Using multiple tactics to manage pests on vegetables




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Topics

- **Overview of management tactics**
- **Examples of common pests & options for managing them**
  - **Vine crops**
  - **Cole crops**

Components of Integrated Pest Management (IPM)

- **Monitoring**
- **Action thresholds**
- **Multiple tactics**
  - **Preventive options**
  - **Remedial options**

IPM uses a combination of tactics

- Cultural
- Host Plant Resistance
- Mechanical
- Biological
- Behavioral
- Microbial
- Chemical
- Genetic
- Regulatory

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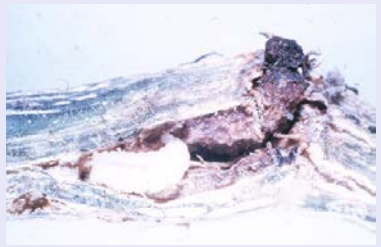
Cultural Controls

- **Minimize infestations by choosing appropriate crop management practices**
  - **What crop is selected**
  - **Where crop is planted**
  - **When crop operations occur**
  - **How field is prepared & planted**
  - **How crop is maintained**
- **Trade-offs usually occur**

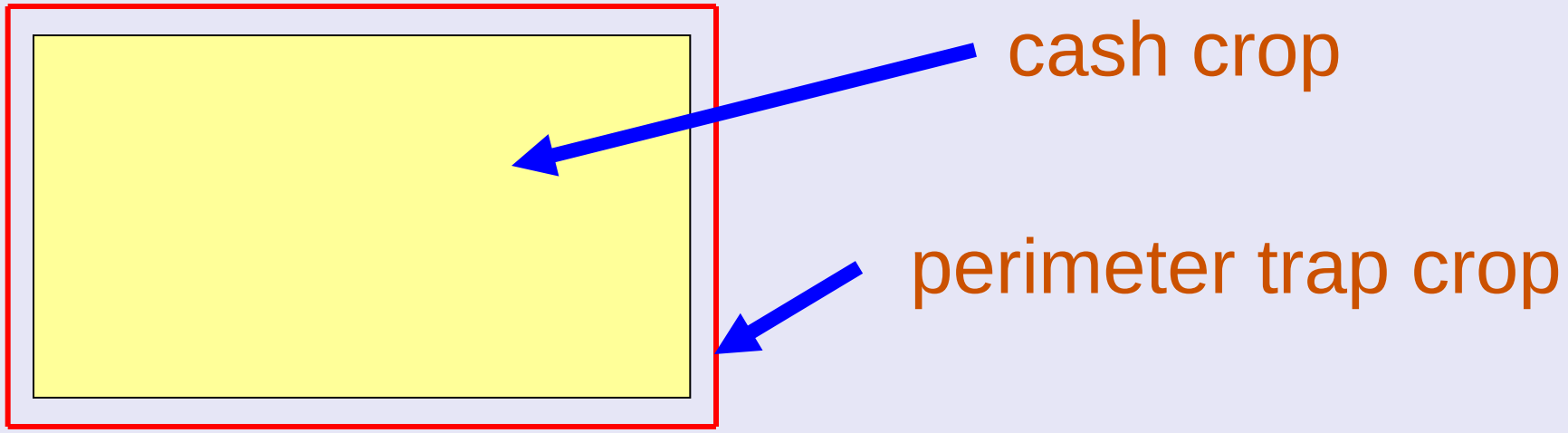
Delayed planting

- **Cucumber beetle** 
  - Problem if plant in mid-May
  - Less problem if plant in early June
- **Squash vine borer** 
  - Same
- **Bean leaf beetle**
  - Peak populations in May, July
  - Fewer in June 

Cover Crops

- **Used to protect soil over winter**
- **Affects onion thrips**
  - **Overwinters in small grains**
  - **Does best in wheat**
  - **Does poorly in rye**

Trap cropping



- **Lure pest away from main crop to a more attractive crop**
- **Planting time options**
  - **Same time**
  - **2 weeks early for trap crop**

Perimeter trap crop

- **Cantaloupe surrounded by Buttercup squash**

Cultural control: trade-offs

Example: Straw Mulch

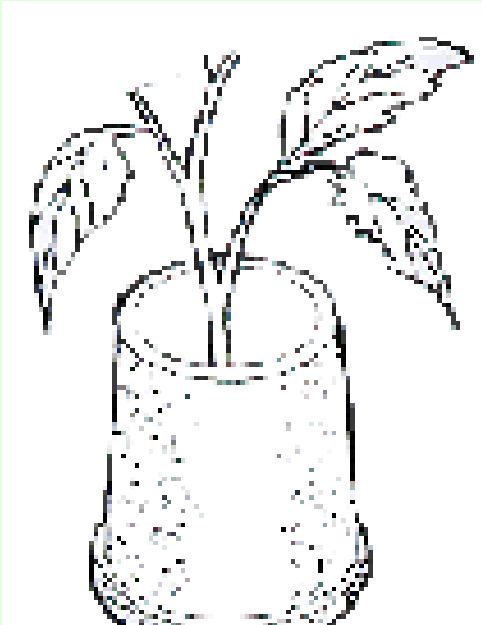
- Benefits
  - Moisture retention
  - Weed suppression
  - Reduces soil splash
  - Reduces fungal spore dispersal
- Makes some pest problems worse
  - cucumber beetles, slugs

Mechanical Controls

- Tactics to prevent or delay pests from infesting a site
- Tactics not needed for purposes other than pest management
- 2 types:
  - Exclusion
  - Removal

Exclusion by barriers

- Row covers **
- Netting, screening
- Paper bags →
- Localized shields
- Copper barriers
- Trenches (deep furrows)
- Plant collars →
- Fences



Row covers to exclude pests

- **Lightweight**
  - –‘Agri-bon 15’, ‘Insect Barrier’
  - –90% light transmission (vs 70-85% for heavier covers for frost protection)
  - –Sources:
    - **Johnny’s Selected Seed: $67. (10’ x 250’)**
    - **Gardens Alive: $35. (5’ x 110’)**

Row covers to exclude pests

- Beetles on beans
- Leafhoppers on beans
- Worms on cole crops
- Disease vectors:
  - Beetles on cucumbers (before flowering)
  - Aphids

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

- Use with or w/o hoops
- Must be anchored tightly

Mechanical Control by Removal

- By beating/shaking
- Removal trapping
- Removal by vacuum
- Removal by hand
- By aspirator

Removal by beating or shaking

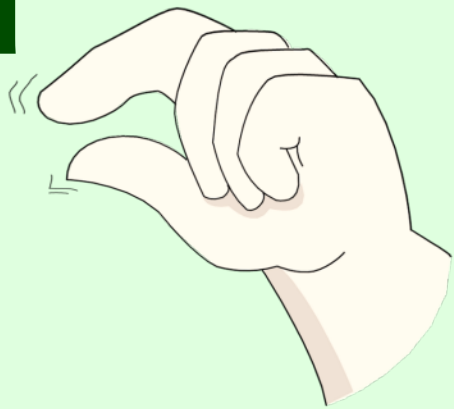
- Hold bucket under plant
- Tap plants with broom
- Then kill pests mechanically
- Repeat daily
- Works for Colorado potato beetle (adults, larvae)

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 hand



- **Labor intensive**
- **Target pests:**
  - Conspicuous pests
  - Pests not too active
  - In relatively restricted area
- **Examples**
  - Spinach leafminer (infested leaves)
  - Hornworms
  - Asparagus beetle (eggs)
  - Japanese beetle

Removal by sanitation

- **Collect and destroy/compost:**
  - **Culled fruit**
  - **Crop residue (after harvest)**
- **Plant clean nursery stock**

Biological Control

- Control of pest by other organisms that act as natural enemies
- Overview of common natural enemies
  - Predators
  - Parasitoids
- Tactics of biocontrol





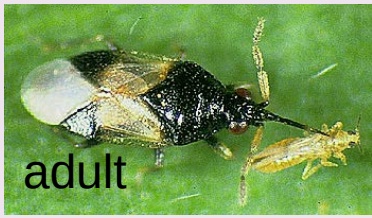


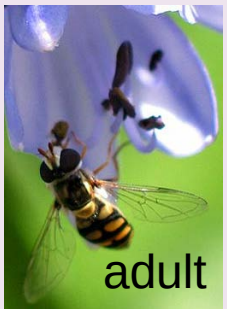
Predators

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

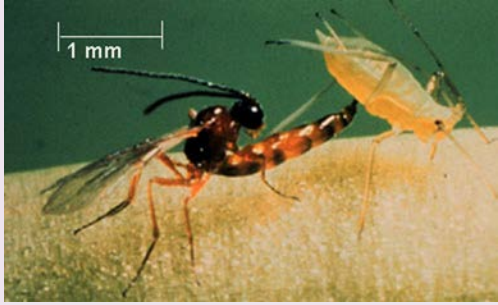
Predators

- Green lacewings
- Lady beetles
- Insidious flower bug
- Damsel bugs
- Hover flies





Parasitoids



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

& Vertebrate predators eat insects!

- Bats
- Toads
- Birds
- Geese
- Hogs

Biological Control

- **Conservation tactics**
  - Avoid broad-spectrum insecticides
  - Provide refuge planting
- **Augmentation tactics**
  - Buy from insectary
    - Rincon-Vitova in California
  - Collect locally, then transfer







Refuge planting for natural enemies

- **Adult parasitoids need nectar**
- **Adult predators need pollen**
- **Plant flowering border at field edge to enhance biocontrol**

Refuge planting for natural enemies

sweet alyssum *

Phacelia

nasturtium

cilantro

dill

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

Chemical Control

- **Options:**
  - **Use no chemicals**
  - **Use conventional insecticides**
  - **Use chemicals allowed for organic farms (on OMRI list)**

Insect control products on the OMRI List

- **Behavioral control**
  - pheromone mating disruption
- **Microbial control**
  - viruses
  - B.t. (DiPel)
- **Smothering agents**
  - soaps
  - oils
- **Nerve poisons**
  - spinosad (Entrust)
  - pyrethrins (PyGanic)
- **Repellents**
  - kaolin (Surround)
  - neem
  - garlic

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Insecticides

- **OMRI-listed, narrow spectrum**
  - **viruses** (Gemstar)
  - **pheromones** (CheckMate-TPW)
  - **bacteria** (*B.t.*: Dipel)
- **OMRI-listed, broad spectrum**
  - **soaps**
  - **oils**
  - **botanicals: neem, pyrethrins**
  - **fungi: *Beauveria***

Spinosad in ‘Entrust SC’

- **Targets:**
  - Mostly caterpillars
  - Some thrips, beetles, leafminers
- **Expensive! ($689 for 1 quart at Johnny’s Seeds)**
- **Rates 1.5 to 10 fl oz/A (most 3 - 4 fl oz/A)**

Repellent: ‘Surround’

NovaSource® Tessenderlo Group

Surround® WP

Crop Protectant

OMRI™ Listed
Organic Materials Review Institute

Cucurbit Vegetables
Such as cucumber, summer and winter squash, pumpkin, citron melon, muskmelon, and watermelon

PEST	LBS/ACRE	APPLICATION INSTRUCTIONS
Cucumber beetle, grasshoppers	25-50	Suppression only*. Start prior to infestation, applying every 5-7 days, with the first two applications 3 days apart.
Powdery mildew		Suppression only*. Apply every 7-14 days as required to maintain coverage.
Sunburn and heat stress	25-100	See I D.
*If complete control is needed, consider using supplemental controls.		

Microbial Insecticides

- **Bacteria**
  - **B.t. (sprayable!): Dipel**
- **Viruses**
  - **Gemstar**
- **Fungi**
  - ***Beauveria bassiana* (Mycotrol, Naturalis)**
- **Protozoans**
  - ***Nosema* (Hopper Stopper; Nolo Bait)**
- **Nematodes**
  - ***Steinernema carpocapsae* (Millenium)**
  - ***Heterorhabditis bacteriophora* (Symbion)**

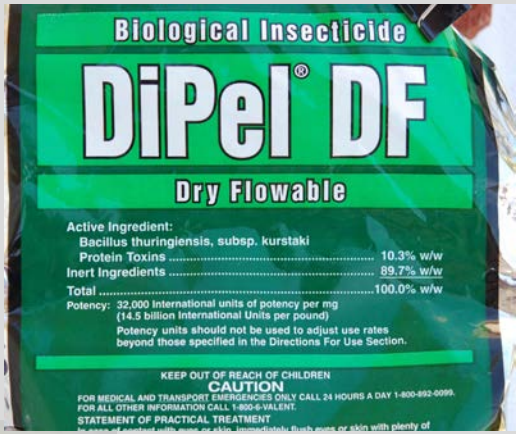
What is B.t.?

- **A natural soil-borne bacterium**
- **Species: *Bacillus thuringiensis***
- **This bacterium produces crystal-like proteins that kill certain insects**
- **Found world-wide**
- **Produced by fermentation methods**
- **Discovered 1915; used since 1957**

How does B.t. work?

- B.t. must be eaten by target insect
- B.t. contains toxins that are activated by insect's gut enzymes
- toxins paralyze insect's digestive tract
- feeding stops within 2 hours after eating B.t.
- death takes 1 - 5 days

B.t. products for caterpillar control

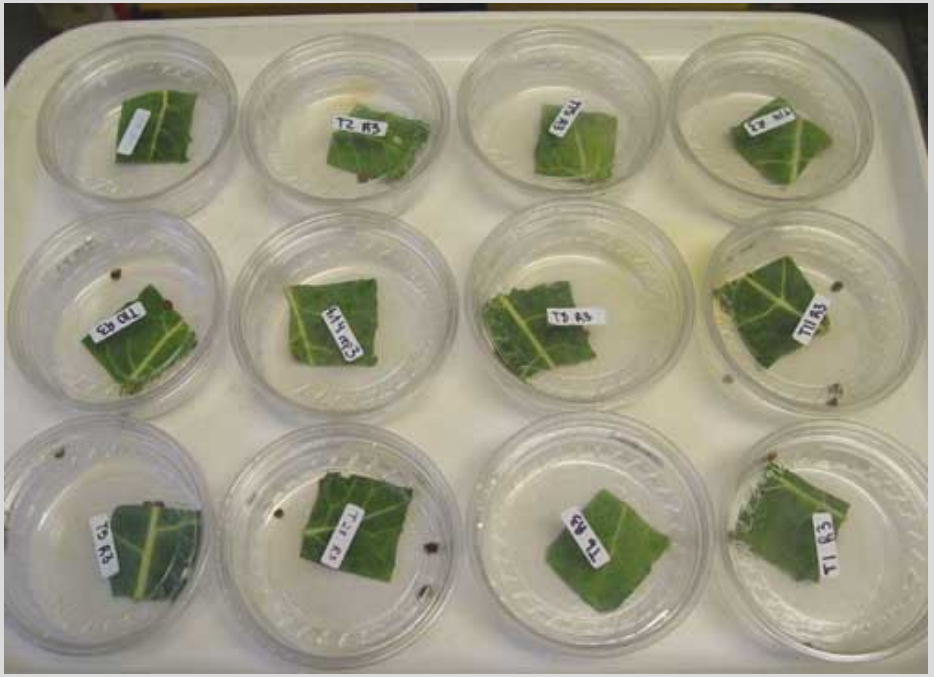


- **DiPel** (Valent)
- **XenTari** (Valent)
- **Biobit** (Valent)
- **Javelin** (Certis)
- **Agree** (Certis)

B.t. performance

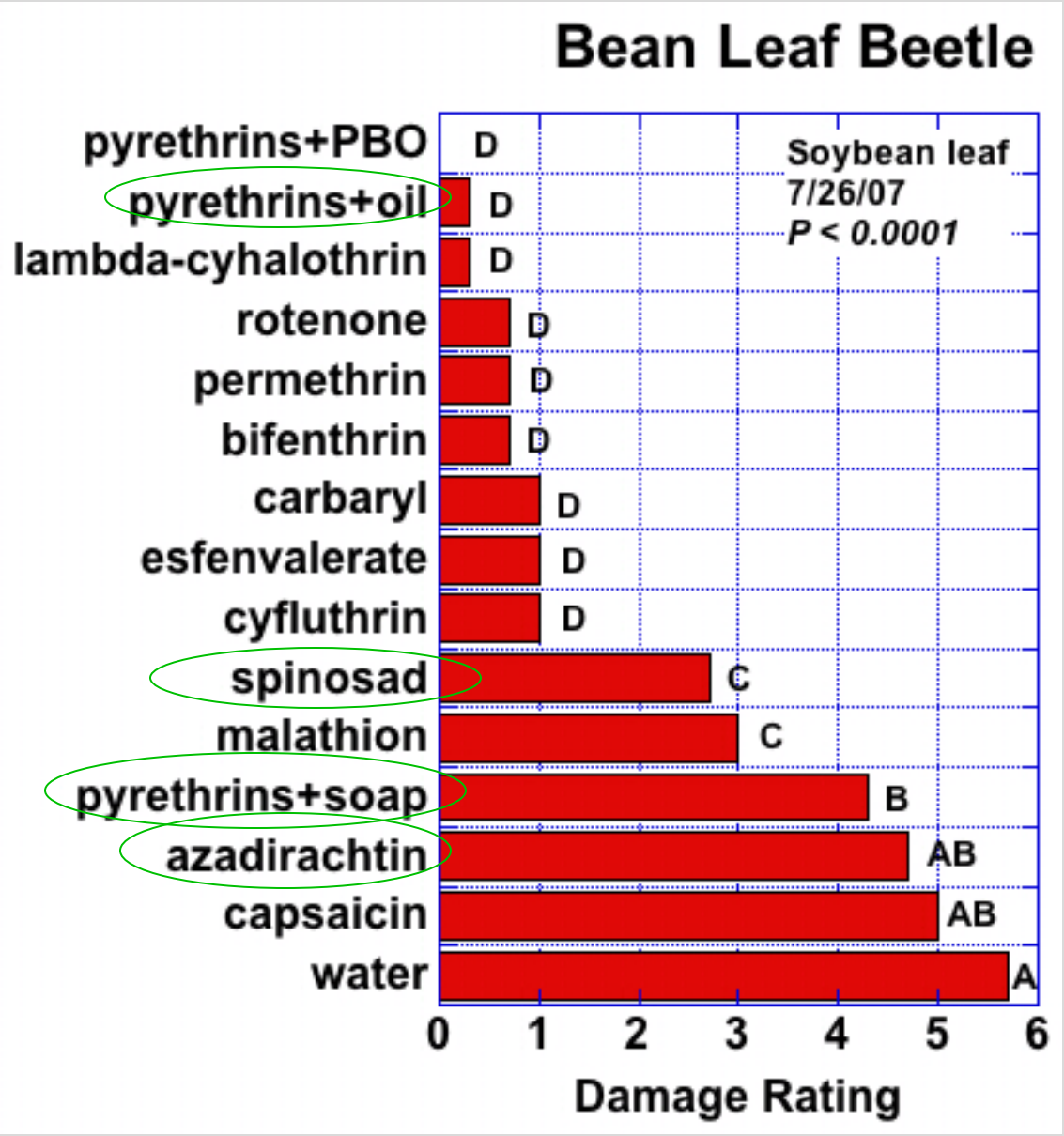
- **Sometimes erratic due to:**
  - Breakdown in U.V. light
  - Reduced toxicity against older larvae
  - Incomplete spray coverage
  - Too long a spray interval
- **Best if:**
  - Target young larvae
  - Apply at 3-7 day intervals
  - Get thorough coverage
    - Lot of water (>35 gal/A)
    - Good pressure (60 psi)

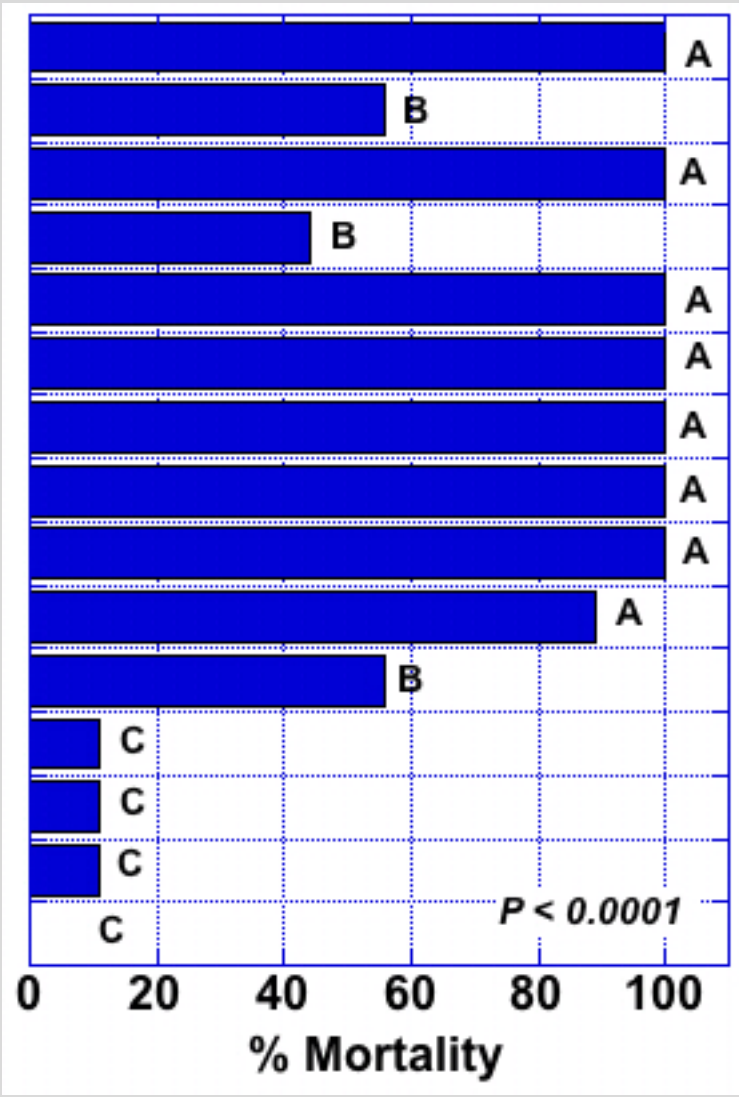
Lab bioassays to evaluate insecticide efficacy



- Defoliation
- Mortality

Bean Leaf Beetle





Trends in efficacy

spectrum	*Exc./Good*	*Good/Fair*	*Fair/Poor*
broad	pyrethrins + PBO carbaryl esfenvalerate lambda-cyhalothrin cyfluthrin bifenthrin	permethrin malathion pyrethrins +oil	neem seed oil azadirachtin capsaicin garlic pyrethrins +soap
less broad	spinosad endosulfan rotenone	kaolin	
narrow	dicofol soap oil	B.T.	

in red if on OMRI list

Can biological & chemical control ever be integrated?

- **Use selective chemical**
  - **Kills pest but *not* natural enemies**
  - **Allows natural enemies to help kill pest**
  - **Example: B.t. (Dipel)**
  - **Use product with very short residual activity**
  - **Example: soap**

Tactics for common pests

- Cole crops
- Vine crops

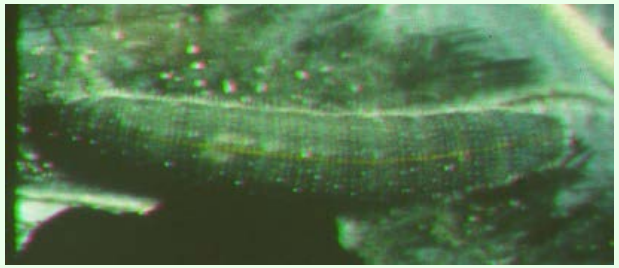
Cole Crop Pests

	Head Crops	Leaf Crops	Root Crops
• Caterpillars	★	★	
• Thrips	★		
• Flea beetles		★	
• Aphids		★	
• Root maggots			★

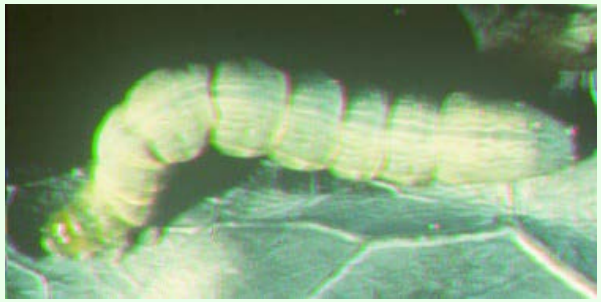
Tactics for cole crop pests

	Cultural	Biological	Chemical
• Caterpillars		★	★
• Thrips	★		★
• Flea beetles			★
• Aphids		★	
• Root maggots	★		★

Cole crops: 3 Caterpillar Species



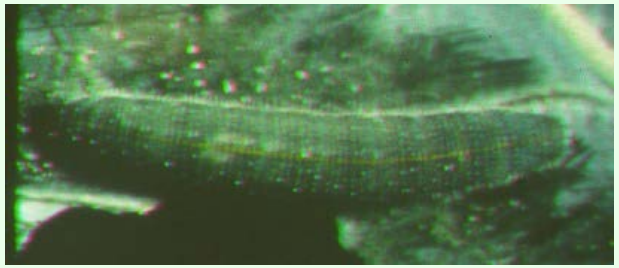
Imported cabbageworm



Cabbage looper

Diamondback moth

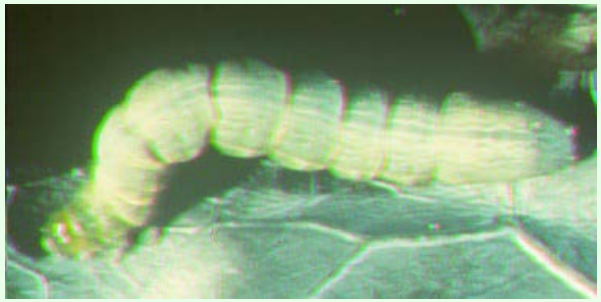
3 Caterpillar Species & their parasitoids



Imported cabbageworm

Cotesia larvae spinning cocoons

Cotesia adult wasp



Cabbage looper

Copidosoma floridanum wasps emerging from one cocoon

Diamondback moth

Diadegma insulare oviposits on larvae

Biological & microbial control of caterpillars on cole crops

- **Use the microbial insecticide BT as a selective insecticide, spray or dust**
  - **'DiPel', 'Xentari', etc.**
  - **Kills caterpillars**
  - **Does not kill parasitoids**
  - **Allows natural enemies to help kill pests**
- **Spinosad also easy on parasitoids**
- **Plant border of sweet alyssum to attract parasitoids**

How are B.t. sprays most effective for cabbageworm control?

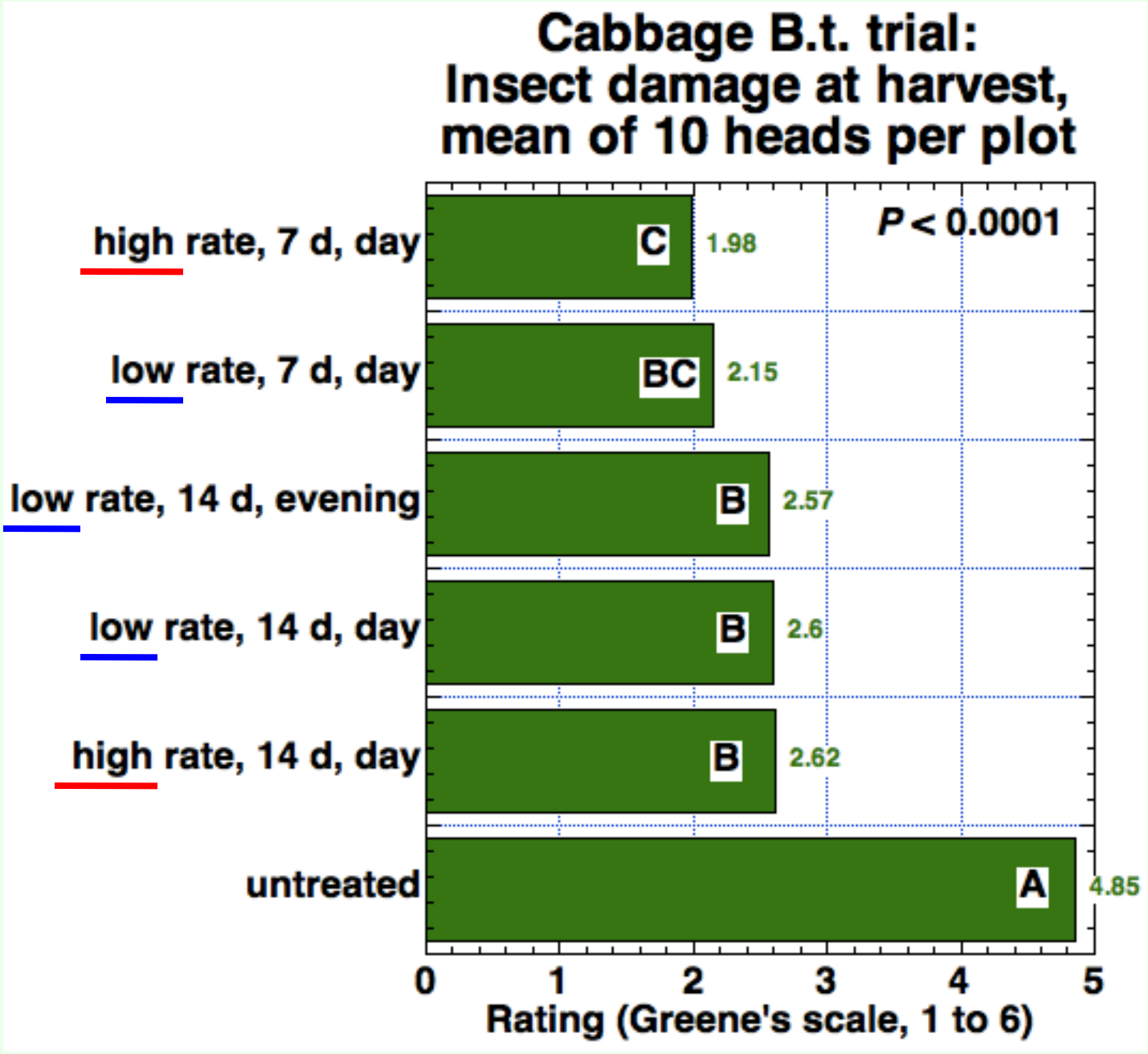
- Rate?
- Frequency?
- Time of day?

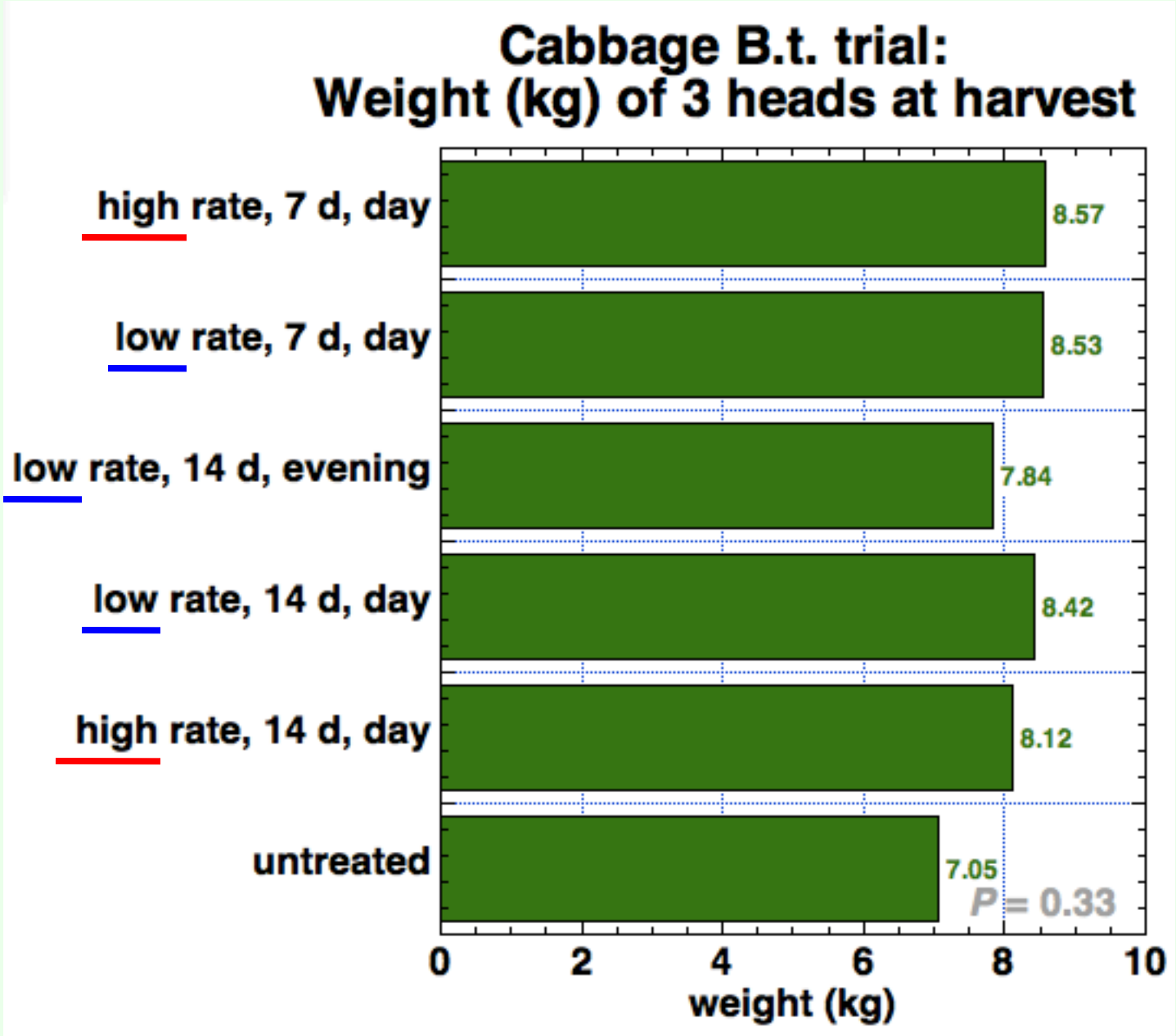
Cabbage trial, 2012

- cv ‘Bravo’
- Transplanted 18 May
- Scouted weekly for insects
- 1st spray 18 days after planting
- Sprays for 11 weeks
- Harvest 20 August

Cabbage B.t. treatments

Treat-ment	Rate of Dipel DF	Frequency	Time
1	-	-	-
2	Low (0.5 lb/A	Every 7 days	daytime
3	Low (0.5 lb/A)	Every 14 days	daytime
4	High (1.0 lb/A)	Every 7 days	daytime
5	High (1.0 lb/A)	Every 14 days	daytime
6	Low (0.5 lb/A)	Every 14 days	evening

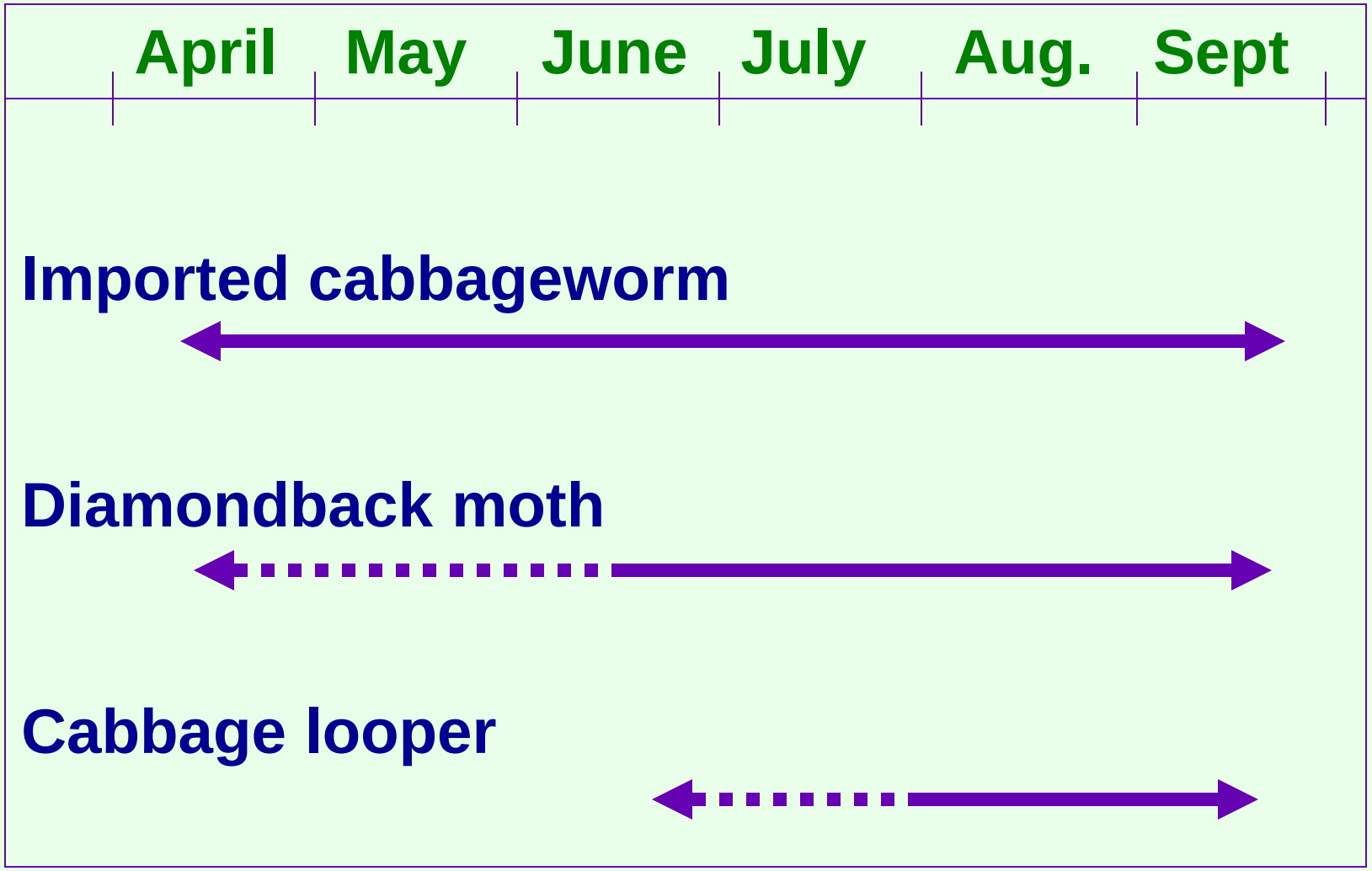

Cabbage B.t. trial:
Insect damage at harvest,
mean of 10 heads per plot
P < 0.0001
high rate, 7 d, day
C
1.98
low rate, 7 d, day
BC
2.15
low rate, 14 d, evening
B
2.57
low rate, 14 d, day
B
2.6
high rate, 14 d, day
B
2.62
untreated
A
4.85
0
1
2
3
4
5
Rating (Greene's scale, 1 to 6)


Cabbage B.t. trial:
Weight (kg) of 3 heads at harvest
high rate, 7 d, day
low rate, 7 d, day
low rate, 14 d, evening
low rate, 14 d, day
high rate, 14 d, day
untreated
8.57
8.53
7.84
8.42
8.12
7.05
P = 0.33
0
2
4
6
8
10
weight (kg)

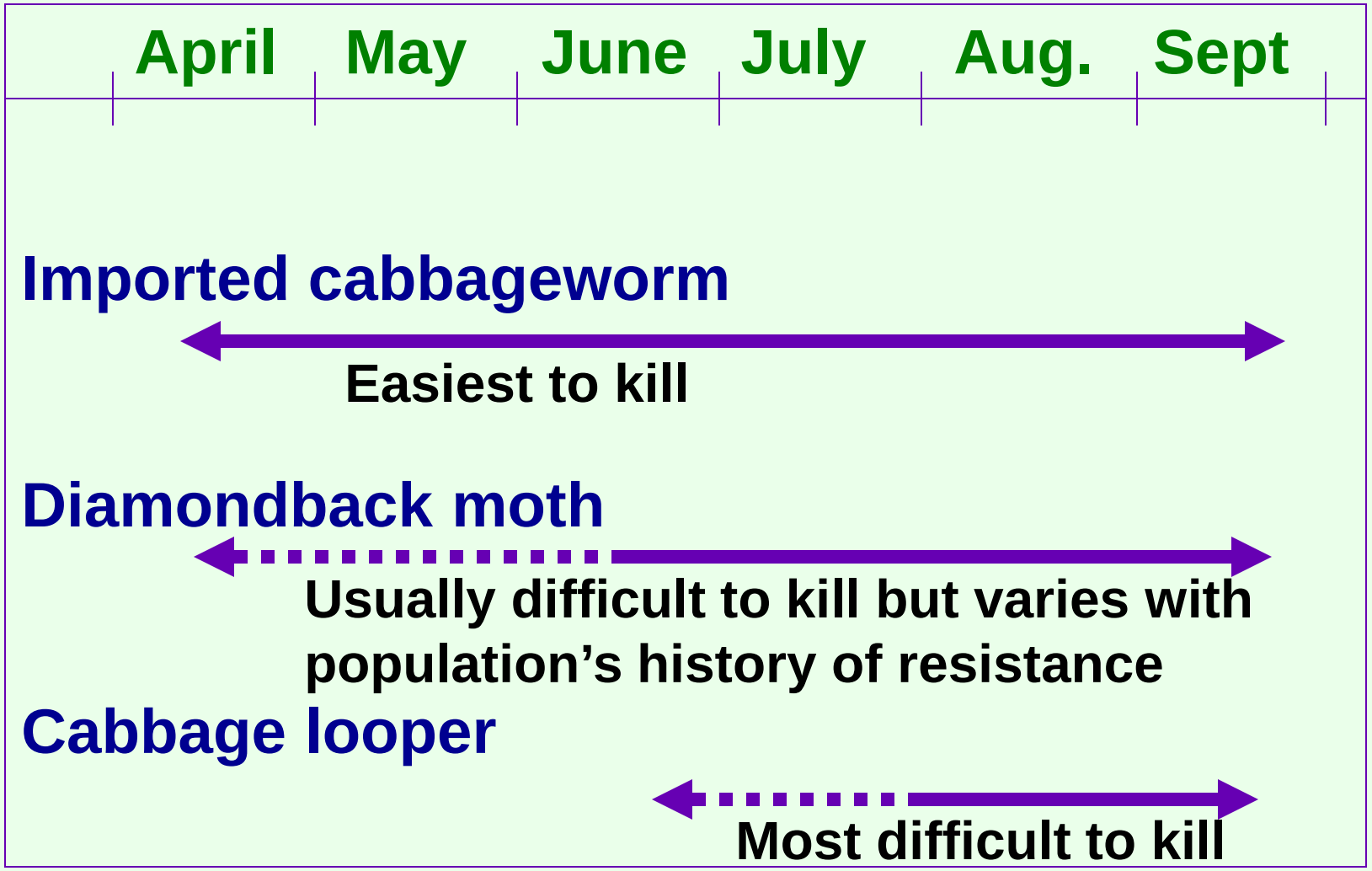
B.t. trial conclusions

- **Frequency more important than rate**
  - **Every 7 days better than every 14 days**
  - **Low rate as effective as high rate**
- **Daytime spray as effective as evening spray**

Cabbage caterpillar calendar



Cabbage caterpillar calendar & response to insecticides



Insecticides for caterpillar management on cole crops

Insecticide	*Imported cabbage-worm*	*Diamond-back moth*	*Cabbage looper*	*Natural enemies*
Conventional	**Excellent control**	**Fair control**	**Good control**	**Poor survival**
B.t.	**Good control**	**Good control**	**Fair control**	**Excellent survival**

Thus B.t. works best when diamondback moth or imported cabbageworm is dominant pest

Insecticide Calendar

- **Early & mid-season (April to July)**
  - **if imported cabbageworm &/or diamondback dominant**
  - **use only B.t.**
- **Mid- to late season (August)**
  - **if cabbage looper dominant pest**
  - **use Confirm, SpinTor, or Proclaim**
- **Late season (Sept.-October)**
  - **if cabbage looper dominant pest**
  - **use pyrethroids (Baythroid, etc.)**

Thrips on Cabbage

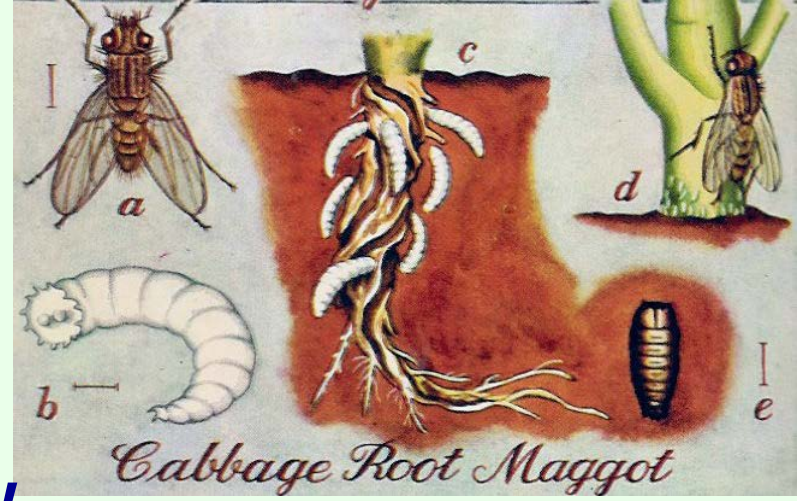
Less damage:	More damage:
Bravo	Azan
Fresco	Atria
Cheers	Coleguard
Titanic 90	Megaton
KingCole	Upton
Superkraut	Hinova
	Krautpacker
	Rodolpho
	Superdane

Data on >80 varieties
C.Hoy, K.Scaife, M.Kleinhenz

Cultural controls for thrips

- **Select thrips-tolerant variety**
- **Choose winter cover crop**
  - **Thrips do best in wheat**
  - **Thrips do poorly in rye**
- **Avoid planting near wheat**
  - **Thrips infestation often follows wheat harvest**

Planting date & Cabbage Maggot



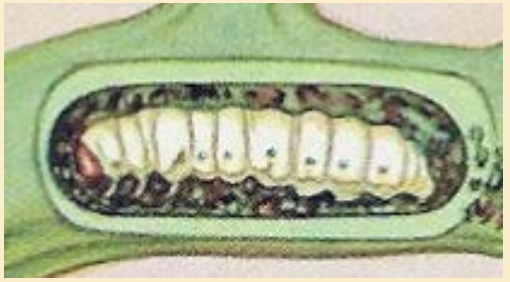
- **Crop most susceptible if in <u>seedling</u> stage when new adults are laying eggs**
- **Emergence of the adults:**
  - **on different calendar dates each year**
  - **but always at the same time that certain well known plants are flowering**

GEN.	PLANT	AVG. BLOOM (Ohio)
1	yellow rocket	early May
2	day lilies	late June
3	Canada thistle	early August
4	New England aster	early Sept.

Choose planting date to avoid cabbage maggot

- Do not transplant during the time that these plants are blooming
- Do not seed approximately 2 weeks before these plants are blooming
- Ideal time to seed is toward the tail end of bloom period, because seedlings would appear:
  - just after maggot flies disappear
  - well before the next flight begins

Managing Insect Pests in Commercial Vine Crops



Cucurbit Pests

- Cucumber beetles **
- Aphids
- Two-spotted spider mite
- Squash bug
- Squash vine borer

Cucumber beetles

Important damage:

- Chew seedlings
- Transmit bacterial wilt
- Chew on fruit surface

Less critical damage:

- Chew on flowers
- Larvae chew on roots

Natural enemy of cucumber beetles

- **Parasitoid fly, *Celatoria***
- **Looks like a small house fly**
- **Kills adult cucumber beetles**
- **Common in Ohio**
  - **Striped cucumber beetle, adults:**
    - **0 to 38% in survey 13 farms, 2003 & 2004**
  - **Spotted cucumber beetle, adults:**
    - **4% at 1 site, 2000**
- **We need to encourage its survival!**

Beetle infected with nematodes

Cultural controls & cucumber beetles

- **Plant late (mid-June)**
  - **After initial peak invasion**
- **Avoid straw mulch**
  - **Favors development of larvae in soil**

Perimeter trap crop

- **Squash more attractive than cantaloupe**

Row covers

- **Good in recent trials with cantaloupe**

Cucumber beetles & conventional insecticides

- **Seed applied systemics**
  - FarMore FI400 (since 2009)
- **Soil applied systemics**
  - Admire Pro (since 2000) or generics
  - Platinum 2SC
- **Foliar applied**
  - Before flowering:
    - Sevin; Pounce or other pyrethroids
  - During flowering:
    - No good choices due to honey bee toxicity
    - Never spray in morning; best in evening

Admire applied in-furrow provides excellent control of striped cucumber beetle on pumpkin seedlings

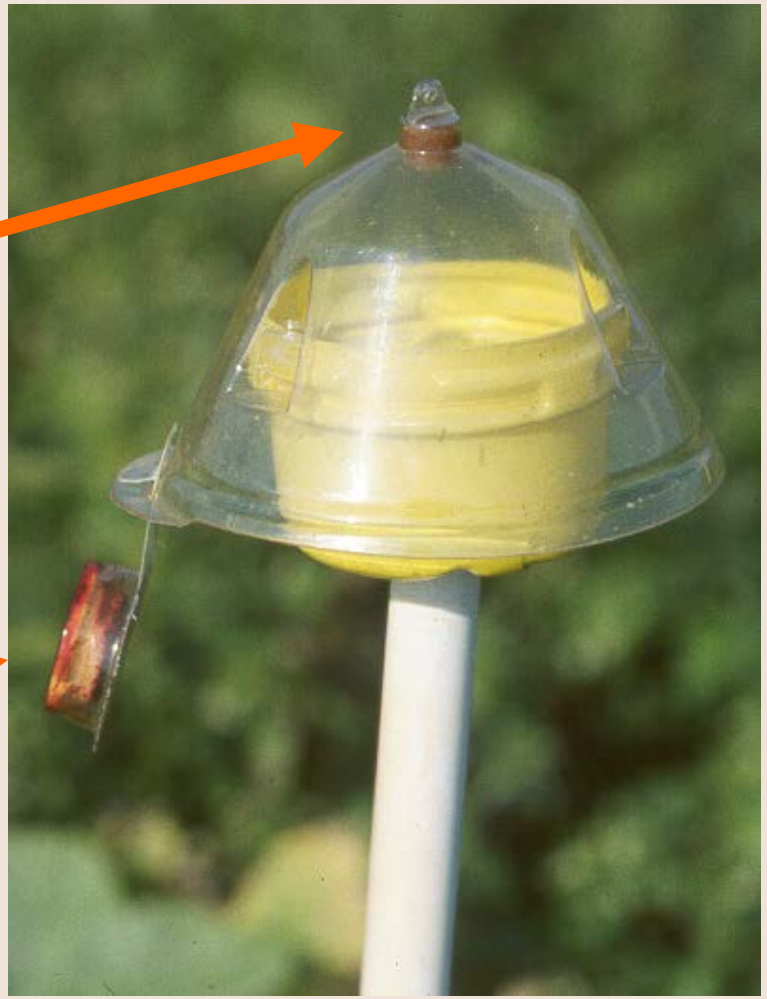
Seed Treatment

- For direct-seeded crops
- Advantages
  - Efficacy equal to in-furrow treatment
  - Convenience; easier application
  - Much lower rate of A.I. per acre
    - Compare to in-furrow:
    - ~25 times less (pumpkins at 3,000 seeds/A)
    - ~2 times less (pickles at 45,000 seeds/A)
- Control good during critical cotyledon to 2-leaf stage
- Control not lasting past 2-leaf stage

Cucumber beetle management by mass trapping

Cucumber Beetle Kairomone Trap

- **Developed by Trécé Inc.**
- **Poison bait: cucurbitacin + carbaryl (inside trap)**
- **Volatile lure: mimic squash flowers**
- **Most effective <u>before</u> flowers form**



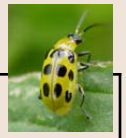
Potted squash plants treated with soil drench of Admire

One trapping station = one trap & one box of 3 potted plants treated with Admire

5 traps at the edge of 1 plot

traps 20 ft apart

Cucumber beetle management options

Category	*Tactics*
Cultural	**Delay planting (early June)** **Plant early trap crop** **Avoid straw mulch**
Mechanical	**Row cover (seedlings)** **Early trap-out**
Biological	**Conserve parasitoids (no spray)**
Chemical	**Buy treated seed** **Rescue spray**

Cucurbit Pests

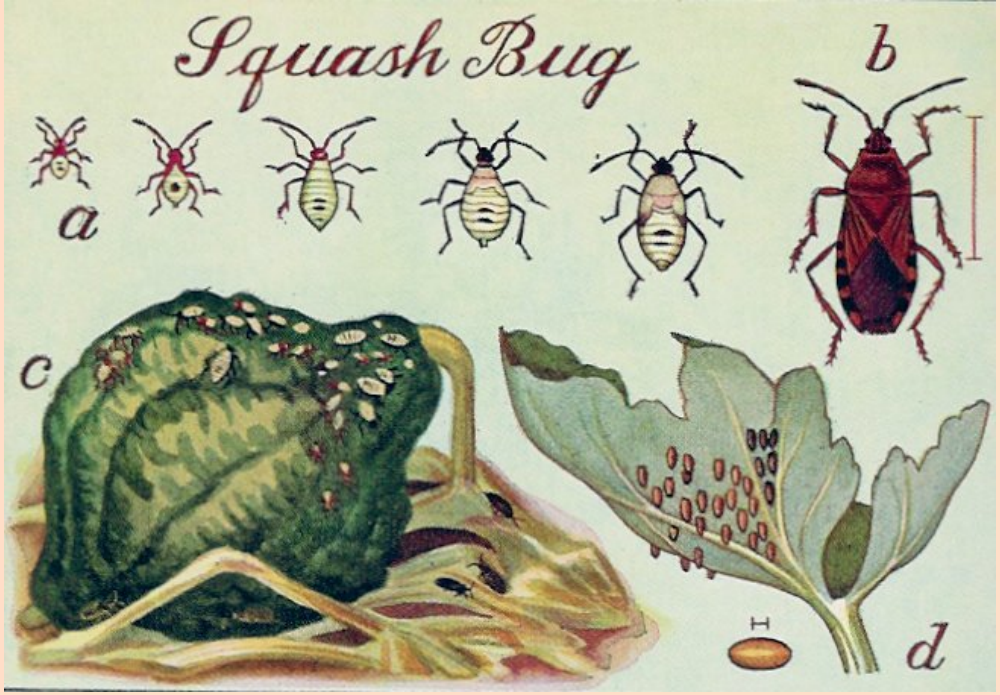
- Cucumber beetles
- Aphids
- Two-spotted spider mite
- Squash bug
- Squash vine borer

Aphids & Viruses on Cucurbits

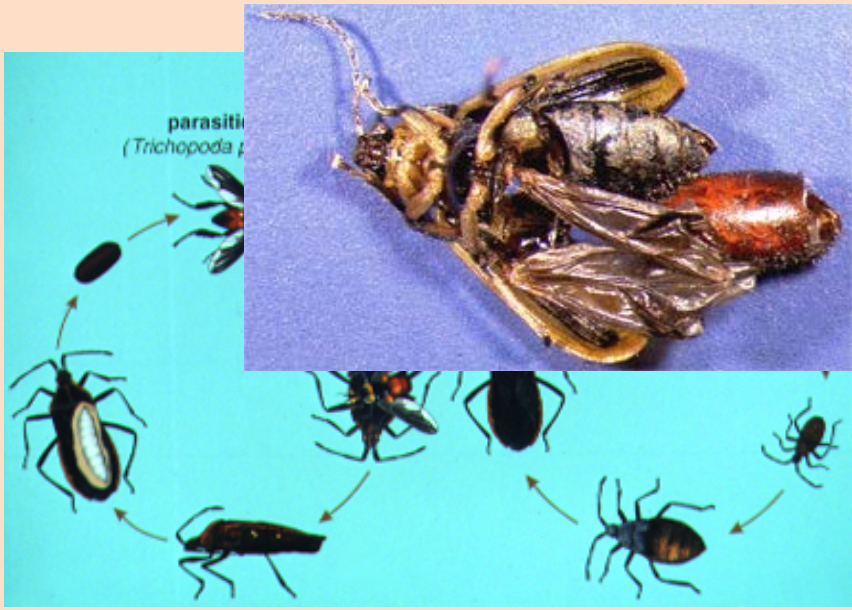
- **Tactics tested:**
  - **Stylet oil**
  - **Row covers**
  - **Reflective mulch**
  - **Soil-applied systemic insecticides**
  - **Foliar insecticides**
- **All helped control aphids but none affected virus**
- **Best hope is resistant varieties**

Spider Mites

- Tolerable at low density
- Suppressed by natural predators
- Flare up in hot dry weather
- Soft control:
  - Insecticidal soap
  - Hort. Oil
- Chemical control:
  - Agri-Mek or others


Squash Bug
a
b
c
d

Squash Bug: Biological control



- **Feather-legged fly**
  - ***Trichopoda pennipes***
  - **parasitoid**
  - **lays egg on adult or large nymph**
  - **common in Ohio**
- **Egg parasitoid wasps**

Squash Bug: Cultural control

- **Rotate with non-curcurbit crops**
- **Promote early growth of crop**
- *** Destroy crop remains**

Squash Bug: Mechanical control

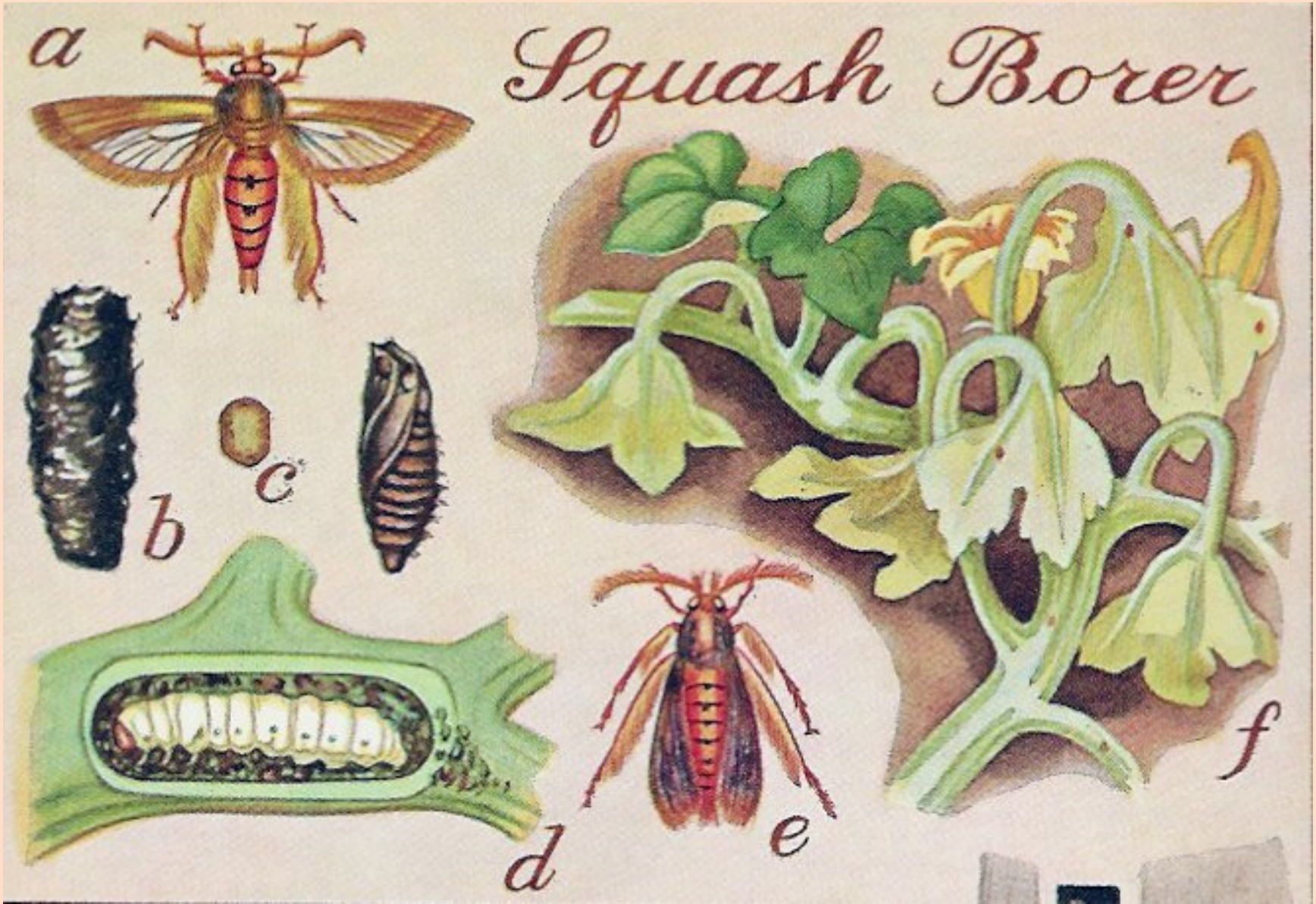
- **Shelter trap**
  - **Board trap or shingle trap**
  - **On ground under squash plant**
  - **Check daily in early morning**
  - **Decide how to kill**

- **Row covers (until flower)**
- **Hand-pick egg masses**

Squash Bug: Chemical control

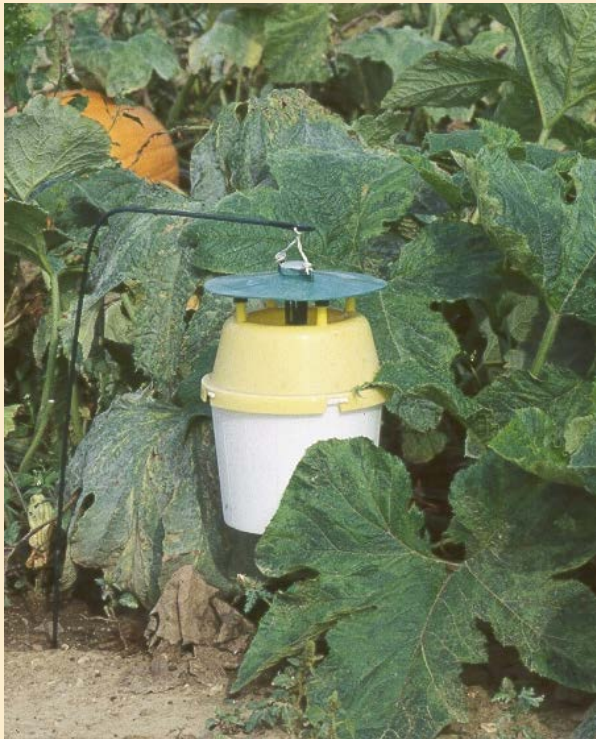
- **Challenges**
  - **Nymphs more susceptible than adults**
  - **Hard to contact in canopy**
  - **Need good spray pressure**
- **Insecticide choices:**
  - **Pyrethroids (Ambush, Asana, Baythroid, Capture, Danitol, Permethrin, Pounce) = *good***
  - **Sevin = *poor***

Squash Vine Borer



Squash vine borer: trap for monitoring

- pheromone lure available to attract adult male moths
- trap helpful with timing insecticide to target hatching eggs

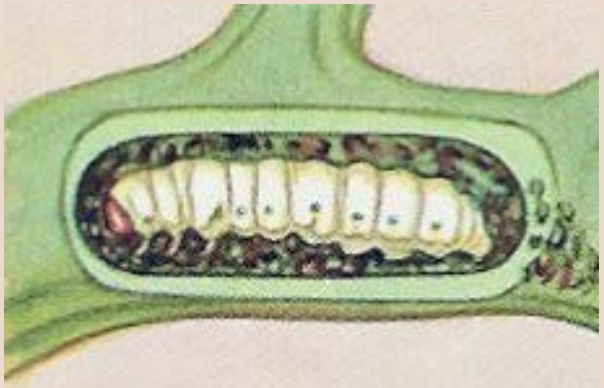


Squash Vine Borer: Chemical Control

- **Timing:**
  - **4 sprays, 1 week apart**
  - **At time of egg hatch**
  - **Estimate by catch of moths in trap**
  - **Peak hatch usually early July**
- **Products: pyrethroid (Ambush, Asana, Baythroid, Brigade, Danitol, Permethrin, Pounce) or EverGreen (pyrethrins + PBO)**
- **Direct spray at base of stems**

Squash Vine Borer: Management

- **Cultural**
  - **Plant late for main crop**
  - **Small planting early as trap crop**
- **Mechanical**
  - **Row covers (until flowering)**
- **Chemical**
  - **Insecticide**



Cucurbit pest management

Category	*Tactics*
Cultural	**Delay planting (early June)** **Plant early trap crop** **Avoid straw mulch** **Crop rotation**
Mechanical	**Row cover (seedlings)** **Shelter traps** **Hand-pick eggs** **Destroy crop remnants** **Early trap-out**
Biological	**Conserve natural enemies**
Chemical	**Buy treated seed**

Questions?