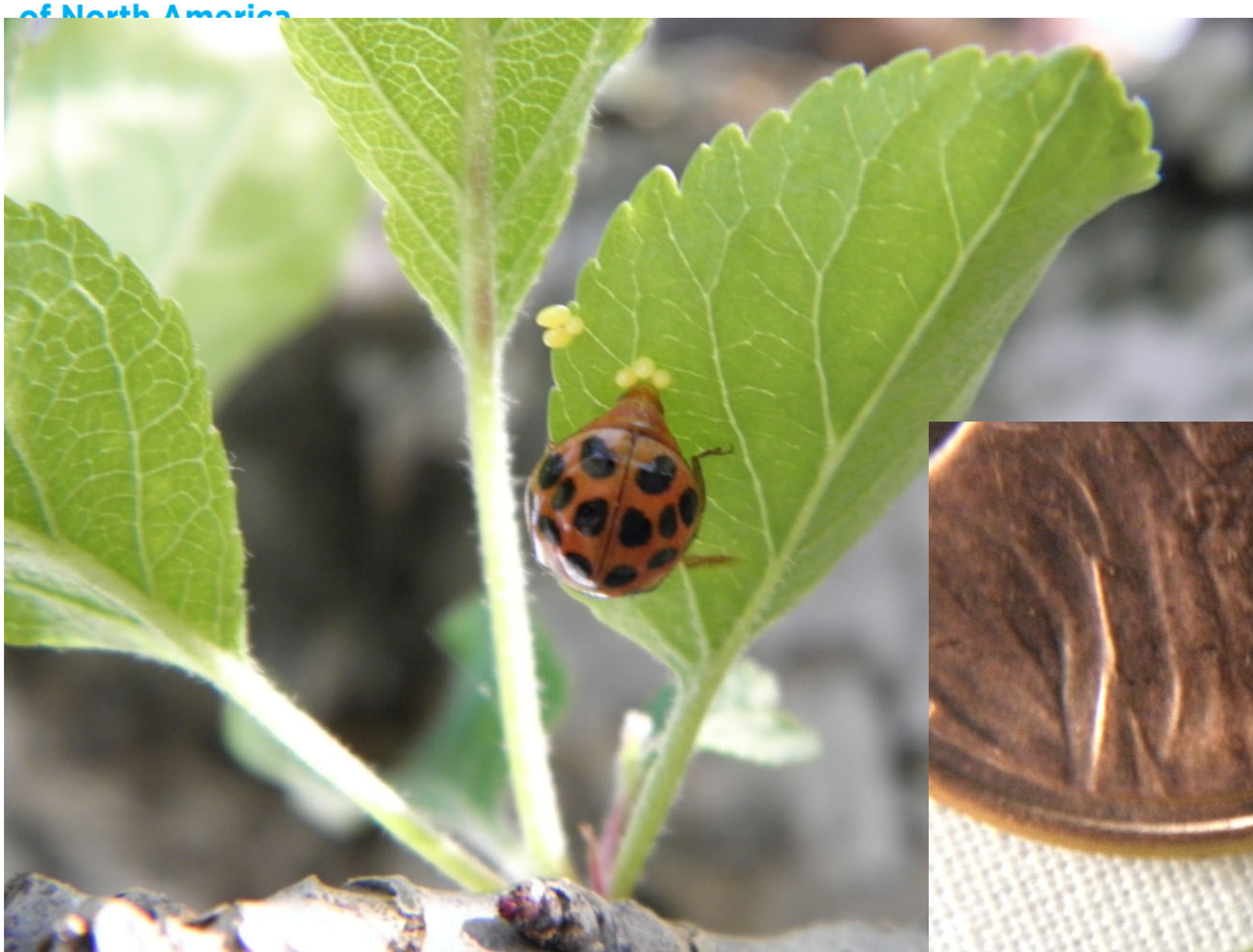
Scouting for Biological Controls



Lady beetle oviposition (above) nymph (right).

Scouting for Biological Controls

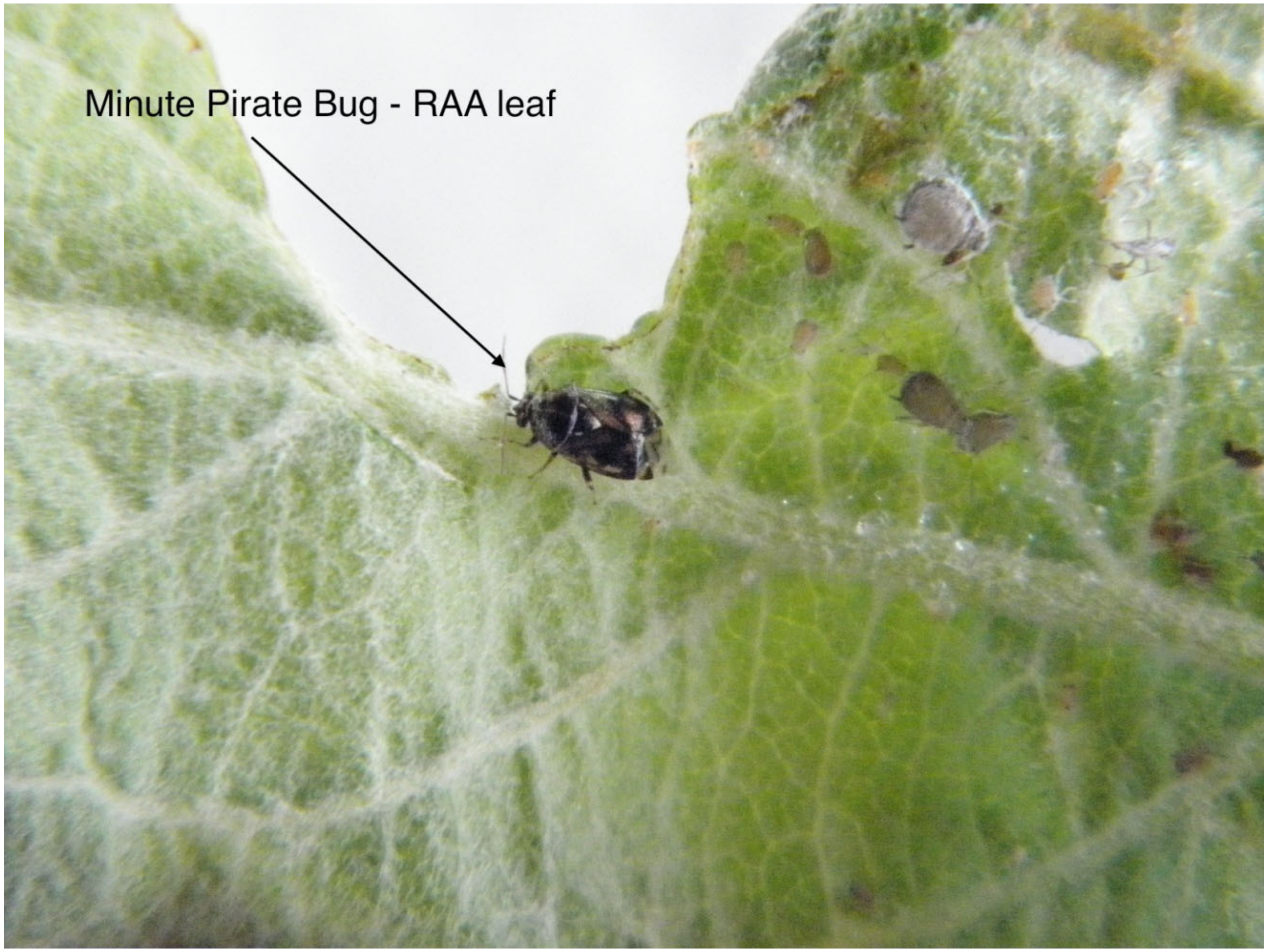
Syrphid fly adult (left), larva (lower left), egg (below).

Scouting for Biological Controls

Wooly apple aphid predation by syrphid fly larva.

Scouting for Biological Controls

Green lacewing eggs (left).



Scouting for Biological Controls

Zeta malli predatory mite and eggs (right).

Scouting for Biological Controls

Scouting for Biological Controls

Spine soldier bug and other native stink bugs are generalist predators. Unfortunately several of these native species can also cause significant economic damage to fruit during harvest.


Generalist Predator
Green LaceWing larva
(these hatch from white
eggs on slender stalks
visible on leaves)


Business End


Minute Pirate Bug
- Soybean aphid


Cecidomyid larva
PLH nymph

Thank you

Questions

Slide credits & contributions:

John Aue, Threshold IPM Services

Christelle Guedot, UW Madison

Peter Jentsch, Cornell Hudson Valley Lab