Introduction to Integrated Pest Management

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FACILITY
MINNESOTA DEPARTMENT
AGRICULTURE

Photo: Green Noise

Photo: Green Noise

“spirit” of pest management

Peace is easily maintained;
Trouble is easily overcome before it starts.
The brittle is easily shattered;
The small is easily scattered.
Deal with it before it happens.
Set things in order before there is confusion.

Lao Tzu, from *Tao te Ching, Ch. 64*
(Trans. by Jane English & Gia Fu Feng)

Technical Definition of IPM

- "(IPM) is an effective and environmentally sensitive approach to pest management that relies on a combination of common-sense practices."

- "IPM programs use information on the life cycles of pests and their interaction with the environment. "

- "This information, in combination with available pest control methods, is used to manage pest damage by the most economical means, and with the least possible hazard to people, property, and the environment."

Source: Adapted from US EPA

Slightly Technical Definition of IPM

- Use more than one tool.
- Learn your insect life cycles.
- Do no harm...or as little harm as possible to other inhabitants of the ecosystem...

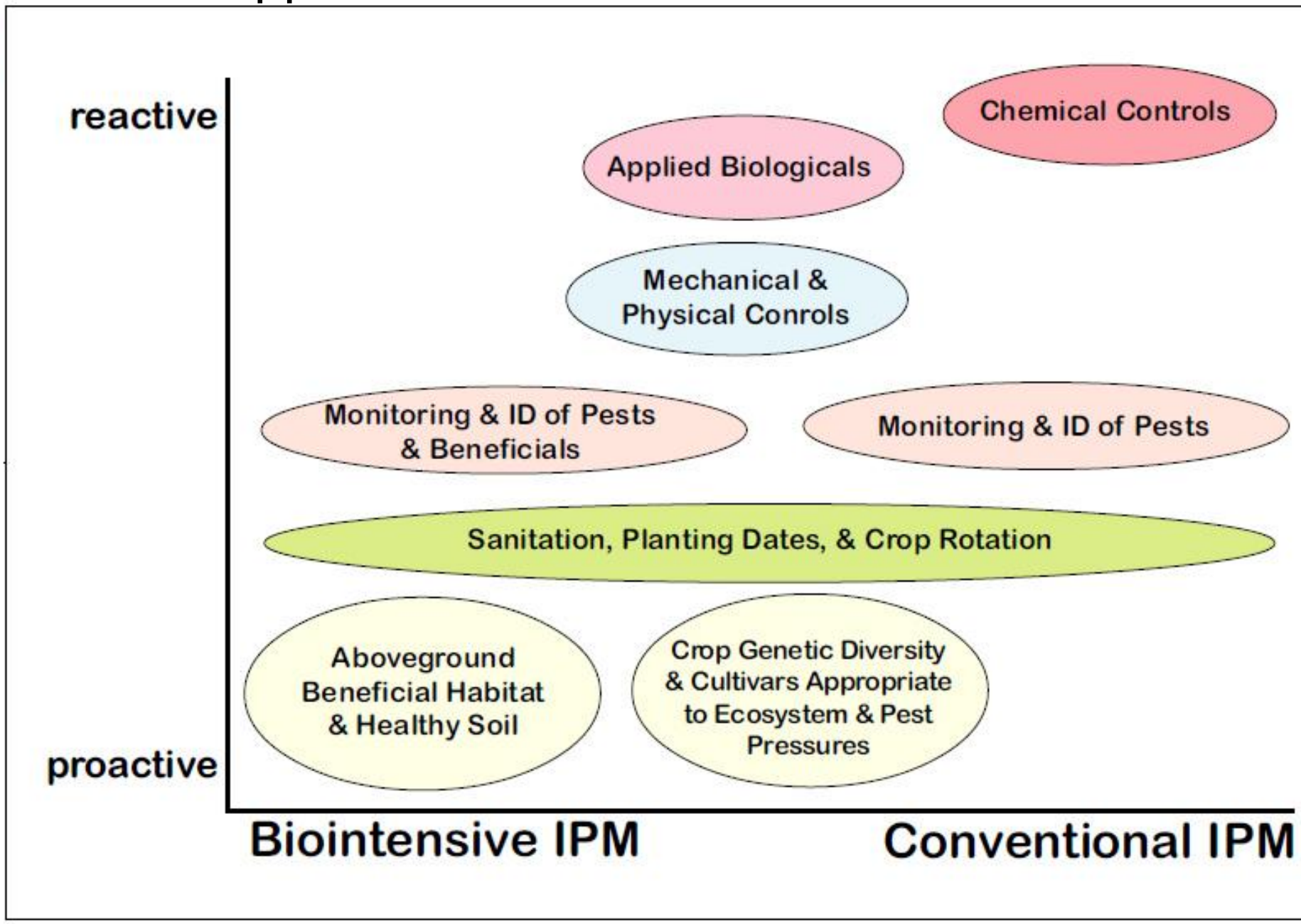
Source: Adapted and interpreted from US EPA

ghtly Less Technical Definition of IPM

- IPM emphasizes...an adaptable decision-making process *rather than* a one-size-fits-all treatment regime.
- IPM rewards...knowledge and awareness of insect biology (intimacy/intuition) *over* uninformed or rigidf treatment plans.
- IPM encourages...the use of multiple tools *instead of* a single tool.
- The success of IPM favors...prevention and prediction *over* reaction.

Source: Green Noise

Different Approaches to “IPM”



Four Ts of insect pest management

Insect pest management involves making decisions...

...The Four T's (4T) approach is a way to break down this process into smaller, more man-age-able bi ts

Four Ts of insect pest management

- TARGET (Specific pest / life cycle stage)
- TIMING (When to act appropriately for the certain life cycle stage)
- TOOL (Which product / tool to use), and
- TECHNIQUE (How to use your product or tool to enhance its efficacy against your bugs).

Four T - Questions

1. What species/life stage am I trying to manage? (TARGET)

2. When do I manage it? (TIMING)

3. What tool(s) do I use to manage it? (TOOL)

4. How can I improve my results? (TECHNIQUE)

Target:

Aphids

Target:

Apple maggot

Target:

Codling moth

Target:

Japanese beetle

TARGET (1 of 4 Ts)

- **Species**

- **Life cycle stage**
  - Egg
  - Larva
  - Pupa
  - Adult

TIMING (2 of 4 Ts)

Image: US Department of Agriculture

TIMING (2 of 4 Ts)

April	May	June	July	August
6 AM	12 PM		6 PM	12 AM

TIMING (2 of 4 Ts)

Simple Degree Day Calculation

$$DD = [(Tmax + Tmin)/2 – base\ temp.$$

TIMING (2 of 4 Ts)

Simple Degree Day Calculation

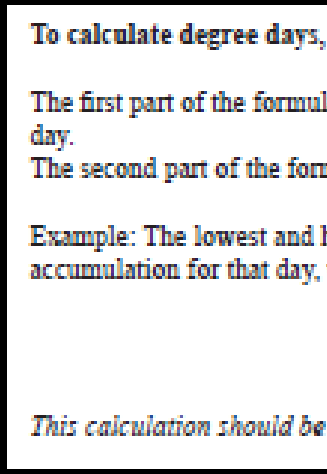
DD = [(Tmax + Tmin)/2 – base temp.

50 F and 80 F

80 + 50 / 2 – 50 F

65-50

15 DD

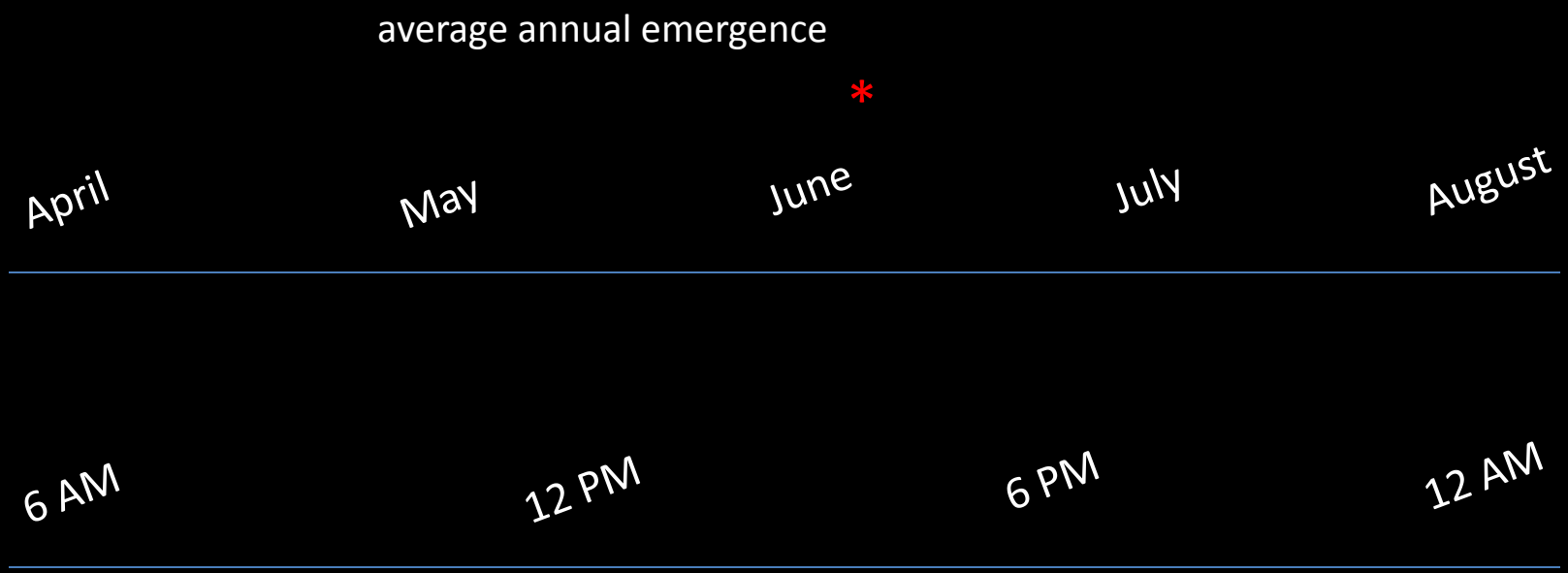

To calculate degree days,

The first part of the formul
day.
The second part of the for

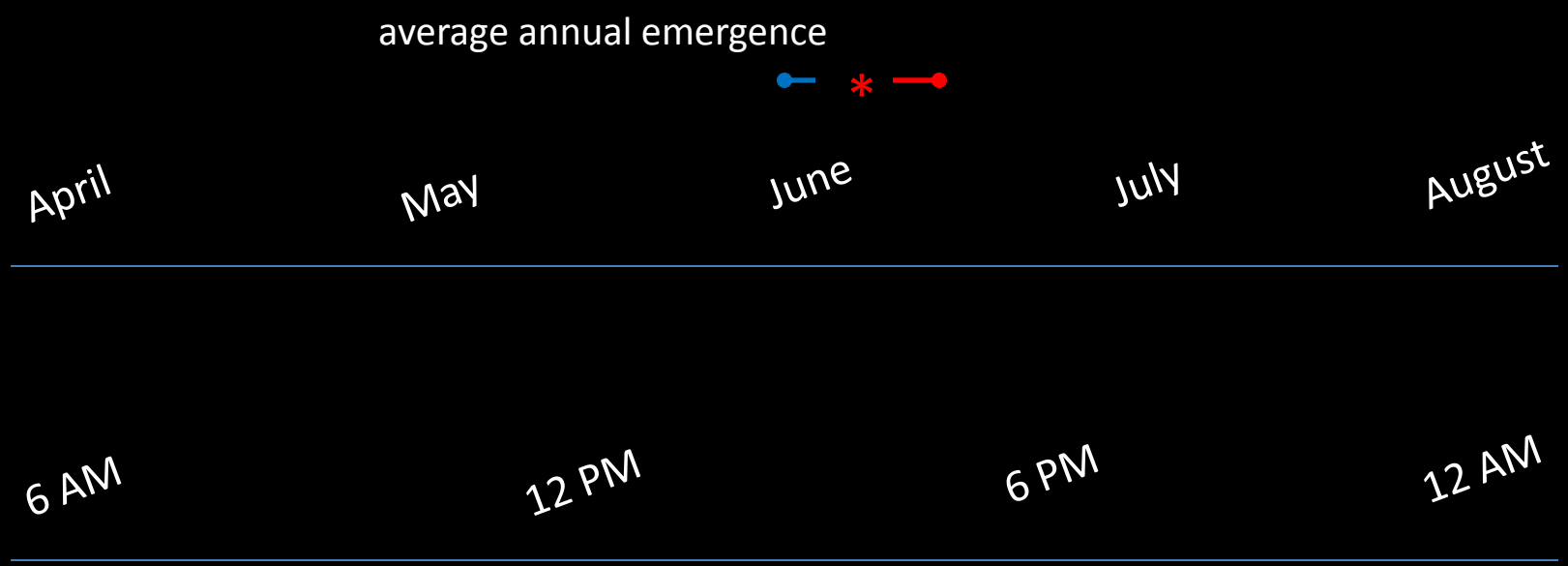
Example: The lowest and h
accumulation for that day,

This calculation should be

TIMING (2 of 4 Ts)



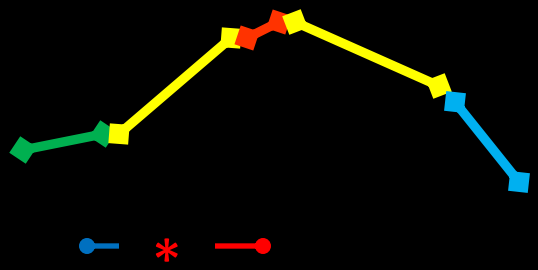
TIMING (2 of 4 Ts)



TIMING (2 of 4 Ts)

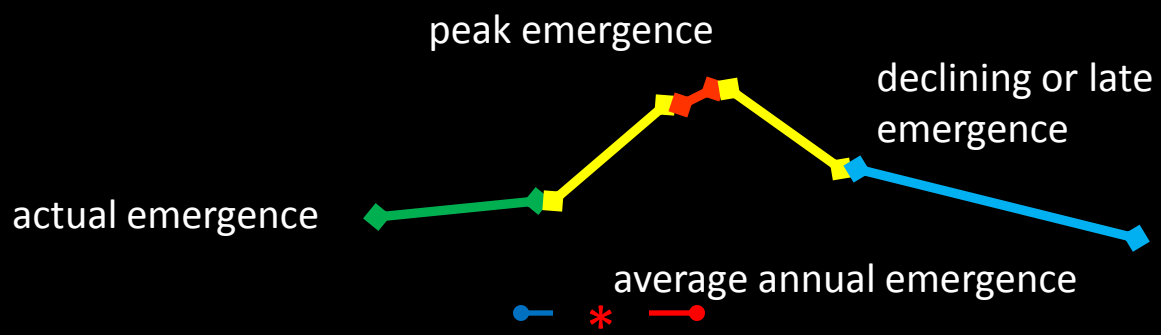
average annual emergence

actual emergence



Mon May 27
Tues May 28
Wed May 29
Thurs May 30
Fri May 31
Sat June 1
Sun June 2
Mon June 3
Tues June 4
Wed June 5
Thur June 6
Fri June 7
Mon June 8
Tues June 9
Wed June 10

TIMING (2 of 4 Ts)



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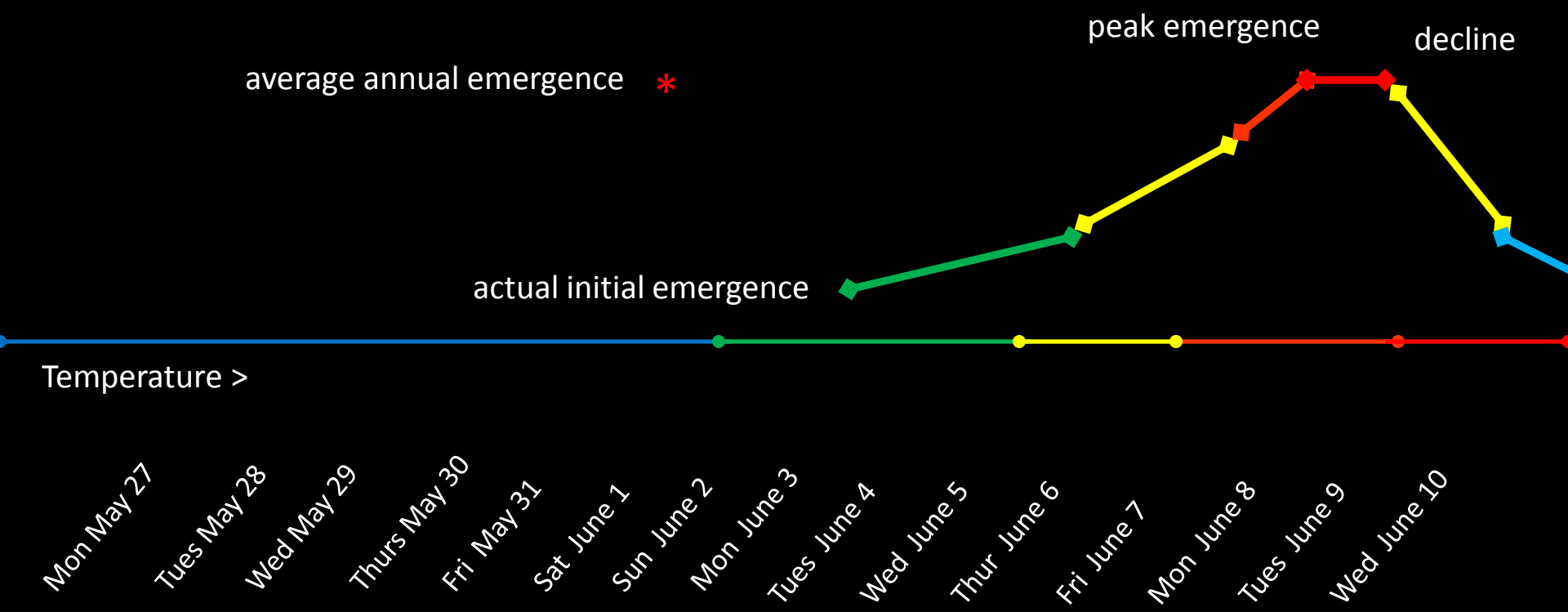
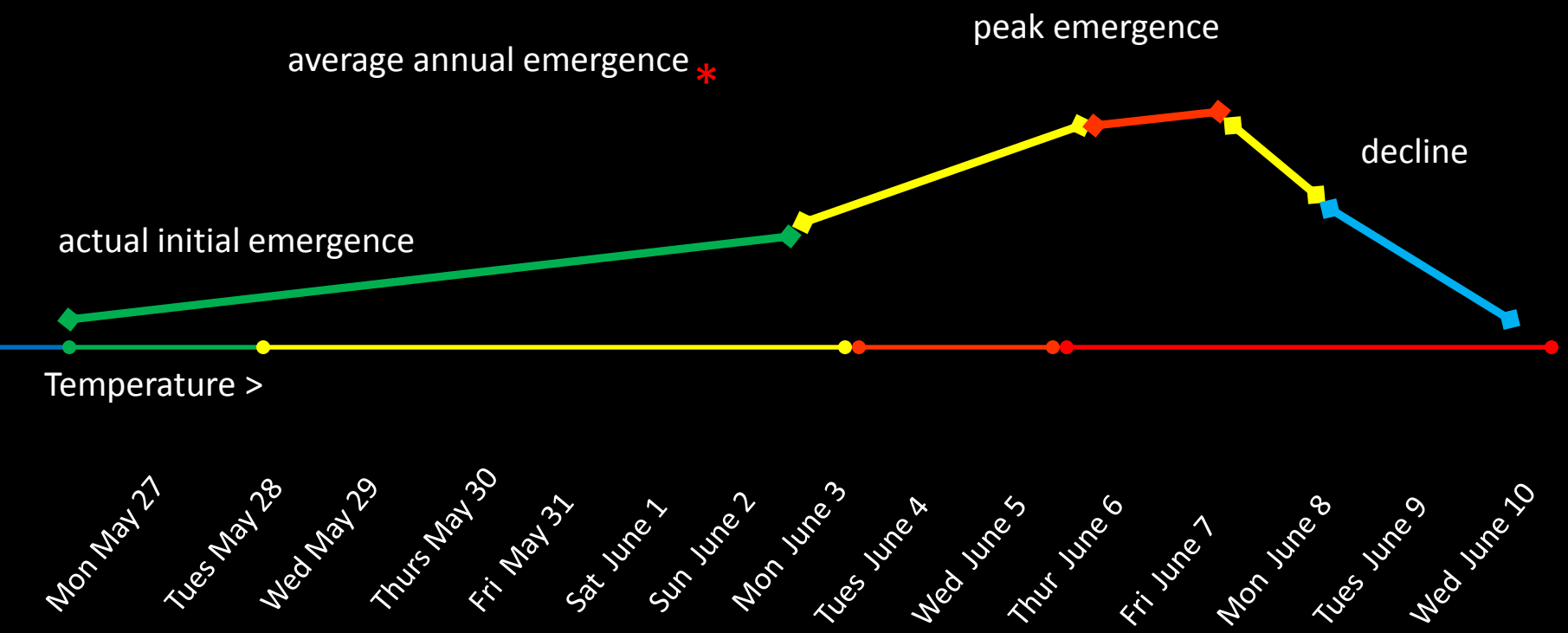
Cool spring_delayed emergence_example_cabbage flea beetle



Warm spring_delayed emergence_example_cabbage flea beetle



Extreme

>4 whitefly adults per 3 plants and obvious immatures present

High

>3 whitefly adults per 5 plants and obvious immatures present

Moderate

>2 whitefly adults per 10 plants and some immatures observed

Low

>1 whitefly adult per 20 plants and few or no immatures observed

Extreme

>15 apple maggot adults per baited
red sphere trap placed every 10 trees

High

>10 apple maggot adults per baited
red sphere trap placed every 10 trees

Moderate

>5 apple maggot adults per baited
red sphere trap placed every 10 trees

Low

>1 apple maggot adults adult per baited
red sphere trap placed every 10 trees

Source: New England Apple Pest Management Guide

TOOLS (1 of 4 Ts)

- _Cultural Tools
- _Mechanical, Material, Physical Tools
- _Biological Tools
- _Monitoring and Trapping Tools
- _Chemical Tools

Cultural

Trap cropping

Plant care (fertilizer, mulching, watering)

Plant location (soil quality, shade/light, matching location to plant preferences)

Plant selection (resistant to disease/pests, zone hardy, tolerant to poor conditions)

Time-based techniques (late season crop)

Habitat adjustment (removing plants that provide habitat during the growing season or secondary hosts that provide habitat for overwintering)

Concept image: Dr. Ayanava Majumdar, Louisiana Gardener, 2/28/11

Mechanical/Material/ Physical

Bug vacuum
Atrix Express Plus Bug Vacuum
$249.00
DoMyOwnPestControl.com

Other examples:
Pruning
Hand-picking
Row covers
Branch mesh
Bagging apples
Heat
Humidity
Light
Airflow

Biological Control, “Classical”
Releasing *Aphthona spp.* to manage leafy spurge

Photo: MDA Weed Biocontrol Program

Monitoring and Trapping

Chemical (Synthetic)

Product: Sevin*
Active ingredient: Carbaryl (22.5%)

Mode of action: Cholinesterase Inhibition

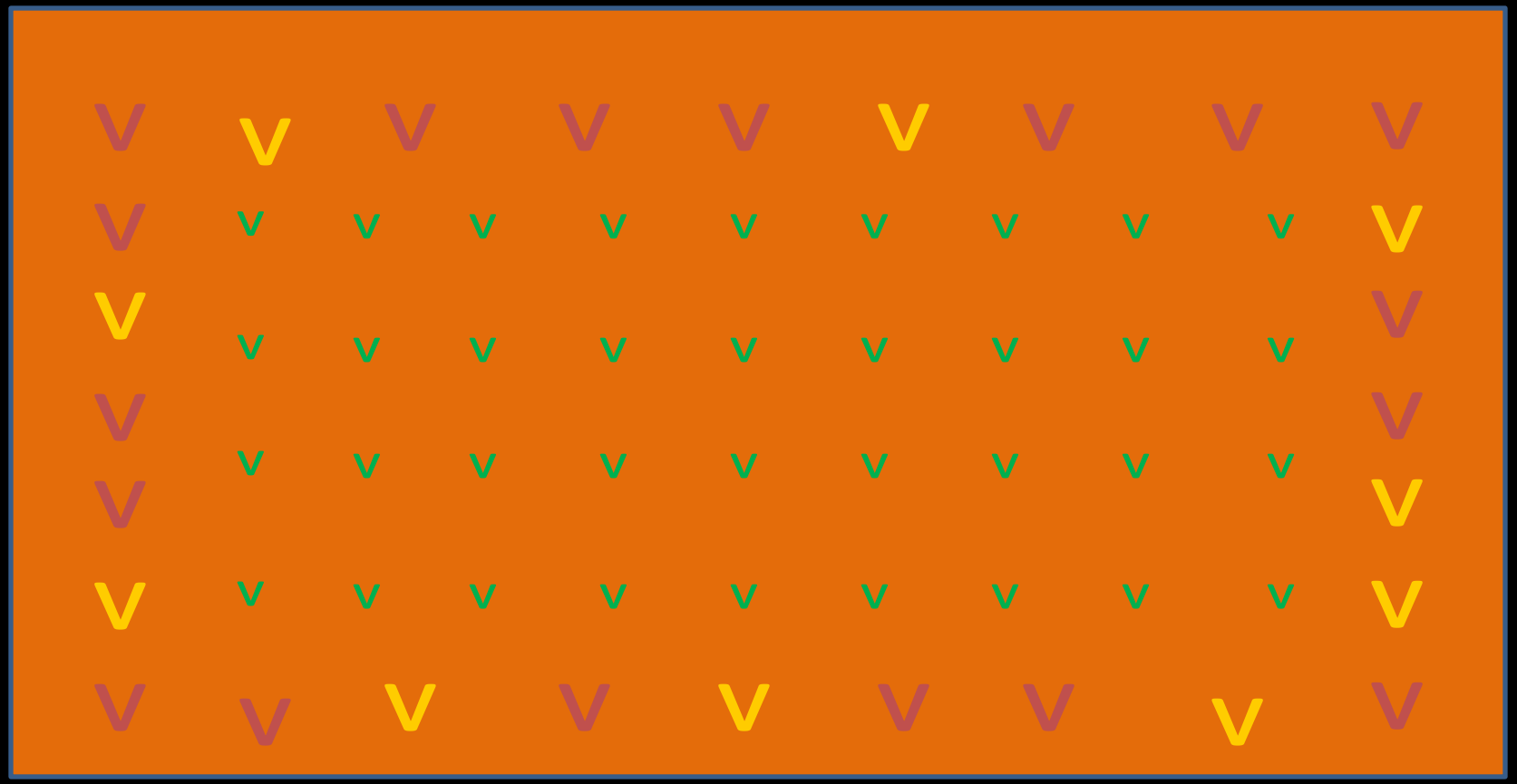
“Organophosphate and carbamate insecticides are known as *cholinesterase* *inhibitors. They bind to the enzyme that is* normally responsible for breaking down ACh after it has carried its message across the synapse. When an insect has been poisoned by a cholinesterase inhibitor, thecholinesterase is not available to help break down the ACh, and the neurotransmitter continues to cause the neuron to “fire,” or send its electrical charge. This causes overstimulation of the nervous system, and the insect dies.”

from Maryland Cooperative Extension Leaflet #43

*Inclusion does not mean or imply an endorsement

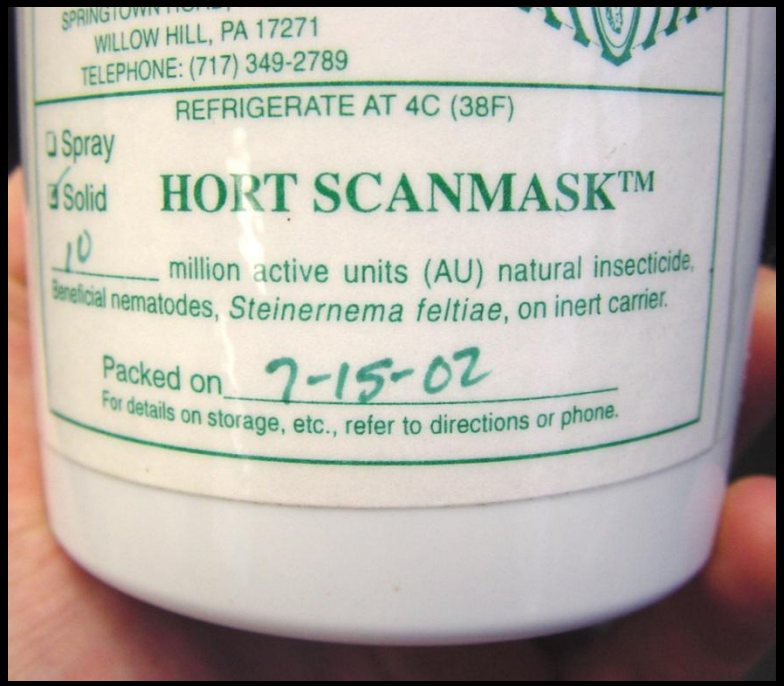
Photo: Green Noise

TECHNIQUE (4 of 4Ts)



Perimeter trap cropping

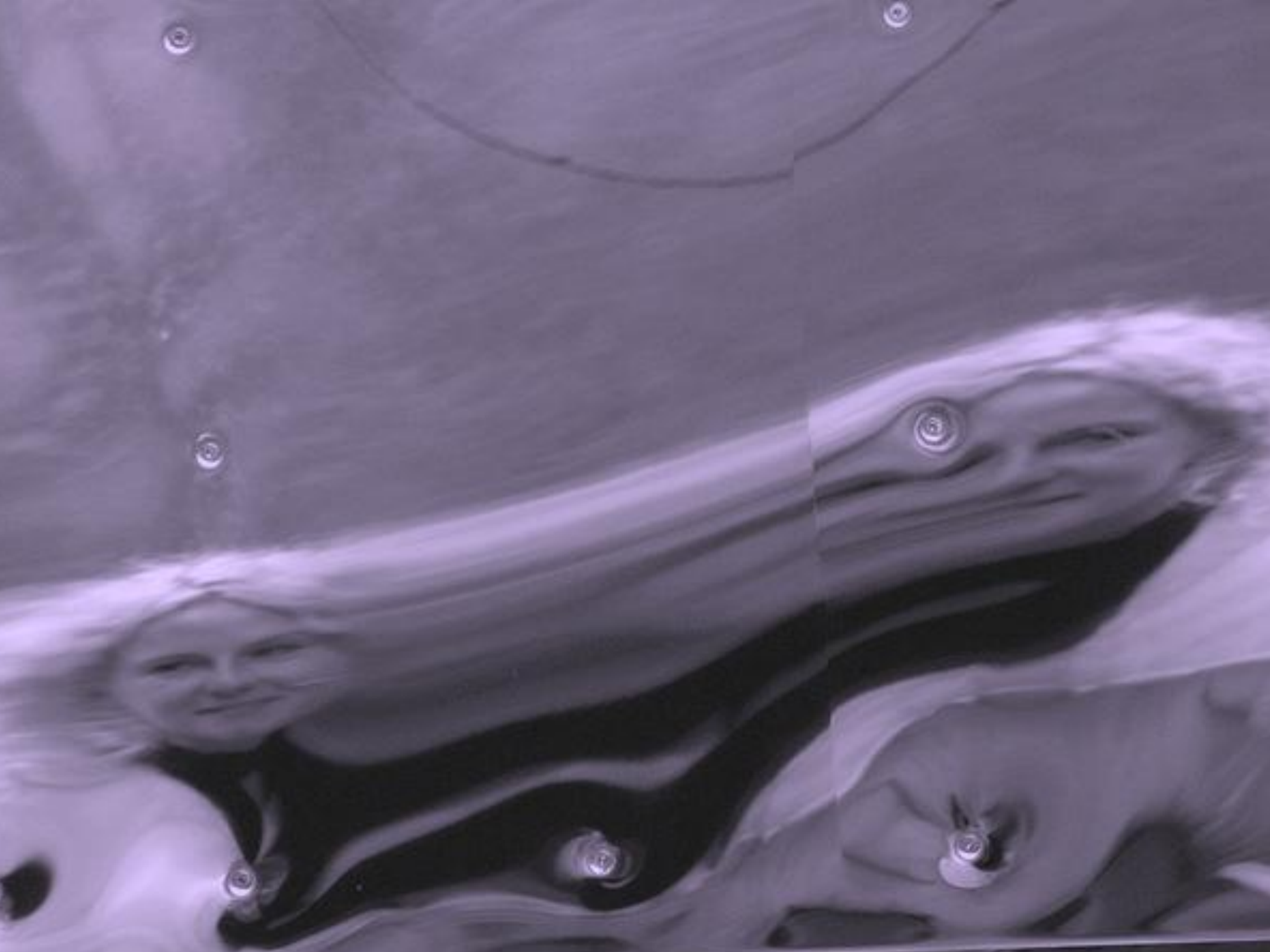
TECHNIQUE (4 of 4Ts)



Preparing the soil for applying beneficial nematodes for soil-dwelling insects

TECHNIQUE (4 of 4Ts)

Applying spray pesticides where the insects are present, such as under the leaf. And repeating applications as necessary.



Insect Classification, Functions and Mouthparts

Insect Orders

Coleoptera - beetles

Lepidoptera - moths

Orthoptera – grasshoppers, crickets, cockroaches, mantids

Diptera - flies

Neuroptera – lacewings, mantispids

Hymenoptera – bees & wasps

Homoptera – cicadas, aphids, leafhoppers

Hemiptera – true bugs

Odonata – dragonflies & damselflies

Dermaptera - earwigs

Siphonaptera - fleas

Thysanoptera – thrips

Source: MDA Biocontrol Program, Dr. John Luhman

Insect Orders…….and Etymology

Coleoptera - beetles

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Dermaptera - earwigs

Siphonaptera - fleas

Thysanoptera – thrips

Coleoptera – “sheath-winged”

Lepidoptera – “dust-winged”

Orthoptera – “straight winged”

Diptera – “two-winged”

Neuroptera – “nerve-winged”

Hymenoptera – “net-winged”

Homoptera – “same-winged”

Hemiptera – “half-winged”

Odonata – “toothed”

Dermaptera – “skin wingless”

Siphonaptera – “”sucking wingless”

Thysanoptera – “fringe-winged”

Source: MDA Biocontrol, Dr. John Luhman

Functions

Pollinators >>>

Plant feeders

Predators

Parasitoids

Pathogens

Scavengers

Decomposers

Food

Bumblebee (*Bombus impatiens*) pollinating anise hyssop *(Agastache foeniculum)*

Photo: Green Noise

Pollinators

Functions

Pollinators >>>

Plant feeders

Predators

Parasitoids

Pathogens

Scavengers

Decomposers

Food

Adult hoverfly on goldenrod flowers
Image by Gail Eichelberger
www.beautifulwildlife garden.com

Functions

Pollinators

Plant feeders >>>

Predators

Parasitoids

Pathogens

Scavengers

Decomposers

Food

Alfalfa Lady Beetle on bouncing bet

Photo: MDA, Insect Identification by Dr. John Luhman

Plant feeders

Functions

- Pollinators
- **Plant feeders >>>**
- Predators
- Parasitoids
- Pathogens
- Scavengers
- Decomposers
- Food

Photo: MDA Weed Biocontrol Program

Functions

Pollinators

Plant feeders

Predators >>>

Parasitoids

Pathogens

Scavengers

Decomposers

Food

Soldier bugs feeding on a cabbage butterfly caterpillar

Photo: Green Noise

Predators

Functions

Pollinators

Plant feeders

Predators

Parasitoids >>>

Pathogens

Scavengers

Decomposers

Food

Photo: MDA Biocontrol

Functions

- Pollinators
- Plant feeders
- Predators
- **Parasitoids >>>**
- Pathogens
- Scavengers
- Decomposers
- Food

Photos: Encarsia formosa (left), Pimpla disparis (right)
MDA Biocontrol

Parasitoids

Pupal Parasitoids

Pupal Parasitoids

Photos:Pimpla disparis wasp (left), European corn borer pupa (middle), European corn borer caterpillar (right, bottom) MDA Biocontrol

Egg Parasitoids

Egg Parasitoids

Trichogramma ostriniae adult wasps (left), parasitized ECB egg masses (top right), ECB larvae emerging from egg masses (right bottom)

Photos: MDA Biocontrol

Functions

Pollinators

Plant feeders

Predators

Parasitoids

Pathogens >>>

Scavengers

Decomposers

Food

Photo: Forestry Images

Functions

Pollinators

Plant feeders

Predators

Parasitoids

Pathogens

Scavengers

Food

Ants scavenging bird dung

Photo: Green Noise

Functions

Pollinators

Plant feeders

Predators

Parasitoids

Pathogens

Scavengers

Food

Moth fly larvae in scummy dishwater with crushed cheerios

Photo: Green Noise

Decomposer-scavengers

Functions

Pollinators
Plant feeders
Predators
Parasitoids
Pathogens
Scavengers
Decomposers
Food >>>

"If all mankind were to disappear, the world would regenerate back to the rich state of equilibrium that existed ten thousand years ago.

If insects were to vanish, the environment would collapse into chaos."

– E.O. Wilson

Argipes spp. spider snacking on a grasshopper

Photo: Green Noise

Mouthparts

Chewing

Piercing-Sucking

Rasping-Sucking

Sponging

Sponging-Cutting

Photos: MDA Biocontrol

Mouthparts

Chewing

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Photo: Green Noise

Mouthparts

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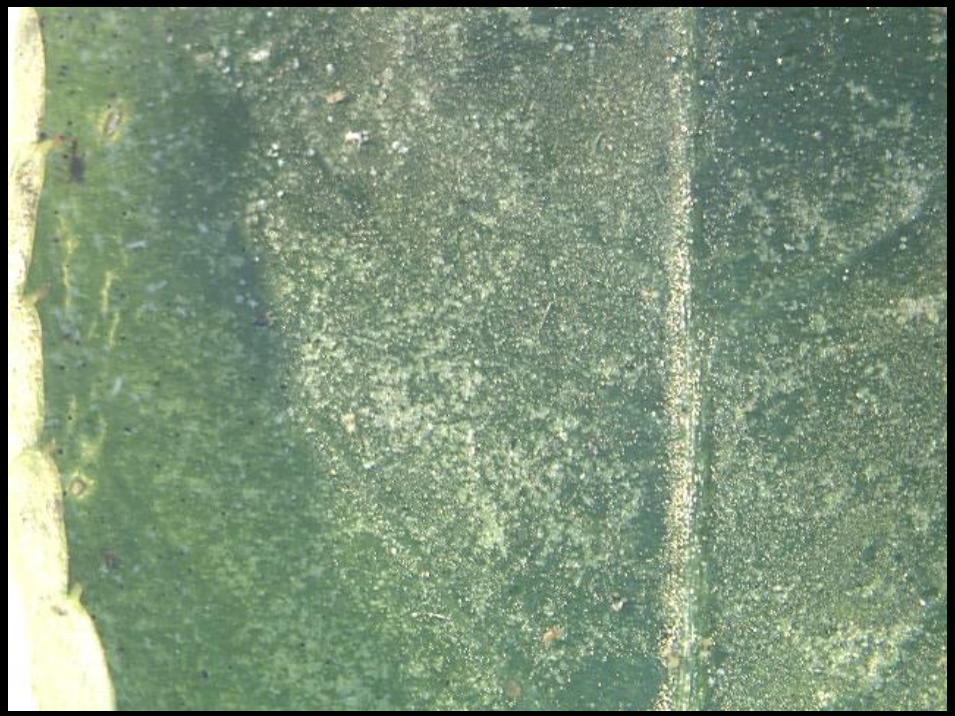


Photo: MDA Biocontrol

Mouthparts

Chewing

Piercing-Sucking

Rasping-Sucking

Sponging

Sponging-Cutting

Photo: Tree of Life

Mouthparts

Chewing

Piercing-Sucking

Rasping-Sucking

Sponging

Sponging-Cutting

Photo: Tree of Life

Examples of Common Plant Pests

And how to use the 4T approach
to deal with them...

Japanese beetle (*Popillia japonica* Newman)

TARGET (1 of 4 Ts)

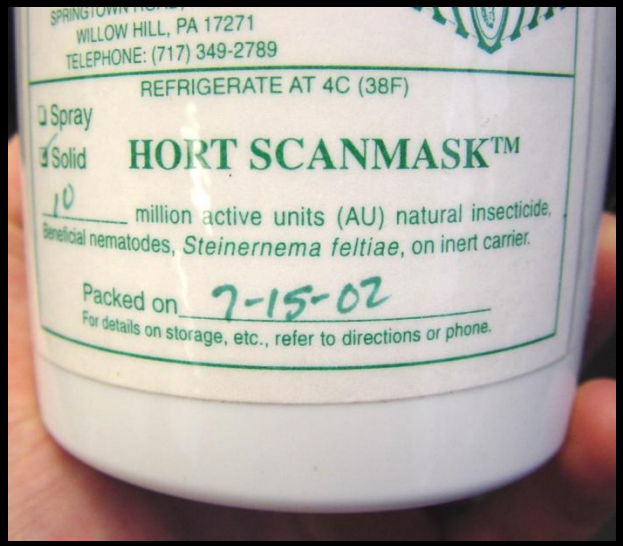
Japanese beetles on wild grape

Japanese beetle grubs
Photo: David Faulkner, University of Illinois

TIMING (2 of 4 Ts)

Image: US Department of Agriculture

TOOL (3 of 4 Ts)



Container of 10 million nematodes

Nematodes in vermiculite

Nematodes

Beneficial nematodes for Japanese beetle control

Species - *H. bacteriophora* (Hb)

TOOL (3 of 4 Ts)

Nematodes

Japanese beetle grub infected with nematodes

TECHNIQUE (4 of 4 Ts)

Photo: Peggy Greb, Forestry Images

Photo: Dr Relling, Flickr Creative Commons

1. **Water** before and after application of nematodes.
2. Continue to irrigate target area for 2 to 10 days after initial release of nematodes.
3. According to one study, average parasitization was ~80% when **soil temps** are on the warm side - between 70-86 degrees F.
4. Minimum release rate = 1 billion nematodes per acre.
5. Nematodes are most effective against **young grubs**, so **release in mid-August** to **late September** for best results.
6. Use species Heterorhabditis bacteriophora (Hb).

Colorado potato beetle

Photo: USDA

Photo: Boyd Hagen

Photo: USDA

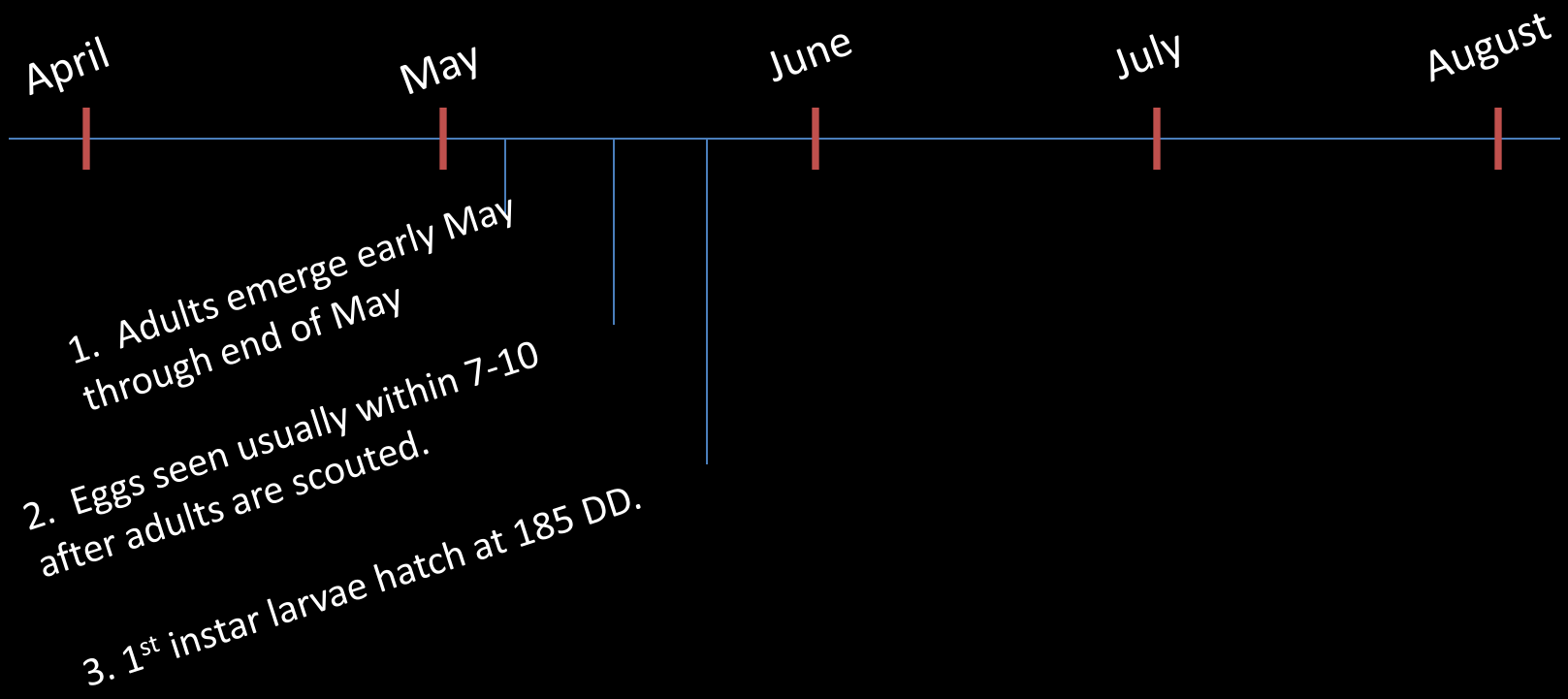
TARGET (1 of 4 Ts)

Colorado potato beetle adult
Photo: USDA/Scott Bauer

Colorado potato beetle eggs
Photo: Agrarian Nation

Colorado potato beetle larvae
Photo: USDA

TIMING (2 of 4Ts)



Biofix: When eggs are first scouted.

TIMING (2 of 4Ts)

April | May | June | July | August

1. Adults emerge early May through end of May
2. Eggs seen usually within 7-10 after adults are scouted.
3. 1st instar larvae hatch at 185 DD.

Control of adult beetles

1. Rotate crops (Cul)
2. Mulch for habitat (Cul)
3. Trap crops (early crop) (Cul)
4. Flame thrower (Phy/Mec)
5. Row covers (Phy/Mec)
6. Release beneficial nematodes before planting (in mid-April) (Bio)

Biofix: When eggs are first scouted.

TOOLS/TECHNIQUE (3 / 4 of 4Ts)

Control of adult beetles

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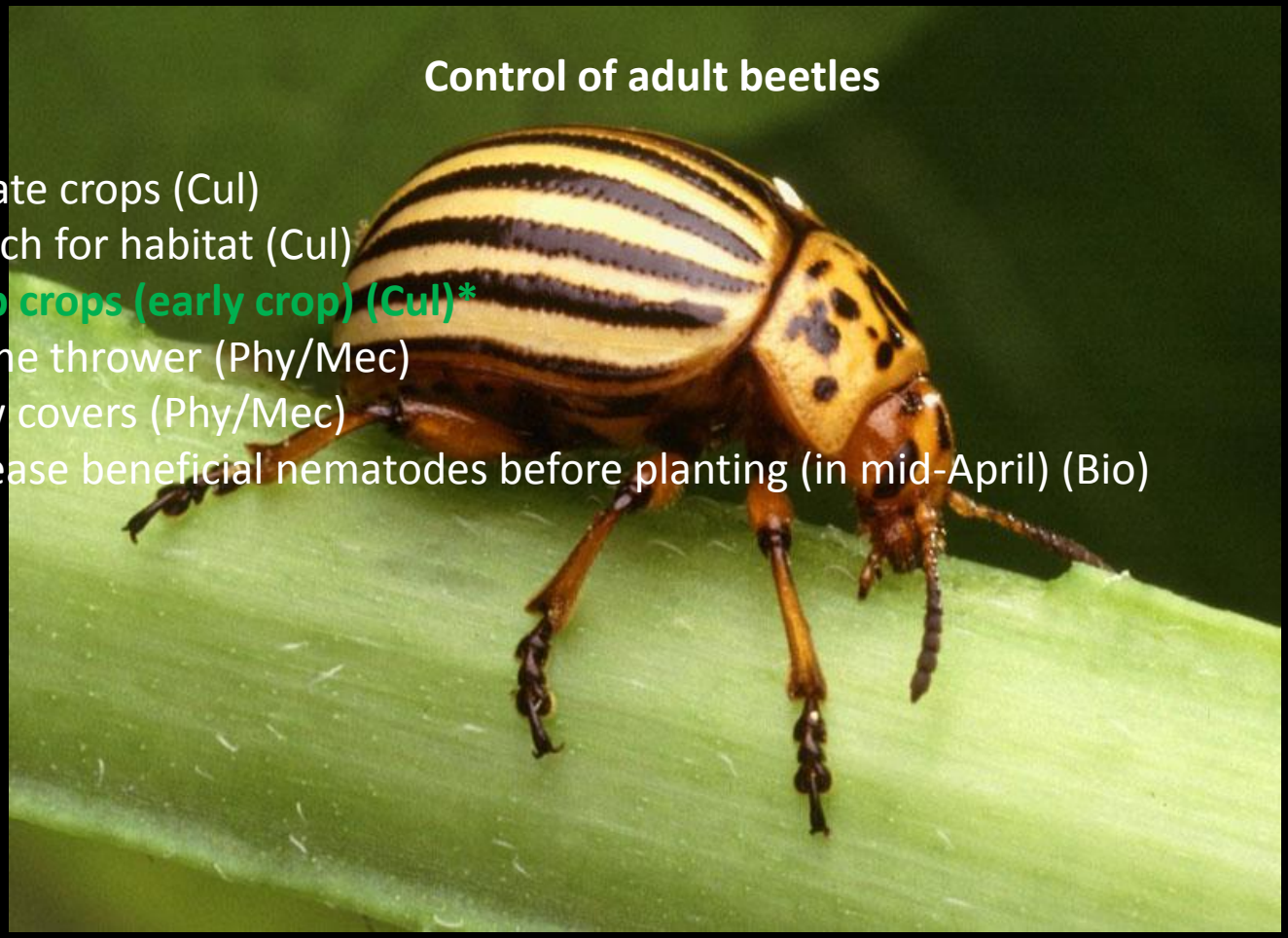
TOOL/TECHNIQUE (3 / 4 of 4Ts)



1. Rotate crops (Cul)
2. Mulch for habitat (Cul)
3. **Trap crops (early crop) (Cul)***
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5. Row covers (Phy/Mec)
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TECHNIQUE (4 of 4Ts)

Perimeter trap cropping

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Perimeter trap cropping

TIMING (2 of 4Ts)

April | May | June | July | August

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Control of eggs

1. Hand crush (Phy/Mec)
2. *Edovum puttleri* (Bio)

Biofix: When eggs are first scouted.

TOOL/TECH. (3/4 of 4Ts)

V	X	V	V	V	X	V	V	V
V	V	V	V	V	V	V	V	X
X	V	V	V	V	V	V	V	V
V	V	V	V	V	V	V	V	V
V	V	V	V	V	V	V	V	X
X	V	V	V	V	V	V	V	X
V	V	X	V	X	V	V	X	V

Monitoring and hand crushing of eggs – every other row

TOOL/TECH. (3/4 of 4Ts)

V	X	V	V	V	X	V	V	V
V	V	V	V	V	V	V	V	X
X	V	V	V	V	V	V	V	V
V	V	V	V	V	V	V	V	V
V	V	V	V	V	V	V	V	X
X	V	V	V	V	V	V	V	X
V	V	X	V	X	V	V	X	V

Monitoring and Hand Crushing of Eggs – every 6 plants

TIMING (2 of 4Ts)

April | May | July | August

1. Adults emerge early May through end of May
2. Eggs seen usually within 7-10 after adults are scouted.
3. 1st instar larvae hatch at 185 DD.

Control of young larvae

1. Hand crush (Phy/Mec)
2. *Bacillus thuringiensis tenebrionis (Btt)* (Bio)
3. Neem oil (Chem)
4. Spinosad (Chem)

Biofix: When eggs are first scouted.

TOOL (3 of 4Ts)

Insecticidal soap with neem oil

Spinosad

squash vine borer

Photo: U of MN, Jeff Hahn.

TARGET (1 of 4 Ts)

Squash vine borer adults mating
Photo: Jeff Hahn, U of MN

Squash vine eggs
Photo: Maria Schneider

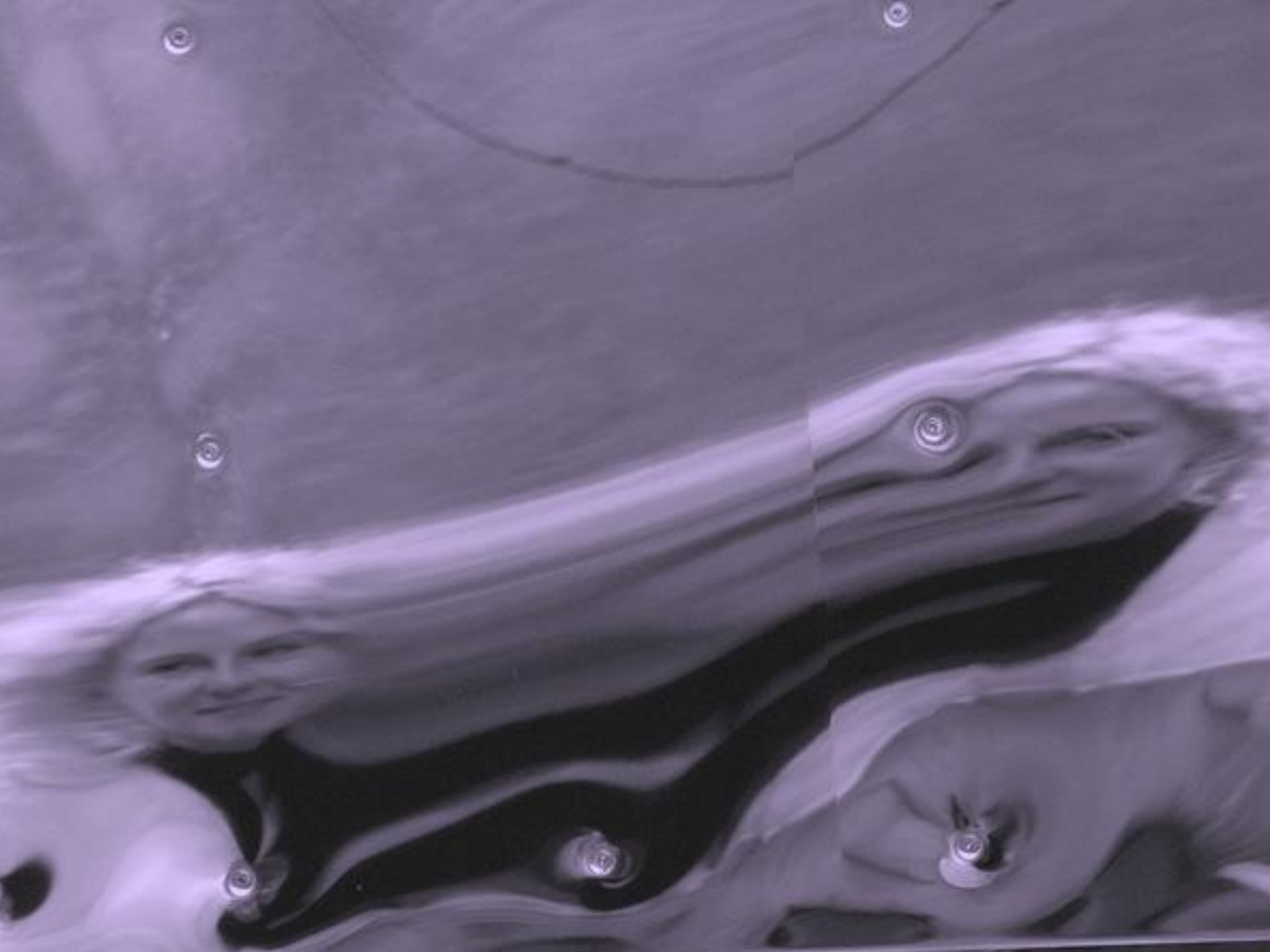
TIMING (2 of 4Ts)

April May June July August

1. Adults emerge late June/early July or ~950-1000 DD
2. Eggs seen usually days after adults are scouted.
3. Caterpillars hatch and burrow into vines within 7 days of being laid..

TOOLS (3 of 4Ts)

1. Plant late varieties to lessen injury. (CUL)
2. To prevent egg-laying, wrap a collar of aluminum foil around lower stems . (PHYS/MECH)
3. Spray stems with spinosad after eggs are seen. (CHEM)
4. Cover plants with floating row cover until flowering. (PHYS/MECH)
5. For active borers, make a vertical slit upward from where where frass is observed. Use a razor or sharp knife and cut half-way through the stem. Remove borer. Bury the wounded vine to induce supplemental rooting. (PHY/MECH)
6. B.t. or beneficial nematode Steinernema carpocapsae can be injected into wound to kill borers. (BIO)
7. Butternut and cushaw are resistant; yellow crookneck less susceptible than zucchini. (CUL)



5. Biological Control

Biological Control – Classical (Import)

Classical

Augmentative

Conservation

Photo: MDA Weed Biocontrol Program

Biological Control, Classical
Aphthona spp.

Photo: MDA Weed Biocontrol Program

Biological Control, Classical
Collecting *Aphthona spp.*

Photo: MDA Weed Biocontrol Program

Biological Control, Classical
Sorting *Aphthona* for distribution

Photo: MDA Weed Biocontrol Program

Biological Control, Classical

Photo: MDA Weed Biocontrol Program

Biological Control, Classical
A couple of years apart

Photo: MDA Weed Biocontrol Program

Biological Control, Augmentative

Images: European corn borers infested with Beavaria bassiana (bottom); Bottle of Mycotrol, a bioinsecticide that contains *B. bassiana* spores (from Arbico Organics)
Photos of infested larvae: MDA Biocontrol

Biological Control, Conservation

Photo: Green Noise

Biological Control, Conservation

Photo: Green Noise

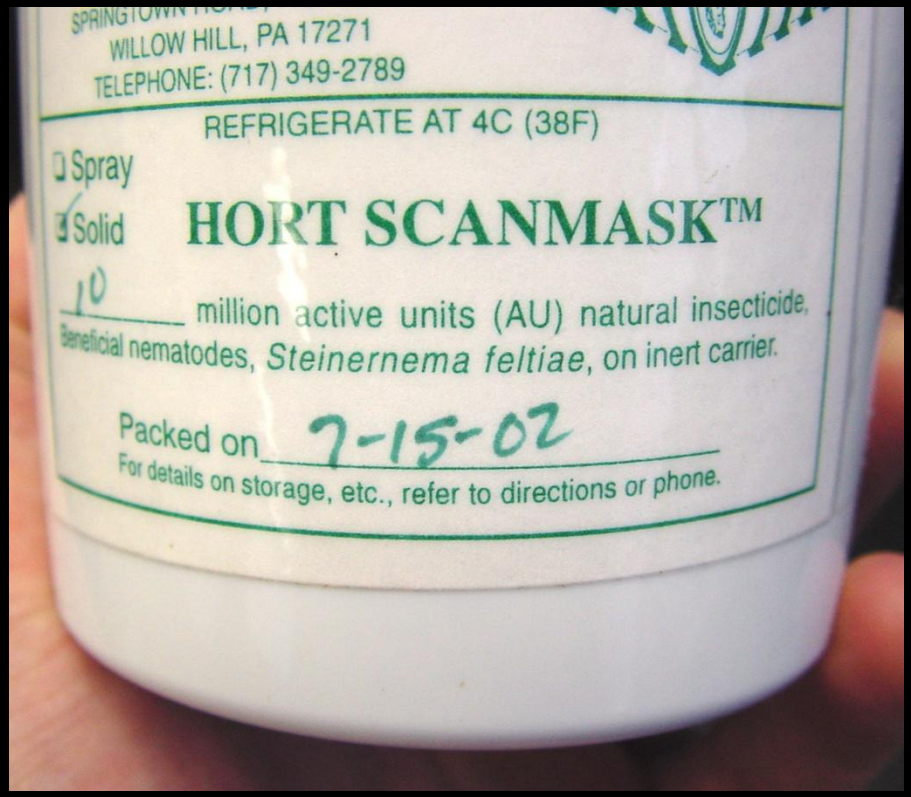
Biocontrol, Augmentative

Beneficial nematodes

Heterorhabditis bacteriophora
- This species has a “hunting c characteristic and is able to penetrate cell walls with its hooklike mouthpart.

Steinernema felitae
- A shallow-dwelling nematode species. Prefers to live at a 3” soil depth.

Steinernema carpocapsae
- Recommended for caterpillars such as webworms cutworms, and borers.



Photos: MDA Biocontrol,
Info: MDA Biocontrol, Green Methods, University of Kentucky

Biological Control

Approaches to biological control (3)

Importation (“Classic”)

Increase (Augmentative)

Conserve (Conservation biological control)

Types of Natural Enemies (4)

Predators

Parasitoids

Plant-feeders

Pathogens

Top photos: Green Noise
Bottom: MDA Biocontrol

Biological Control

Bio-control vs Natural Control

Top: *Aphidius colemani* , parasitic wasps of aphids that can be purchased from biological control suppliers.

Bottom: *Macrosiphum spp*. Aphids on goldenrod parasitized by naturally-occurring parasitic wasps.

Photos: Green Noise

Natural Control

Ladybeetle eggs on a plum leaf infested with wooly aphids.

Photo: Green Noise

Biological Control, Augmentative

Hippodamia convergens ladybeetle adults

Aphidius matricariae adults

Photo left: MDA Biocontrol
Photo right: Green Noise

Biological Control

Predators

Parasitoids

Plant-feeders

Pathogens

Soldier bug feeding on a cabbage butterfly caterpillar.

Photo: MDA Biocontrol

Types of Bio-Agents

Parasitoids

Photos: Encarsia formosa (left), Pimpla disparis (right)
MDA Biocontrol

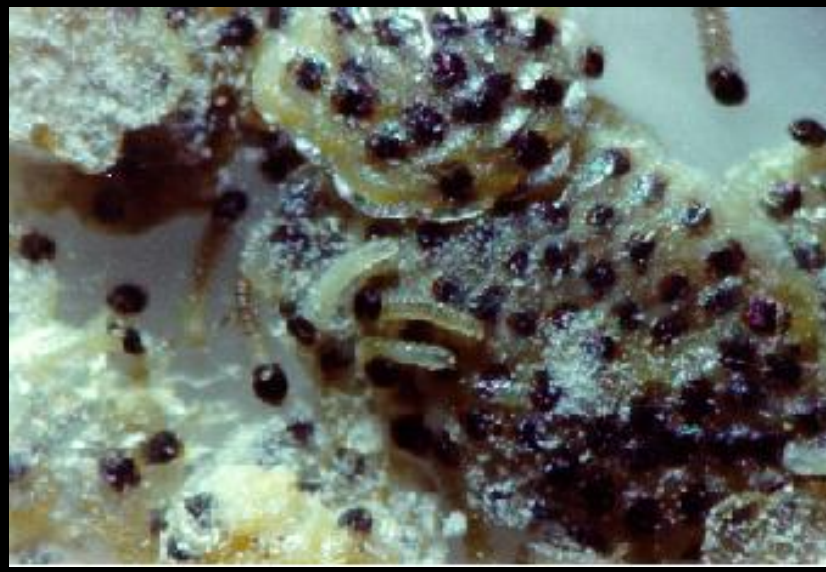
Types of Bio-Agents

Parasitoids

Photos:Pimpla disparis wasp (left), European corn borer pupa (middle), European corn borer caterpillar (right, bottom) MDA Biocontrol

Types of Bio-Agents

Parasitoids



Trichogramma ostriniae adult wasps (left), parasitized ECB egg masses (top right), ECB larvae emerging from egg masses (right bottom)

Photos: MDA Biocontrol

Types of Bio-Agents

Plant feeders

Cyphocleonus achates (left). Aphthona spp. on leafy spurge (right).

Photos: MDA Biocontrol

Types of Bio-Agents

Pathogen – *Beauvaria bassiana*

European corn borer larvae infected with *Beauvaria bassiana* fungi. This species of fungus is available in liquid commercial formulations that can be sprayed on crops like conventional synthetic pesticides.

Photos: MDA Biocontrol



Progression of parasitism of *Macrosiphum spp*. aphids on cup leaves.

Source: Green Noise

Conventional pesticides*

Organophosphates & Carbamates

Mode of action: Synaptic poisons. Prevents nerve impulse transmissions. Insects "think" themselves to death.
Example organophosphate pesticide common names: chlorpyrifos, diazinon
Example organophosphate pesticide brand names: DuraGuard, Knox Out GH
Example carbamate pesticide common names: bendiocarb
Example carbamate pesticide brand names: Turcam

Insect Growth Regulators (IGR)

Mode of action: Chitin synthesis inhibitors or juvenile hormone mimics.
Example pesticide common names: diflubenzuron, fenoxycarb, s-Kinoprene, pyriproxifen
Example pesticide brand names: Adept, Precision, Enstar II, Distance

Pyrethroids

Mode of action: Affects the nervous system. Axonic toxins.
Example pesticide common names: Pyrethrin
Example pesticide brand names: 1100 Pyrethrum TR, EXclude

Chloronicotinyls (aka, Neonicitinoids)

Mode of action: Inhibits nerve impulse reception, prevents normal behavior when messages cannot be "received"
Example pesticide common name: Imidacloprid
Example pesticide brand names: Merit, Marathon, Imicide

*This list is not intended to be comprehensive.
Inclusion does not mean or imply an endorsement.

List compiled by: Green Noise

Biorational pesticides, including botanicals*

Insecticidal oils and soaps (Contact pesticides)

Insecticidal soap – Safer Soap, Des X INsecticidal Soap Concentrate,
Horticultural oil – Sesame oil, Suffix Oil-X,
Hot pepper or garlic sprays

Microbials (Pathogens)

Bacillus thuringiensis (Bt) – Dipel, Xentari
Beauvaria bassiana – Mycotrol
Streptomyces fungus – Mycostop, Actinovate AG
Trichoderma – RootShield
Saccharopolysora spinosa – Spinosad, Conserve, Entrust, Tracer,Success, etc

Minerals (Repellents or Dessicants)

Kaolin clay – "Surround"
Diatomaceous earth

Botanicals* (Stomach poisons, Suffocators, Repellants, or Nervous system poisons)
Rotenone – Contact and stomach poison found in several subtropical leguminous shrubs – derris, cube, timbo
Pyrethrum/Pyrethrins – Pyganic, Safer Insect Killer with soap (III) - affects the nervous system of insects
Neem – Agroneem, AZA-Direct, Azatrol, Ecosense, Ecoside, Neemix, Ozoneem, NeemAzad 1%
Sabadilla – Contact and stomach poison made from seeds of a Lily family plant. Applied as a dust with sulfur or lime.
Also toxic to bees.
Ryiana – Stomach poison made from stems and roots of a South American shrub, *Ryania speciosa*. Longer residual activity. Toxic to mammals.
Other – Hot pepper, herb, seed, or garlic sprays

*This list is not intended to be comprehensive.
Inclusion does not mean or imply an endorsement.

List compiled by: Green Noise

Check the Status of Products

- Organic Materials Review Institute (OMRI)

  http://www.omri.org/omri-lists/download

- Database on NOSB Recommendations for Materials Considered for Use in Organic Agricultural Production and Handling (XLS)

Check Organic Regulations

- National USDA Organic Program

  http://www.ams.usda.gov/AMSv1.0/nop

For Next Workshop
Sat. April 27

1. Use the plant pest planning sheet

to sketch out your management plan for your primary insect of concern.

• Name your target species.

• Name your target life stage.

• Name at least THREE different IPM tools you plan to use to manage your pest and WHEN you plan to use them.

• List the advantages and the potential drawbacks or issues that are involved with your management approach.

• How will you evaluate your effectiveness of your management approach?

• Meet, Skype, phone conference, or confer with your group between now and April 27.

• Prepare to present your management plan to the large group next meeting.

2. Use the plant pest planning sheet to sketch out your management plan for a second insect of concern.

•Follow the same steps as described above.

Primary pests

- Colorado Potato beetle
- Squash vine borer
- Apple maggot
- Cabbage butterfly
- Cabbage flea beetle
- Japanese beetle
- Slugs

Secondary pests

- Onion maggot
- Spinach leafminer
- Two-spotted spider mite
- Aphids
- Squash bugs
- Bean Leaf beetle

Other examples

Apple Maggot DD Life Events

- Base Temperature for AM = 50 F
- **Approximate initial spring emergence in MN: from mid-June to mid-July**
- **Degree day adult emergence: ~900 DD**
- **Degree day flight peak: ~1400 DD**
- Eggs laid singly under the fruit skin
- Larvae develop under the fruit ~30 days
- **Overwintering**: Fruit tend to fall, maggots leave fruit and burrow under the soil to pupae until the following year….which leaves them vulnerable to nematodes

Info: University of Minnesota Extension, Michigan State IPM Resources, MDA IPM Program

Example IPM plan #3: apple maggots (lite)

Mass trapping

Product: Red sphere trap, tanglefoot, grocery store apples

Target pest: Apple maggot

Host plants: Apple trees

a) **Timed trapping.** In late June/early July, place red sphere traps and/or grocery store apples covered with Tanglefoot every 10-15’ depending on the pressure.

a) **Larval disruption**. Diligently remove infested apples and apples that fall to the ground in the late summer/fall to prevent maggots

Info: University of Minnesota Extension, Michigan State IPM Resources, MDA IPM Program

Example IPM plan #4: apple maggots (aggress.)

Mass trapping, pesticide, defensive barrier, post-season cultural techniques, and biological control.

Product: Red sphere trap, tanglefoot, grocery store apples , Spinosad, kaolin clay, plastic bags, mesh, beneficial nematodes

Target pest: Apple maggot

Host plants: Apple trees

a) **Timed trapping.** In late June/early July, place red sphere traps and/or grocery store apples covered with Tanglefoot every 10-15' depending on the pressure.

b) **Time trapping with organic-approved bio-insecticide**. In late June/early July, place red sphere traps and/or grocery store apples baited with scent volatiles and laced with Spinosad for greater adult reduction.

c) **Place baited traps**. Trap baits. Place volatiles attractants with baits for greater attratction.

d) **Defensive barrier**. Spray weekly applications of Surround kaolin clay to reduce attraction and visibility. Bag each fruit or cover limbs with mesh bags to prevent adults from laying eggs.

e) **Larval disruption**. Diligently remove infested apples, apples that fall to the ground, and leaves in the late summer/fall to prevent maggots from pupating successfully.

f) **Biological control**. Release beneficial nematodes into the ground late August or early September to help control or impact next generation of apple maggots. See: Steinernema carpocapsae and Heterorhabditis bacteriophora.

Examples of sources: Great Lakes IPM (apple lures), Planet Natural (kaolin clay), Green Methods (nematodes)

Info: University of Minnesota Extension, Michigan State IPM Resources, MDA IPM Program

Example IPM plan #5: squash vine borer (lite)

Mass trapping, pesticide, defensive barrier, post-season cultural techniques, and biological control.

Pest: Squash vine borer (Melitta curcurbitae)

Product: Yellow sticky cards

Host plants: squash, cucumbers,

a) Expect adults. Action: Setup yellow sticky cards and/or floating row covers before **DD~900-1000. Late June or early July adults emerge from cocoons in the ground. Plant varieties that are not as preferred by squash vine borers, such as "butternut squash, cucumbers, melons, and watermelons" (U of MN nExtension).**

b) Look for eggs 1 week after first adults are seen. **DD~1000-1200. Late June or early July. Watch for nymphs.**

c) Apply pesticide treatment s~8 days after seeing first adults. Or

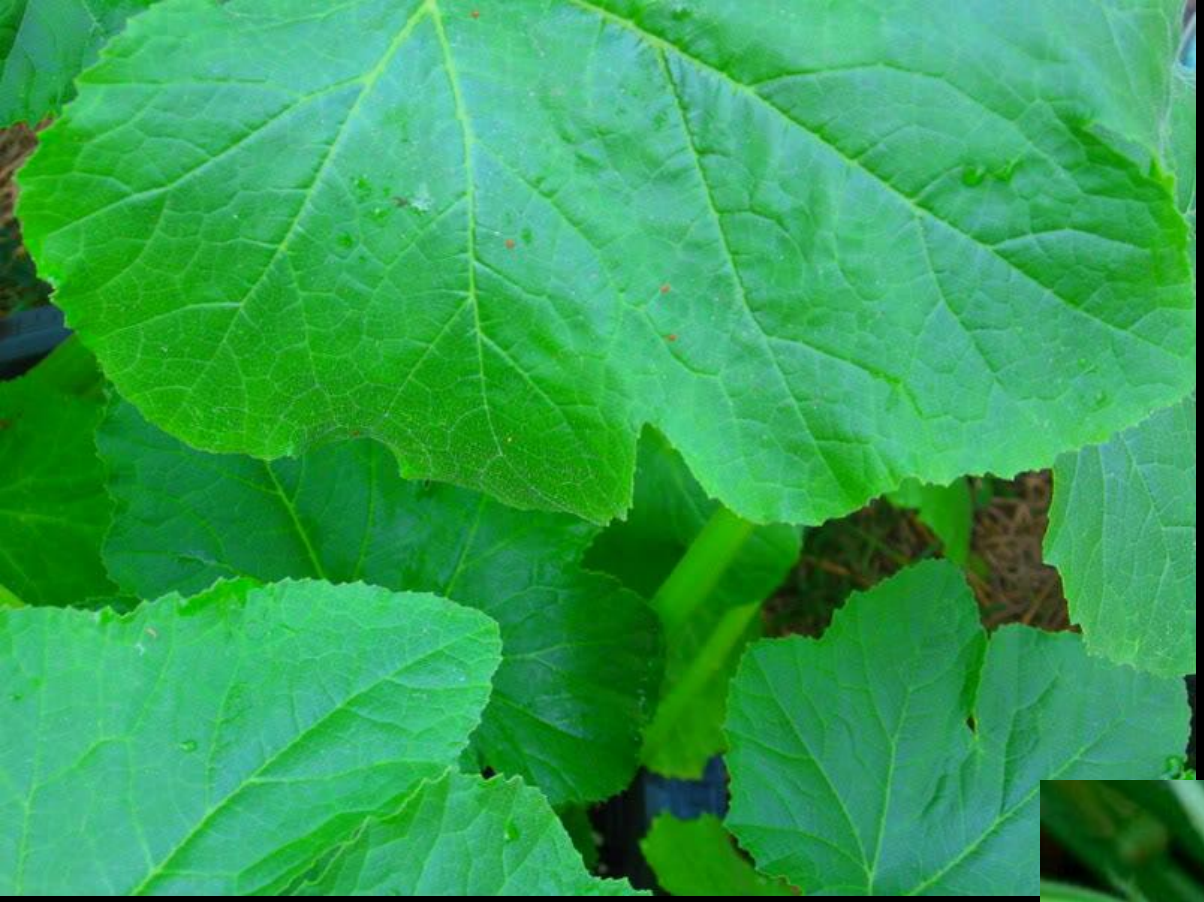
d) Scout for frass tunnels. Action: Remove borers with a razor blade, if needed. Bury vine.

e) Destroy infested plants used as a trap crop, and plant second crop of squash.

Photo: U of MN, Jeff Hahn.

Examples of sources: Great Lakes IPM (apple lures), Planet Natural (kaolin clay), Green Methods (nematodes)

Info: University of Minnesota Extension, The Ohio State IPM,



Bottom Image: Maria Schneider
Top image: Author unknown. Photo found on Village Garden Web website.

IPM plan #6: Squash bugs
Anasa tristis

a) Expect adults late May/early June. Action: Scout and squash on sight and/or add floating row covers.

b) Scout for for bronze egg masses. Crush on sight.

c) Scout for nymphs 8-14 days after observing 1st egg masses. Crush on sight.

d) Scout twice weekly for more evidence of sawdust-ish entry points.

e) Use resistant varieties such as Butternut, Royal Acorn, Sweet Cheese

f) During season: lay boards or shingles under plants to attract aggregates of squash bugs. Destroy them in the morning.

g) Post season: Remove debris around plants that they may use to overwinter.

Encourage habitat for Tachinid fly, *Trishopoda pennipes, or Sceleonids such as Eumicorsoma spp.*

Apply sabadilla, ryalia, rotenone during nymphal stage.

Info: U of Minnesota VedgeEdge, Midwest Vegetable Production Guide for Commercial Growers (Purdue), National Sustainable Agriculture Information Service

Image: VegeEdge, U of M Extension

IPM plan #7: Cabbage butterflies *Pieris rapae*

Goal: Prevent visual damage from cabbage butterfly on commercial cabbage
Strategy: Active, Constant Prevention.

1) **Monitor twice a week after expected spring adult emergence. (~May 20)**
2) **Setup yellow sticky traps around perimeter of plot. (~May 24)**
3) **Catch observed adult butterflies with a net. (~May 24-June 15)**
4) **Scout for eggs 1 week after first sign of adults. Crush on sight. (~May 30-June15)**

4a) Remove yellow sticky cards. (June 15)

5) **Scout for caterpillars based on visual damage 2 weeks after first sign of adults. Crush on sight. (~June 1-June 30)**
6) **Order and release green lacewing larvae and soldier bug attractant lure, if # of caterpillars exceeds 1-2 per leaf after random sample of 30 leaves. (June 7)**
7) **Spray insecticidal soap under leaves if # of caterpillars exceeds 3-4 per leaf after random sample of 30 leaves. (June 7)**
8) **Scout for mature larvae and/or chrysalis based on visual damage 4-5 weeks after first sign of adults. (June 30)**
9) **Setup yellow sticky cards 5-6 weeks after 1st sign of adults and/or 1-2 weeks after first sign of chrysalises. (July 1)**

Image: VegeEdge, U of M Extension

Example IPM plan #8: Japanese Beetle Nematodes & Milky spore.

Product: Beneficial nematodes, milky spore,

Target pest: Japanese beetle

Host plants:

Biocontrol, Augmentative

Beneficial nematodes

Heterorhabditis bacteriophora

Source: MDA, USDA, Forestry Images

IPM and Biocontrol Supplies

Great Lakes IPM

http://www.greatlakesipm.com

Green Methods (Biocontrols, mainly)

http://greenmethods.com/site/

Good luck! See you April 27!

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