How to manage insect pests in vegetable gardens with minimal use of chemicals

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The goal
The reality
Topics

• Approaches to pest management
• Overview of tactics
• I.d. & management of common pests
Topics

• Approaches to pest management
• Overview of tactics
• I.d. & management of common pests
Types of insect pest damage

• Direct damage
• Indirect damage
• Disease transmission (vector)
• Contamination
Strategies of Pest Management

• Acceptance (do nothing)
• Eradication
  — eliminate pest populations
• Suppression
  — reduce pest to tolerable levels
Pest suppression: the search for a weak link in pest’s life cycle
Integrated Pest Management (IPM)

• a comprehensive approach to dealing with pests
  ─ strives to reduce pest status to tolerable levels
  ─ using multiple tactics
    • effective
    • economically sound
    • ecologically compatible
Components of IPM

- Monitoring
- Action thresholds
- Multiple tactics
Monitoring

- Techniques
  - Scouting
  - Knockdown
  - Sweeping
  - Trapping
Action Threshold

• Pest density or amount of damage at which action should be taken to prevent an increasing pest population from causing economic damage
### Action thresholds: beans

<table>
<thead>
<tr>
<th>Pest</th>
<th>Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bean leaf beetle</td>
<td>&gt;1 beetle/seedling or &gt;20% defoliation pre-pod or &gt;10% defoliation after pods</td>
</tr>
<tr>
<td>Potato leafhopper</td>
<td>1 nymph per 10 leaflets</td>
</tr>
</tbody>
</table>
Components of IPM

• Multiple tactics
  ― Preventive options
  ― Remedial options
IPM uses a combination of tactics

• Mechanical
• Cultural
• Biological
• Microbial
• Chemical
Do chemicals fit in IPM or not?

IPM Continuum

No Chemicals  Intensive Chemicals
Approaches to pest management by suppression: **Organic vs other**

• More concern with restoring checks & balances

• Willingness to use tactics:
  – More **knowledge** intensive
  – More **labor** intensive
  – More expensive

• Use chemicals or not???
Mechanical Controls

- Exclusion
- Removal
Exclusion by barriers

- Row covers **
- Netting, screening
- Plant collars
- Paper bags
- Copper barriers
- Trenches (deep furrows)
- Fences
Row covers to exclude pests

• Install on day of planting
• Remove
  — When first flowers appear (cucurbits)
  — At final harvest (broccoli, beans)
Row covers to exclude pests

- Lightweight
  - ‘Insect Barrier’, ‘Agri-bon 15’
  - 90% light transmission
    (vs 70-85% for heavier covers for frost protection)
- Sources:
  - Johnny’s Selected Seed: $24. (10’ x 50’)
  - Gardens Alive: $10. (8’ x 20’)

Lightweight – ‘Insect Barrier’, ‘Agri-bon 15’ – 90% light transmission (vs 70-85% for heavier covers for frost protection) – Sources: • Johnny’s Selected Seed: $24. (10’ x 50’) • Gardens Alive: $10. (8’ x 20’)
Row covers

• Use with or w/o hoops
• Must be anchored tightly
• Be prepared to mend rips
Cages to exclude garden pests

- Bell cloche
  - $30/3
- Pest Control Pop-up
  - $25 for 4’ x 4’ x 1’
  - $45 for 4’ x 4’ x 4’

(Gardeners Supply Company)
Mechanical Control by Removal

- Shelter traps *
- Attraction traps
- By tapping, shaking *
- By aspirator *
- Removal by hand
- Removal by vacuum
Removal by shelter traps

- Board trap (shingle trap) for squash bug
- Tree bands for caterpillars
Removal by attraction traps

- Dish of beer for slugs
  - Catches many slugs
  - Often not significant decrease in population
Removal by tapping or shaking

- Tap plants by broom or hand
- Tap into bucket or tray
- Daily
- Example: Colorado potato beetle (adults, larvae)
Removal by aspirator

- Aspirator = Mouth-operated suction device
- $8 – 14 from:
  - BioQuip
  - Forestry Suppliers
  - Gempler’s
- Good for flea beetles, bean leaf beetle, cucumber beetle
Removal by aspirator:
Eggplant flea beetle
Removal by hand

• Labor intensive

• **Target pests:**
  – Conspicuous pests
  – Pests not too active
  – In relatively restricted area

• **Examples**
  – Spinach leafminer (infested leaves)
  – Asparagus beetle (eggs)
  – Japanese beetle
  – Hornworms
Sanitation

• Collect and destroy/compost:
  – Culled fruit
  – Crop residue (after harvest)

• Plant clean nursery stock
Cultural Control

• How soil is prepared
  – Till vs no-till
• Which crops are planted
  – Trap cropping *
• Where crops are planted
  – Crop rotation
• When crops are planted
  – Delayed planting *
• How crop is maintained
  – Irrigation
  – Weeding
Delayed planting

• Cucumber beetle
  – Problem if plant in late May
  – Less problem if plant in mid-June
Delayed planting

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• Squash vine borer
  – Same
Delayed planting

• **Cucumber beetle**
  – Problem if plant in late May
  – Less problem if plant in mid-June

• **Squash vine borer**
  – Same

• **Bean leaf beetle**
  – Peak populations in May, July
  – Fewer in June
Trap cropping

• Lure pest away from main crop to a more attractive crop

• Then kill the pest in trap crop
  — Mechanical
  — Chemical
Trap cropping

- Planting time options
  - Same time
  - 2 weeks early for trap crop
Trap cropping adapted to garden scale

Squash, trap crop, planted 2 weeks early

Cantaloupe, Main crop
## Trap cropping examples

<table>
<thead>
<tr>
<th>Main crop</th>
<th>Trap crop</th>
<th>Target pest</th>
</tr>
</thead>
<tbody>
<tr>
<td>cabbage</td>
<td>collards</td>
<td>diamondback moth</td>
</tr>
<tr>
<td>cabbage</td>
<td>kale</td>
<td>harlequin bug</td>
</tr>
<tr>
<td>cucumber</td>
<td>hubbard squash</td>
<td>cucumber beetles</td>
</tr>
<tr>
<td>peppers</td>
<td>sweet corn (late)</td>
<td>Europ. corn borer</td>
</tr>
</tbody>
</table>
Cultural control: trade-offs

Example: straw mulch

• Benefits
  – Moisture retention
  – Weed suppression
  – Reduces soil splash
  – Reduces fungal spore dispersal

• Makes some pest problems worse
  – Cucumber beetles, slugs
Biological Control

• Control of pest by other organisms that act as natural enemies

• Common natural enemies
  – Predators
  – Parasitoids
Biological Control: Predators

- Develop at expense of more than one prey item
- Predator often larger than prey
- Prey usually killed & consumed quickly
Predators

• Green lacewings

• Lady beetles

• Insideous flower bug

• Damsel bugs

• Hover flies
Biological Control: Parasitoids

• Develop at expense of a single host
• Lay egg in or on host insect
• Host is usually killed slowly
Parasitoids

• **Braconid wasps**
  – On hornworm: *Cotesia congregata*
  – On imported cabbageworm: *Cotesia glomeratus*
  – On aphids: *Diaeretiella rapae*

• **Ichneumonid wasps**
  – On diamondback: *Diadegma insulare*

• **Tachinid flies**
  – On squash bug: *Trichopoda pennipes*
  – On cucumber beetle: *Celatoria setosa*
& Vertebrate predators eat insects!

- Bats
- Toads
- Birds
- Geese
- Hogs
Biological control by conservation of local natural enemies

• **Tactics:**
  – Avoid broad-spectrum insecticides
  – Refuge planting for natural enemies
  – Collect-&-transfer generalists
Conservation of local species

• What to do? Provide resources to enhance enemy activity
  – Add pollen source
  – Add nectar source
  – Spray sugar/protein mix
  – Provide winter shelter
  – Release alternate prey (or nursery crop)
Insectary planting as refuge for natural enemies

- Adult parasitoids need nectar
- Adult predators need pollen
- Plant flowering border to enhance biocontrol
Biological control by augmentation of local natural enemies

• Tactics:
  – Buy from insectary
  – Collect and transfer
Augmentation: Collect & transfer

• What to do?
  – Hunt for generalist predators
  – Collect them
  – Transfer them to crop

• Who, where, when?
  – Ladybug larvae on **Spirea** in May
  – Lacewings & aphid midges on **apple** leaves in early June
  – Damsel bugs on **alfalfa**, April-June
Spirea : bridal wreath

• Often infested by spirea aphid in May
• Good source of ladybugs & lacewings
Our smartphone app!

• **Name:** Good Bugs +

• **Platforms:**
  – For iPhone & Android

• **Now free** (was $2.99)

• **Topics:**
  – Natural enemies: i.d., biology, mgmt
  – Pollinators
  – Native plants that support them
Chemical control
Chemical control

- Insecticides 🎃
- Repellents
- Attractants
Microbial control

• Kill insects by making them **sick**
• Typically by spraying product containing micro-organisms
Do any insecticides have valid place in organic gardening?

- **Strict organic gardeners**: no
- **Many organic gardeners**: yes, if natural origin
OMRI: The Organic Materials Review Institute

- List of products allowed
- Crops & processing
- Certified organic growers

Example of label with OMRI logo
Insecticides, by Origin

• Natural
  – Minerals & elementals
  – Oils & soaps
  – Abrasion agents: diatomaceous earth
  – Botanicals (plants)
  – Microbials
  – Compounds derived from microbes

• Synthetic
  – Mimics of natural insect hormones
  – Petroleum-based synthetic chemicals
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OMRI ok
OMRI not ok
Note on natural insecticides

• Can be toxic to natural enemies
• “Natural” is not always good!
Smothering or suffocation agents

• oils:
  – from petroleum
  – from plants

• insecticidal soaps:
  – potassium salts of fatty acids
Minerals & elementals

• kaolin
• iron phosphate
• sulfur
kaolin (clay)

- ‘Surround At Home’
- Physical repellent
- Photosynthesis not affected
Abrasion agents: 
Diatomaceous earth
Insecticides from plants (botanicals)

On OMRI list:
• pyrethrum (chrysanthemum)
• azadirachtin (neem tree)

Not on OMRI list:
• nicotine (tobacco)
Repellents from plants:
capsaicin & garlic
Microbial insecticides: cause disease in insects

- Bacteria
- Viruses
- Fungi
- Protozoans
- Nematodes
Insecticide derived from microorganisms: spinosad

- **Dow**: Entrust
- **Bonide**: Capt. Jack’s Deadbug Brew
- **Fertilome**: Borer, Bagworm, Leafminer & Tent Caterpillar spray
- **GreenLight**: Lawn & Garden Spray Spinosad Concentrate
- **Monterey**: Garden Insect Spray
- **Gardens Alive**: Bulls-Eye Bioinsecticide
Lab bioassays to evaluate insecticide efficacy

• Defoliation
• Mortality
## Trends in insecticide efficacy

<table>
<thead>
<tr>
<th>spectrum</th>
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<th>Fair/Poor</th>
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<tr>
<td>broad</td>
<td>pyrethrins + PBO carbaryl esfenvalerate lambda-cyhalothrin cyfluthrin bifenthrin</td>
<td>acetamiprid permethrin malathion pyrethrins + oil pyrethrins + soap</td>
<td>neem seed oil azadirachtin capsaicin garlic</td>
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<tr>
<td>narrow</td>
<td>spinosad soap rotenone dicofol</td>
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*in red if on OMRI list*
So how can pests be managed organically?

• Maximize non-chemical tactics:
  — Knowledge & labor intensive
• Can include chemical control
  — Only if biorational products chosen
  — Usually as last resort
  — Efficacy mostly fair to poor
  — Do not assume that “natural” = good
Common vegetable pests: i.d. & management

- **Specialist pests (15)**
  - Cucurbits (4 pests)
  - Cole crops (2+ pests)
  - Tomato etc. (2 pests)
  - Beans (2 pests)
  - Spinach & swiss chard (1 pest)
  - Asparagus (2 pests)
  - Corn (2 pests)

- **Generalist pests (5)**
Cucumber beetles

Striped cucumber beetle

Spotted cucumber beetle
Cucumber beetles

Important damage by adults:
• Chew seedlings
• Transmit bacterial wilt
• Chew on fruit surface

Less critical damage:
• Larvae chew on roots
• Adults chew on flowers
Bacterial wilt of cucurbits

- **Vectored by cucumber beetles**
  - Transmitted in *feces*
  - Enters via *wound* in plant (such as feeding wound)

- **Hosts:**
  - Well-known killer of cukes & melons
  - Recently adapted to kill squash & pumpkins (but slower)
Cucumber beetle management

• For beginners
  – Mechanical control
    • Screen or row cover (seedlings)
  – Chemical control
    • Spray with carbaryl, permethrin, or pyrethrins+PBO,

• For advanced gardeners
  – Cultural control
    • Early trap crop of squash (Buttercup or Blue Hubbard or Turks Turban)
  – Biological control
    • Conserve parasitoids (by no spray)
  – Behavioral control
    • Kairomone trap
Squash vine borer

- Infests squash, gourd, pumpkins
- Plants often die by July
Squash vine borer

- Infests squash, gourd, pumpkins
- Plants often die by July

- Larva is a caterpillar that bores into stem
- Cocoons in soil overwinter
- Wilting leaves are symptom of infestation
- Adult is a day-flying moth, lays eggs in late June to mid-July
Squash Vine Borer: Management

• Cultural
  – Till soil to destroy pupae
  – Plant late for main crop
  – Small planting early as trap crop

• Mechanical
  – Row covers (until flowering)

• Chemical
  – Insecticide
Squash vine borer

• Chemical control:
  – During egg hatch period, early July
  – Direct at base of stems
  – Minimum 2 sprays 1 week apart
  – Maximum 4 sprays 1 week apart, late June to late July
  – Permethrin or esfenvalerate or pyrethrins+PBO
Squash Bug: Damage

- Suck sap: leaves, stems
  - Patches turn black, die
- Plants wilt
  - can die
  - can live but not develop fruit
- Bugs feed on fruit before harvest
Squash Bug: Biological control

- Feather-legged fly
  - *Trichopoda pennipes*
  - lays eggs on adult or large nymph
- Egg parasitoid wasps
  - *Gryon pennsylvanicum*
  - *Ooencyrtus anasae*
Squash Bug: Management

• Mechanical control
  – Row covers (until flowering)
  – Hand picking, especially eggs
  – Shelter traps: board or shingle

• Cultural control
  – Promote early growth of crop
  – * Destroy crop remains
Removal by shelter traps

- Board or shingle trap
- Check every morning
3 Caterpillars on cole crops

- Imported cabbageworm
- Cabbage looper
- Diamondback moth
3 Caterpillars on cole crops & their parasitoids

- **Imported cabbageworm**
- **Cabbage looper**
- **Diamondback moth**

- **Cotesia larvae** spinning cocoons
- **Cotesia adult wasp**

- **Copidosoma floridanum** wasps emerging from one cocoon
- **Diadegma insulare** oviposits on larvae
Integration of Chemical Control & Biological Control

• Depends on choosing a selective insecticide
  – Kills caterpillars
  – Does not kill parasitoids
  – Use B.T. microbial insecticide
    • ‘DiPel’ etc.
  – Spinosad also easy on parasitoids
• Plant border of sweet alyssum to attract parasitoids
Row covers
Cabbage maggot

• Turnip, radish, other cole crops

• **Symptoms:**
  – Seedlings wilted, stunted
  – Holes or tunnels in roots

• **Life cycle:**
  – Adult fly lays egg at stem base
  – Larvae feed for 3 weeks
  – 3-4 generations per year

• **Control:**
  – Choose planting date to avoid egg peak
  – Cardboard collars on stem
Colorado potato beetle

- **Damage:** chewed leaves
  - By adults & larvae
  - Potato, eggplant, tomato

- **2 generations/year**

- **Control:**
  - Hand pick (knock in bucket)
  - Plant potato early or late but not both
  - Spray larvae with spinosad
Eggplant flea beetle

- Chew many small holes in leaves
- Damage critical to seedlings
- Management:
  - Hand-picking *(aspirate)* daily
  - Insecticides or repellents
- Similar species on:
  - Cabbage (2 species)
  - Potato
Removal by aspirator:
Eggplant flea beetle
Bean beetles

• **Bean leaf beetle:**
  — Adults chew holes through leaves, pods

• **Mexican bean beetle:**
  — A true lady beetle
  — Larvae skeletonize leaves

• **Cultural control:**
  — Exclusion (row covers)
  — Plow after harvest

• **Chemical control:**
  — carbaryl or pyrethrins+PBO
Spinach leafminer & beet leafminer

- Adult fly lays eggs
  - On leaf underside
  - In early spring
- Maggots feed inside leaf, 1-2 weeks
  - Narrow mine when young
  - Large blister-like mines when older
- Pupate in soil
- Several generations per year
- Hand pick infested leaves, early
Common asparagus beetle

Spotted asparagus beetle
Asparagus beetles

• **Common asparagus beetle**
  – Adults feed on spears
  – Adults lay eggs on spears
  – Larvae feed on leaves

• **Spotted asparagus beetle**
  – Adults feed on spears
  – Larvae feed in berries
Asparagus beetles

• Management
  – Hand picking
  – Insecticides or repellents
Corn worms

1. European corn borer
   - Damage at tip or shank or side
   - Two generations per year
   - Damage in June & August
   - Worm appearance:
     • dark brown head
     • body with rows of flat spots
     • body without microspines
2. Corn earworm

- Damage at ear tip only
- Damage usually mid-August & later
- Worm appearance:
  - light brown head
  - body with long stripes
  - body covered with short microspines
Corn Worm Management

• Planting date:
  — Early & late plantings difficult
  — Middle plantings easiest

• Biocontrol:
  — Encourage generalist predators
  — *Trichogramma* egg parasitoid

• Chemical control:
  — B.t. for 1\textsuperscript{st} generation borer
  — Oil + B.t. in ear tip for earworm
  — Spinosad for both pests
Generalist pests

- Spider mites
- Whiteflies
- Aphids
- Japanese beetle
- Brown marmorated stink bug
Two-spotted spider mite

- Often overlooked
- Often mistaken for disease
- Build up in hot dry weather
Two-spotted spider mite: identification

- Tiny (1/60 inch)
- White with 2 black spots
- 8 legs
Two-spotted spider mite: hosts

• Tomato
  — Yellow blotches

• Bean
  — White stippling
Two-spotted spider mite: hosts

- Watermelon
  - Yellow blotches
  - Brown lesions
Two-spotted spider mite: diagnosis

• Fine webbing on leaf underside
• Scout by tapping leaf over paper, look for moving specks
• Early diagnosis for good control

David Cappaert, Michigan State University, Bugwood.org

C. Welty
**Spider mite management**

- Tolerable at low density
- Conserve natural predators
- Overhead irrigation can help
- Soft control:
  - Insecticidal soap
  - Horticultural oil
Whiteflies: hosts

tomato

Photo by C. Welty

squash

Photo by C. Welty

beans

Photo by C. Welty

lettuce

Photo by C. Welty
Whiteflies: size

- Need magnifier to see immatures on underside of leaves
Whiteflies: injury symptoms

leaf scorch  sooty mold
Whiteflies

- Suck sap
- Life stages:
  - Adult
  - Egg
  - Crawler (1\textsuperscript{st} instar)
  - Sessile nymphs
  - Pupa
- Damage done by nymphs from leaf undersides
- Control by soap sprays
Whiteflies: insecticides

• Best controlled by neonicotinoids
  – acetamiprid
  – Imidacloprid
  – be sure to know pre-harvest interval
Aphids

- **Appearance:**
  - Small, soft, 2 ‘tailpipes’
  - Every species with winged & wingless forms

- **Damage:**
  - Suck sap
  - Cause leaf puckers
  - Deposit honeydew
  - Transmit viruses
Aphids

• **Common species:**
  – Potato aphid (tomato)
  – Green peach aphid (lettuce, pepper)
  – Melon aphid (cucurbits)
  – Rosy apple aphid (apple)
  – Green apple aphid (apple)
Aphid control

• Encourage natural enemies by avoiding use of broad-spectrum insecticides

• Suffocate with spray of insecticidal soap

• Reflective mulch to prevent colonization by winged aphids
Japanese beetle

- Attacks many crops:
  - Beans
  - Sweet corn
  - Grape
  - Raspberry
  - Blueberry
  - Plum
  - Peach

- Expect start in early July
Japanese beetle

• Insecticides
  – Sevin (carbaryl)
  – pyrethrins + PBO

• Traps
  – can bring in MORE beetles
  – Do not place close to crop
Brown marmorated stink bug

- Invading Ohio since 2007
- Attacks fruits & seed pods
- Also nuisance pest: invades homes in autumn
BMSB detection in Ohio: in at least 50 of 88 counties as of 2017.
Hosts of Brown Marmorated Stink Bug

• Fruit crop hosts:
  – Peach, apple, pear, cherry, Asian pear
  – Raspberries, blackberries, grapes

• Vegetable crops
  – Sweet corn
  – Peppers
  – Tomatoes

• Agronomic crops
  – Soybean
  – Corn
Brown marmorated stink bug: injury

- corn
- pepper
- beans
- tomato
Note differences in size & shape in pinned specimens side-by-side
Mechanical control of stink bugs

- Lightweight row covers
- The preferred tactic in small plantings
# Stink bug control in gardens

<table>
<thead>
<tr>
<th>Category</th>
<th>Ingredient</th>
<th>Common brand</th>
</tr>
</thead>
<tbody>
<tr>
<td>pyrethroids</td>
<td>bifenthrin</td>
<td>Ortho Max Bug-G-Gon Lawn &amp; Garden Insect Killer</td>
</tr>
<tr>
<td></td>
<td>permethrin</td>
<td>Bonide Eight Insect Control Veg Fruit &amp; Flower</td>
</tr>
<tr>
<td></td>
<td>cyfluthrin</td>
<td>Bayer Advanced Garden, Triple Action Insect Killer for Lawns &amp; Gardens</td>
</tr>
<tr>
<td></td>
<td>gamma-cyhalothrin</td>
<td>Spectricide Triazicide Insect Killer Once &amp; Done!</td>
</tr>
<tr>
<td>neonicotinoid</td>
<td>acetamiprid</td>
<td>Ortho Max Flower Fruit &amp; Vegetable Insect Killer</td>
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<tr>
<td>deterrent</td>
<td>kaolin</td>
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<td>for nymphs, not adults</td>
<td>spinosad</td>
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For beginners:
Which veg crops have fewest pests?

- Lettuce
- Peas
- Parsley
- Basil
Info on fruit & veg. pests
u.osu.edu/pestmanagement

Questions?
e-mail: welty.1@osu.edu
office phone: 614 292 2803
cell phone: 614 746 2429