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PREPARING A NEW GENERATION OF ILLINOIS FRUIT AND VEGETABLE FARMERS

a USDA NIFA BEGINNING FARMER AND RANCHER DEVELOPMENT PROGRAM PROJECT
GRANT # 2012-49400-19565

BASICS OF VEGETABLE INSECT MANAGEMENT

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Context and Objectives

- Previous presentations and discussions on pesticides, OMRI-approved pesticides, and integrated pest management
- Parallel presentations on fruit insect management, weed, disease, and wildlife management
- Today: Describe the key insects and related pests of vegetable crops and explain approaches to their management so that you can make decisions for effective pest management

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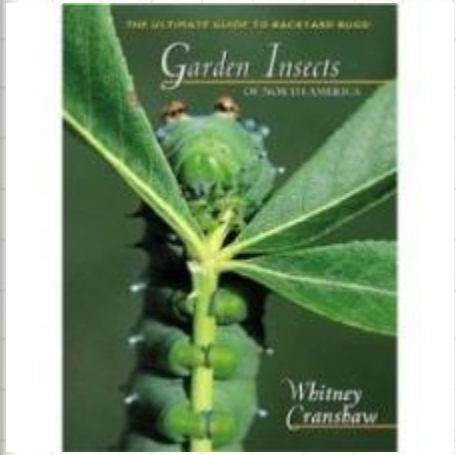
References … entomology in general

- Introduction to Applied Entomology (University of Illinois)

  http://cpsc270.cropsci.illinois.edu/syllabus/index.html

  http://cpsc270.cropsci.illinois.edu/syllabus/lab09.pdf

- **Garden Insects of North America.**
  - W. Cranshaw. ISBN: 9780691095615
    672 pp. 1,400+ color photos.



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The primary cast of characters

- seed and root maggots
- cutworms
- flea beetles
- cabbage worms
- cucumber beetles (& bean leaf beetle)
- squash bug
- potato leafhopper
- Colorado potato beetle
- aphids
- corn earworm
- tomato hornworm
- stink bugs

The slate of tools for insect management

- crop rotation
- cover crops
- tillage
- time of planting
- resistant varieties
- interplanting
- mulching and compost
- row covers / exclusion
- irrigation
- insecticides
- natural enemies
- hand removal
- culling

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Seed and root maggots -- cabbage maggot

- Pupae overwinter, adults fly and lay eggs in early spring
- Most common where planting / transplanting into cool, wet soils and where organic matter is high

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Seedcorn maggot

Life cycle similar to cabbage maggot. Most damaging to early-planted corn, beans, crucifers, and cucurbits during cool, wet weather and in soils with high organic matter. Several generations per year but only first is important. Eggs hatch in 2-3 days; larvae complete development in 7-10 days. Nothing can be done after plants are infested – except replant

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Onion maggot

Life cycle similar to cabbage maggot and seedcorn maggot. Later generations also cause damage, especially in sequential plantings. (The fly below is infected (and killed) by a fungal pathogen.)

Avoiding damage from seed and root maggots

- Destroy crop residues; remove/destroy cull onions
- Plant on well-drained soils if possible
- Limit amount of fresh organic matter
- If planting after a cover crop, incorporate it 3+ weeks before planting
- Plant when soils have warmed to 70^{o} F if possible
- Row covers? Yes, if eggs not already deposited in high organic-matter soils
- Use soil or seed-treatment insecticides as listed in the annual Midwest Vegetable Production Guide

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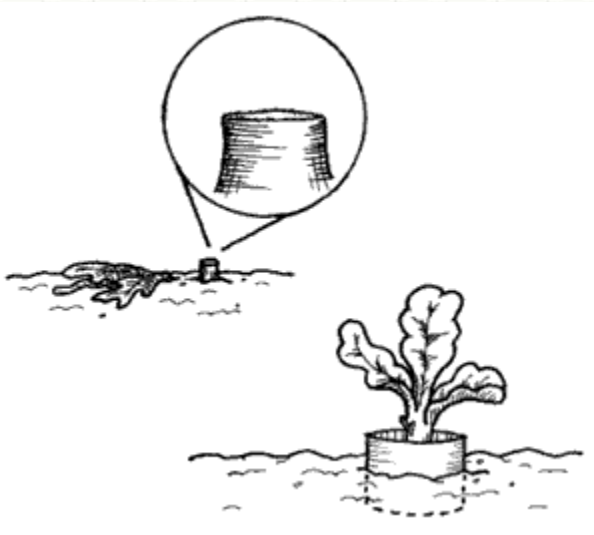
Cutworms

- Black cutworm is a southern migrant each season; other species also damage corn, green beans, tomatoes, and other vegetable crops; some overwinter as eggs or larvae in soil
- BCW moths prefer weedy fields and gardens for egg-laying
- Some “cut” plants; others feed above ground on fruits (and are controlled along with tomato fruitworm and tomato hornworm)

Cutworm management

- Fall tillage and spring tillage
- Weed control prior to planting
- Barriers around individual plants
- Insecticides: carbaryl, pyrethroids (vary by crop)
- *Bacillus thuringiensis* (Bt) or Entrust against foliage feeding species



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Flea beetles

- Very small beetles with hind legs adapted for jumping; also capable of flight
- Several different species feed on cabbage and related plants; tomatoes, potatoes, and eggplant; and sweet corn
- Adults overwinter and move to crops soon after emergence or transplanting
- Threshold in <u>most</u> crops … Where numbers are high enough that feeding stresses seedlings and slows growth <u>or</u> damage to the foliage of greens reduces usefulness

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Flea beetles … on crucifers

- Greatest populations occur in weedy fields and on smooth, glossy-leafed varieties.
- Cultural controls: Intercrop with tomatoes; till in crop residues immediately after harvest. Row covers early.
- Effective insecticides: Carbaryl, pyrethroids. Pyrethrins diatomaceous earth, or kryocide / cryolite for organic growers.

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Flea beetles … on potatoes and fruiting vegetables (eggplant and more)

- Potato flea beetle, palestriped flea beetle, others
- Adults overwinter and move to tomatoes, peppers, potatoes, and related plants
- Threshold = 30 percent defoliation or ≥ 4 beetles per plant when seedlings are < 4 inches tall
- <u>Keep an eye on eggplant especially</u>
- Controls are similar to those listed for crucifers

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Corn flea beetle

- Adult beetles overwinter, carrying the Stewart's wilt bacterium from season to season; survival is temperature-dependent
- Plant Stewart's wilt-resistant hybrids
- Use foliar sprays on seedlings of susceptible hybrids (<5-leaf stage)
  - Threshold = 6 beetles per 100 plants
  - Carbaryl, permethrin, cyfluthrin, or esfenvalerate; pyrethrins or rotenone are alternatives

Widespread use of seed treatments in field corn have reduced equilibrium populations of corn flea beetles throughout the Midwest.

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Cabbage worms or “Leps” (Lepidoptera)

Imported cabbage worm

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Imported cabbage worm

- Overwinter as pupae in a chrysalis; adults are active early in the season – day-flying white butterflies
- Larvae are velvety-green, about 1 inch long when fully grown
- 4-5 week generation time; 4 or 5 generations per year in much of the Midwest
- The easiest of the three major Leps to kill with insecticides … Bt and spinosad (Entrust) are very effective

Diamondback moth

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Diamondback moth

- Overwinters as an adult in protected areas; larvae and pupae are brought in on transplants (and their insecticide resistance spectrum comes from the region of their origin)
- Larvae are light green, 3/8-ich long when fully grown
- 3- to 4-week generation time; 4 to 6 generations per year (the first often on mustard family weeds)
- Lots of insecticide resistance problems around the world

Cabbage looper

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Cabbage looper

- Little successful overwintering in the Midwest (adults in protected areas?); adults migrate in from the south on weather systems
- Larvae 1 ½ inch long when fully grown; only 3 pairs of abdominal prolegs – so a "looper"
- 4 to 6 week generation time; 3 or 4 generations per year in most of Midwest
- Large larvae are difficult to control and not very susceptible to Bt; pyrethroids work best where "cleanup" is necessary; spinosad (Entrust) is an effective alternative

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Thresholds for "Leps" in commercial plantings

- Broccoli and cauliflower
  - Seedbed = 10%
  - Transplant-head = 50%
  - Head to harvest = 10%
- Cabbage
  - Seedbed = 10%
  - Transplant – cup = 30%
  - Cup – head = 20%
  - Maturing head = 10%

Percentages refer to the portion of plants with any live larvae of CL, DBM, or ICW. Check 5-10 plants in each of 5-10 areas in each field, once or twice weekly. On greens, use the thresholds for heading-to-harvest for cole crops or treat if infestations threaten marketability.

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“Lep” control

- Row covers immediately after transplanting
- Use BT products early
- Spinosad is also a selective alternative
- Pyrethroids are effective but kill natural enemies

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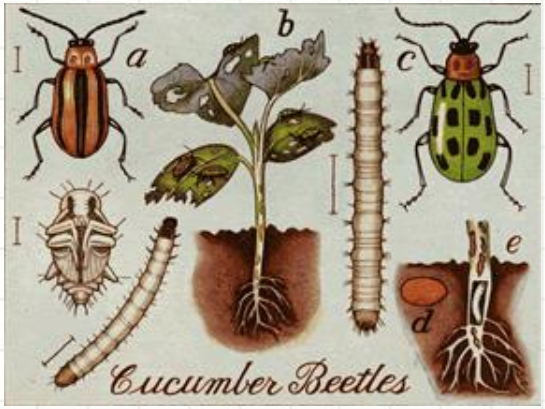
Striped and spotted cucumber beetles



- Overwinter as adults
- Carry and transmit the pathogen that causes bacterial wilt (most damaging to cucumbers and muskmelons)
- 1-2 generations/year (larvae feed on the roots of cucurbits and corn but are not damaging here)
- Control by insecticides, exclusion, and trap crops

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Cucumber beetle thresholds & management

- Muskmelons and cucumbers
  - 1 beetle per plant
  - Or fewer if wilt was severe last year
- Watermelon and squash
  - 5 beetles per plant
- Controls:
  - destroy / till in crops immediately after harvest
  - row covers early; remove for pollination
  - pyrethroids or carbaryl
  - pyrethrins
  - Spray when bees are not active … no wettable powders or dusts

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Striped cucumber beetles vs. western corn rootworms

- Stripes are distinct, “full-length;” underside black
- Feed on leaves, stems, and fruit
- Carry bacteria that causes bacterial wilt
- Arrive in April/May

- Stripes are blurry, short; underside yellow-tan
- Feed primarily on pollen
- Do not transmit bacterial wilt pathogen
- Arrive in July

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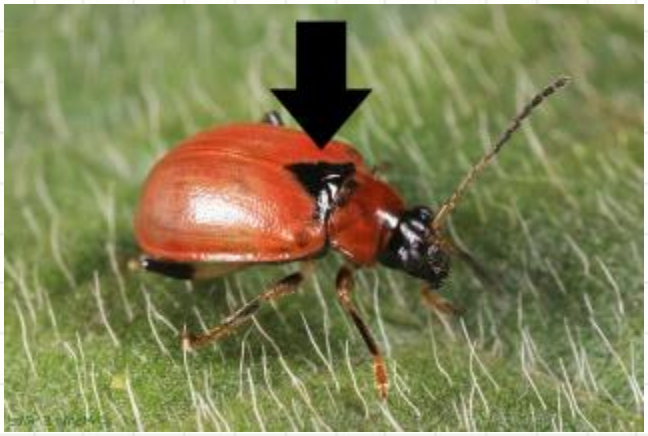
Bean leaf beetle



- Overwinter as adults; larvae feed on the roots of legumes
- Adults feed on many garden crops
- 2 generations/year
- Control by insecticides (same as for cucumber beetles) or early row covers

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Squash bug

- Adults overwinter and become active in early to mid-summer; feed and lay egg masses on squash and pumpkins
- Removal of plant fluids is main cause of damage

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Squash bug

- Count egg masses to make control decisions
  - Threshold = 1 to 1.5 egg masses per plant
- Time insecticide applications to target newly hatched and young nymphs
  - Pyrethroids (particularly Brigade, Warrior, and Mustang Max) are most effective
- Cultural controls: Destroy crop residue at the completion of harvest to eliminate overwintering sites; use row covers early; destroy eggs by hand

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Potato leafhopper

- Migrates into IL each summer
- Adults and nymphs inject toxin when feeding … causes "hopperburn"
- Threshold in green beans
  - Seedling: 2 per foot of row
  - 3rd leaf to bud: 5 per foot of row
- Threshold in potatoes
  - 0.5 adults per sweep and nymphs are present … or
  - 1.5 adults per sweep
- Controls:
  - row covers early
  - carbaryl, pyrethroids, or pyrethrins for organic growers

Colorado potato beetle

- Overwinters as adults in soil
- Eggs laid on leaves; larvae and adults feed on leaves
- 2 generations per year
- Resistance to one or more insecticides is common

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Colorado potato beetle control

- Row covers early
- Hand destruction of eggs, adults, and larvae; trenching and flaming
- *Bacillus thuringiensis tenebrionis* against larvae only
- Sevin or the pyrethroids permethrin, cyfluthrin, or esfenvalerate
- Spinosads (Entrust)

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Aphids

- ~1/16-1/8 inch long
- Winged or wingless
- Pear-shaped bodies
- Cornicles ("tailpipes") often present
- Variable colors
- Species identification difficult
- Adult females give birth to live young
- Many natural enemies

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Aphid life histories

- Many year-around resident species have separate winter and summer hosts
  - Rosy apple aphid
    - Overwinters as eggs on apples, moves to narrow-leaf plantain for the summer, then back to apple
  - Soybean aphid
    - Overwinters as eggs on common buckthorn, moves to soybeans for the summer, then back to buckthorn
- Species that do not overwinter here migrate into the region over great distances
  - Corn leaf aphid, cotton/melon aphid, turnip aphid, others
- Population growth is rapid because of
  - Parthenogenesis (reproduction without males)
  - Giving birth to many nymphs – all of which are female – (instead of laying eggs)
  - Short generation time

Aphids as pests

- Direct impact on plant growth
- Contamination of crops by live aphids or honeydew
- Transmission of plant pathogens – especially viruses

Cabbage aphid damage on cabbage
[Picture by C. Eastman]

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Aphid thresholds

- Few specific thresholds are available
- Infestations are often localized
- Look for presence of natural enemies
- Mark infested areas
- Check again in 5-7 days to see if infestation is increasing or if natural enemies are keeping it under control

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Aphid management

- Conserve natural enemies by spraying only when necessary for other pests – Sevin and pyrethroids are especially problematic
- Remember that you cannot control viruses by killing aphids with insecticides
- Avoid viruses by planting as early as possible

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Transmission of viruses

- Except for potato leafroll virus in production of seed potatoes, the common viruses transmitted by aphids to vegetable crops in the Midwest are transmitted in a nonpersistent manner
  - CMV, WMV, ZYMV, many others
  - Bean aphid, cotton/melon aphid, soybean aphid, green peach aphid, bird cherry-oat aphid, English grain aphid, and many other aphid vectors
  - Rapid acquisition and rapid inoculation
  - Short retention times in the vector
  - Transmission occurs before insecticides can kill the vector in the crop
  - Insecticides generally are NOT effective for limiting the incidence of virus diseases in vegetable crops

Corn earworm = tomato fruitworm

- = *Helicoverpa [Heliothis] zea*
- Larvae feed on the fruits of many crops, including corn, peppers, tomatoes, and green beans

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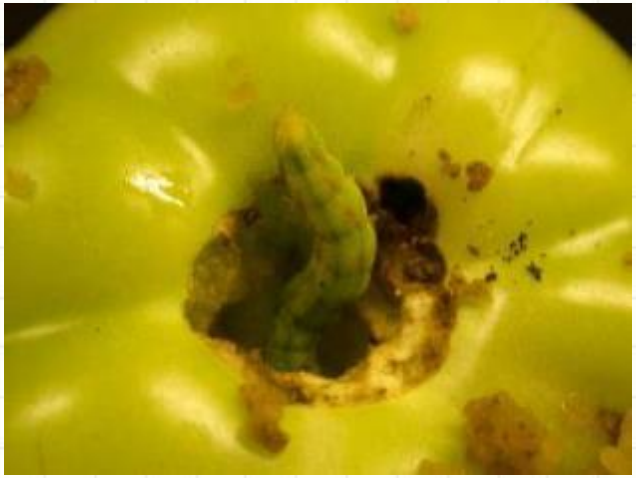
Tomato fruitworm injury to tomatoes



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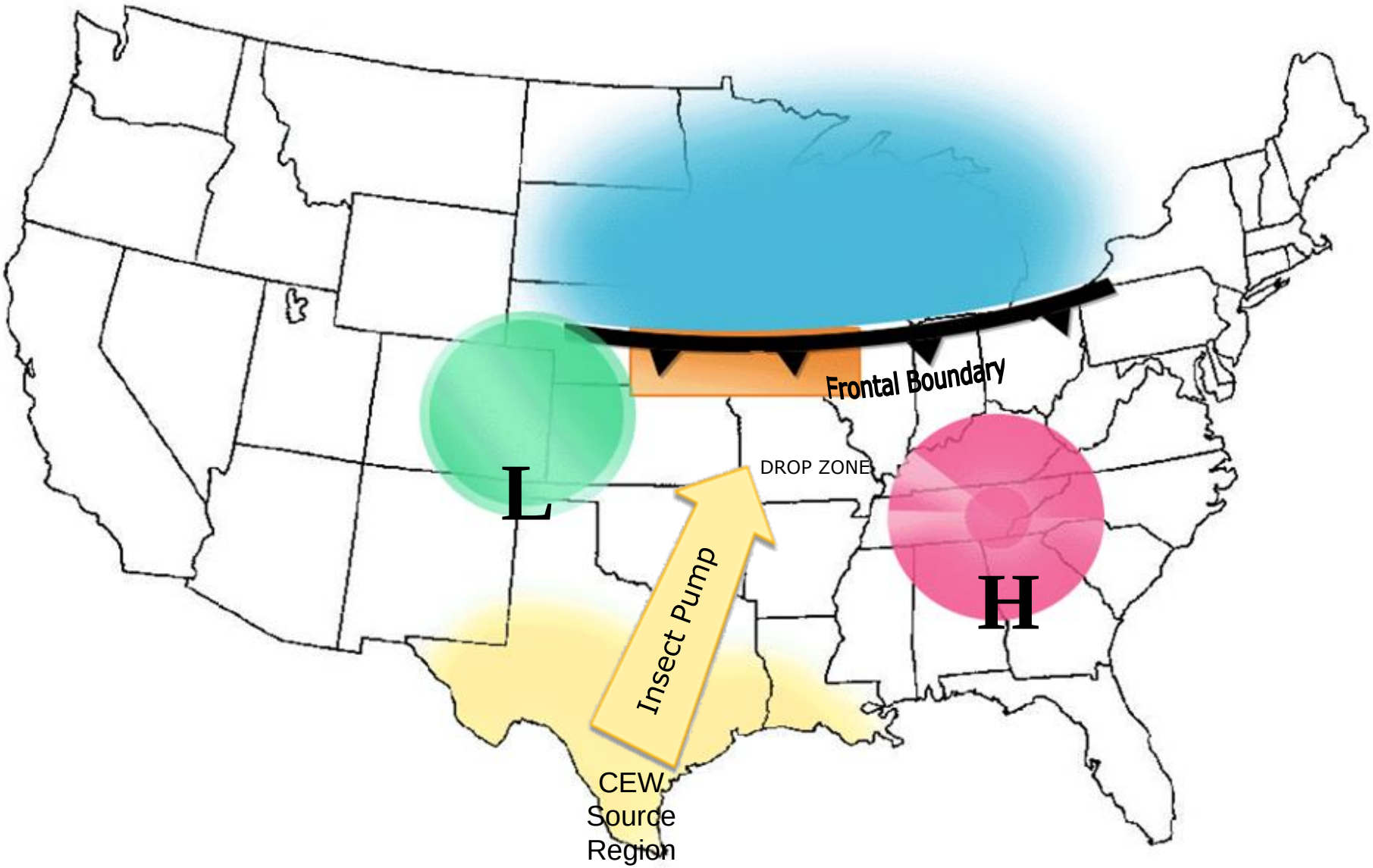


Corn earworm / tomato fruitworm annual migration.

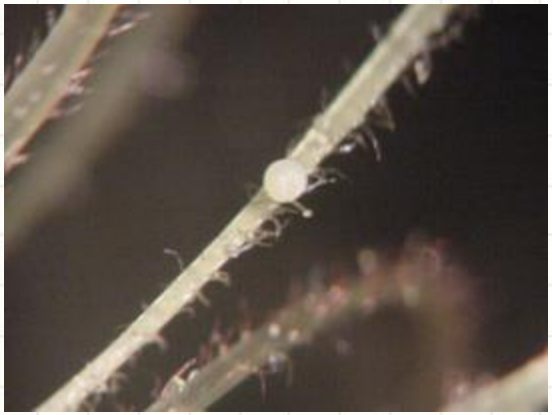
Tomato fruitworm

- Pupae overwinter in some areas, but populations result mainly from migration of adults from the south on weather fronts
- Traps indicate their presence and relative density
- Threshold = 5 – 10 moths per trap per night (more if nearby corn is silking)

Tomato fruitworm

- Insecticides
  - Pyrethroids
  - Sevin
  - Spinosads (Entrust)
  - Bt products (Dipel, etc.)
    - These work in tomatoes but not sweet corn

Corn earworm



Insecticides:
Pyrethroids, Sevin
Spinosads (Entrust) see
http://ipm.illinois.edu/ifvn/contents.php?id=42#vegetable

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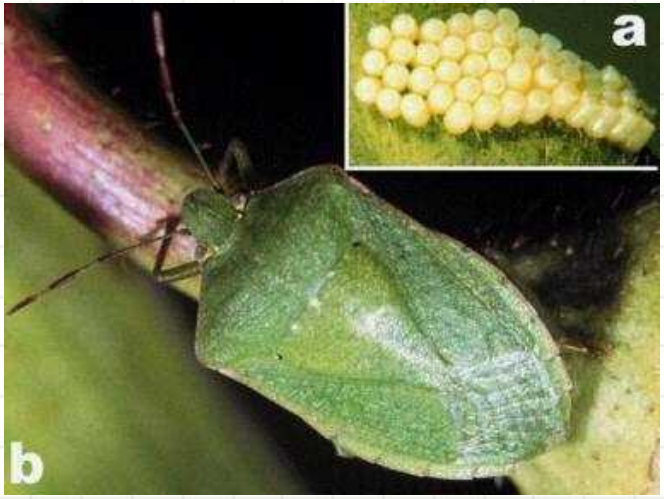
Tomato hornworm

Tomato hornworm

- Pupae overwinter, adults fly in late spring and early summer
- One generation per year
- Threshold = 0.5 - 1 larva per plant (but don't wait to find that one when it's 3 ½ inches long)
- Parasites often limit populations
- Insecticides:
  - Bt
  - Spinosad (Entrust)
  - Pyrethroids

Stink bugs and plant bugs



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Common stink bugs

Over 45 stink bug species occur commonly throughout North America. *Euschistus servus* (upper left), *Euschistus variolarius* (upper right), and *Euschistus conspersus* (lower left), all of which are brownish, are often-cited pests of a variety of crops.

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Green stink bugs

Above: southern green stink bug, *Nezara virdula*. Below: green stink bug, *Acrosternum hilare.* Adults and nymphs.

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Lygus bugs and other plant bugs

There are dozens of common species of plant bugs (Hemiptera: Miridae) in the Midwest and multiple *Lygus* species as well. Left: *Lygus lineolarus* adult and nymph. Below: *Neurocolpus nubilus* adult and nymph.

See:
http://www.uky.edu/Ag/CritterFiles/casefile/insects/bugs/mirid/mirid.htm

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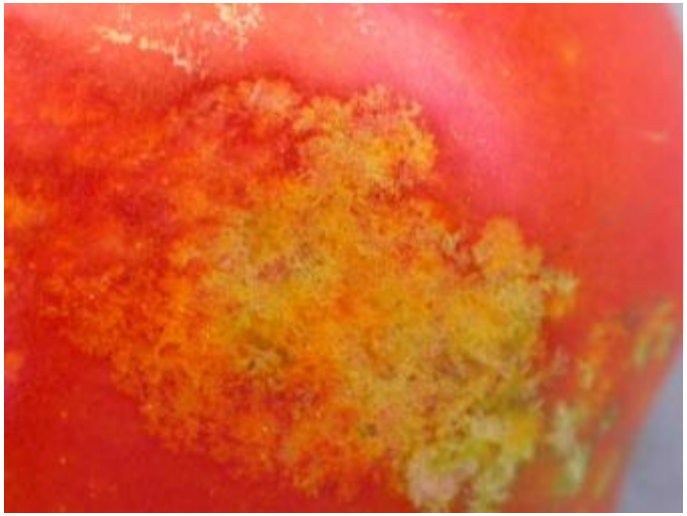
Stink bugs



- White to yellow, corky, pithy areas develop beneath the skin where stink bugs inserted their beaks to feed. Brown stink bug and green stink bug feed on tomatoes and many other crops. They may show up in high numbers as other hosts (including soybeans) dry down or are harvested.
- Stink bugs “drop and hide” when disturbed
- Shaking plants can help to dislodge them so you can detect them
- Detecting early damage is often key to knowing control is necessary

Stink bug control

- Stink bugs are not easily controlled
- Pyrethroids generally are most effective
- These insects feed on flower buds, fruits, and seeds … blooming plants in row middles attract stink bugs and plant bugs … reduce blooming weeds in vegetable plantings

Cultural controls

- Tillage
- Delayed planting
- Earlier planting
- Diversity and stability
- Weed control (effects on beneficial insects?)
- Exclusion

Insecticides with a broad range of effectiveness

- Sevin (carbaryl)
  - Effective against many beetles and caterpillars
  - Liquid formulations such as Sevin XLR Plus are less likely to kill bees.
  - Not effective against aphids, squash bug, or mites
  - Wettable powder formulations are especially toxic to bees
- Pyrethroids
  - Effective against many beetles, caterpillars, squash bug, stink bugs, and leafhoppers
  - Highly toxic to bees
  - Generally not very effective against aphids or mites
- Malathion
  - Most commonly used against aphids but somewhat effective against some beetles

Insecticides: microbials / botanicals / organics

- *Bacillus thuringiensis kurstaki* (Bt)
  - *Effective against caterpillars*
- *Bacillus thuringiensis tenebrionis*
  - Effective against Colorado potato beetle larvae
- Neem (plant-derived oil)
  - Moderately effective against aphids
- Pyrethrins (plant-derived; very short-lived)
  - Effective against some beetles; more effective if combined with piperonyl butoxide but then not approved in certified organic production

Insecticides: microbials / botanicals / organics

- Kaolin (Surround)
  - Water-dispersible clay … some value against some beetles, difficult to apply well in hand sprayers
- Soaps (M-Pede)
  - Effective against aphids, mites, leafhopper nymphs (no residual activity)
- Entrust (microbial)
  - Effective against caterpillars, thrips, a few other specific pests
- Cryolite/Kryocide & diatomaceous earth
  - Abrasives … mixed range of susceptible species

Natural enemies (predators and parasites) and pollinators

- For general information, see
  - http://www.youtube.com/watch?v=r1EYCevAgnY
  - http://www.ncipmc.org/glvwg/pdfs/NaturalEnemiesFlyer-FINAL.pdf
- For information on plants that enhance natural enemy abundance:
  - Growing Plants to Attract Beneficial Insects (http://www.colostate.edu/Depts/CoopExt/4DMG/PHC/benefici.htm)
  - Attracting Beneficial Insects with Native Flowering Plants (http://nativeplants.msu.edu/uploads/files/E2973.pdf)
  - List of pest-repelling plants (http://en.wikipedia.org/wiki/List_of_pest-repelling_plants)
  - High Value Pollinator Plants (http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs141p2_029849.pdf)

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Continuing education … newsletters

- Illinois Fruit and Vegetable News
  - http://ipm.illinois.edu/ifvn/
- Purdue / Indiana Vegetable Crops Hotline
  - http://www.btny.purdue.edu/pubs/vegcrop/index2013.html
- Ohio Vegetable and Fruit Newsletter
  - http://vegnet.osu.edu/newsletter

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For a summary of pesticide recommendations by crop …

- The annually revised ***Midwest Vegetable Production Guide for Commercial Growers***
  - http://mwveguide.org/

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