Organic and IPM Insect Management in Vegetables

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Presentation Outline

- Integrated Pest Management
- Phenology and Degree Days for Monitoring and Control Activities
- Pests and control strategies
  - avoidance in time (rotation, plant dates, phenology, Degree Days)
  - avoidance in space (rotation, trap crops)
  - varietal selection
  - biocontrol and natural enemies
  - **Cucurbit pests** – cucumbers, melons, squash, pumpkins (cucumber beetle, squash vine borer)
  - **Brassica pests** – cabbage, cauliflower, broccoli, mustard greens (caterpillar pests, cabbage maggot, flea beetles, thrips)
  - **Onion pests** – (onion thrips, onion maggot)

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Integrated Pest Management (IPM)

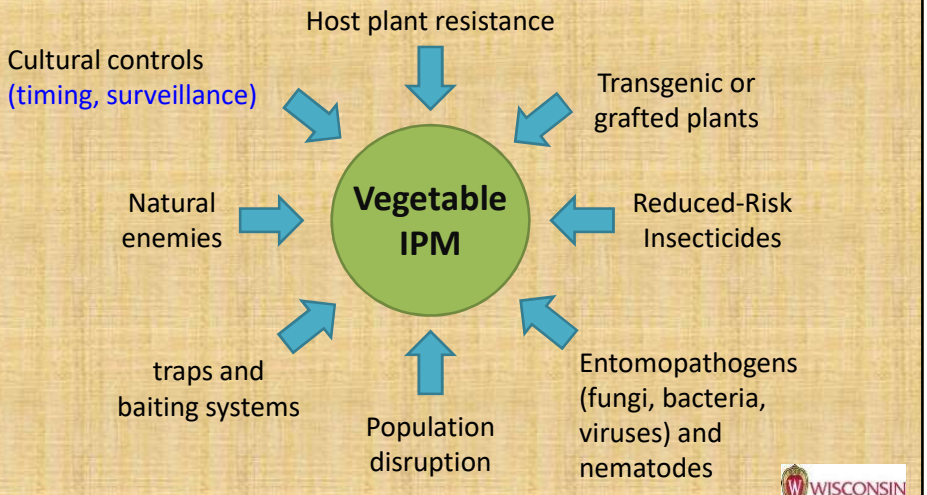
Integrated Pest Management (IPM) is an **effective and environmentally sensitive approach** to pest management based on a combination of strategies.

- Information on pest life cycles in combination with available pest control methods, are used to manage pest damage using the most economical means, and with the least possible hazard to people, property, and the environment.
- IPM uses all appropriate pest management options including, but not limited to, the judicious use of pesticides (least toxic options recommended first).
- In contrast, *organic* food production applies many of the same concepts as IPM but limits the use of pesticides to those that are produced from natural sources, as opposed to synthetic chemicals.

-- Environmental Protection Agency

IPM pest management tactics for vegetables

Use all available tools to manage pest damage in the most economic, socially, and environmentally sound way

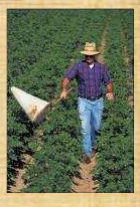


Process of an IPM program

decision flow

Component	Process
monitoring and sampling	inspect crop
pest identification	what pest(s)?
decision-making	what action(s)?
Intervention	take action(s)
follow-up	re-inspect crop
record-keeping	write it down
education	review and learn

- For all garden/farm sizes and *any* management approach (e.g. conventional, agro-ecological, or organic)



Insect Monitoring: Phenology and Degree Days

- Phenology studies correlations between growth stages of plants, animals, insects, disease organisms.
- Event ex. common lilac bloom
- Events occur based on seasonal and climatic changes, particularly with weather or temperature, rather than specific calendar dates.
- Uses biofix: A biological event or indicator of a developmental event, in the life of an insect that initiates the start of growing-degree-day (GDD) calculations.
- GDD based on accumulations of heat units over time since insect development is based on heat

Codling Moth Development

Developmental Stages Based on Degree Days	
First Generation	
Degree Days	Development
220	1% egg hatch
340-360	Greatest egg hatch
920	100% egg hatch
Second Generation	
1100	1% egg hatch
1320-1720	Greatest egg hatch
2100	100% egg hatch
Third Generation	
2160	1% egg hatch

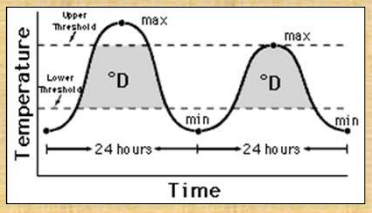
http://agresearch.montana.edu/warc/guides/apple_pest_codling_moth.html

Insect Monitoring: Phenology and Degree Days

- Even when weather delays or accelerates events, they still coincide with each other, if not calendar dates
- Development of insect plant pests is related to availability of their plant food source
- Minimum temperature threshold below which development stops, is most commonly 50°F, (DD50) Note there are other threshold temps for CPB is DD52
- Degree days accumulate when the temperature exceeds the base threshold or (i.e. 50°F)

Colorado Potato Beetle

https://commons.wikimedia.org/wiki/User: Adámozophoto



Example Insects & Associated Degree Days

Colorado potato beetle
(1st generation only)
Base temperature = 50°F
Biofix - Begin counting when first eggs appear
- 1st instar larva at 185 DD_{50}
- 2nd instar larva at 240 DD_{50}
- 3rd instar larva at 300 DD_{50}
- 4th instar larva at 400 DD_{50}
- Pupa at 675 DD_{50}

Fleabeetles
Base temperature = 50°F
Biofix – January 1: 150-200 DD_{50}
(Norway maple, Amelanchier, redbud early bloom)

https://extension.colostate.edu/topic-areas/insects/flea-beetles-5-592/

Degree Day Calculation

Each day, record the high and low temperatures, and find the average daily temperature by adding the daily high and low temperatures together and dividing by two:

$$\textit{Ave. Daily Temp.} = \frac{\textit{High Temp.} + \textit{Low Temp.}}{2}$$

Next, subtract the base temperature from the average daily temperature to get the degree days for that day:

$$\textit{Daily } DD_{50} = \textit{Ave. Daily Temp.} - \textit{Base Temp.}$$

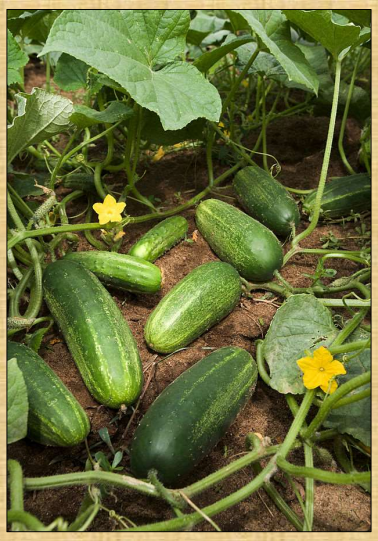
$$\textit{Ave. Daily Temp.} = \frac{60 + 50}{2} = 55$$

$$\textit{Daily } DD_{50} = 55 - 50 = 5\ DD_{50}$$

https://pddc.wisc.edu/

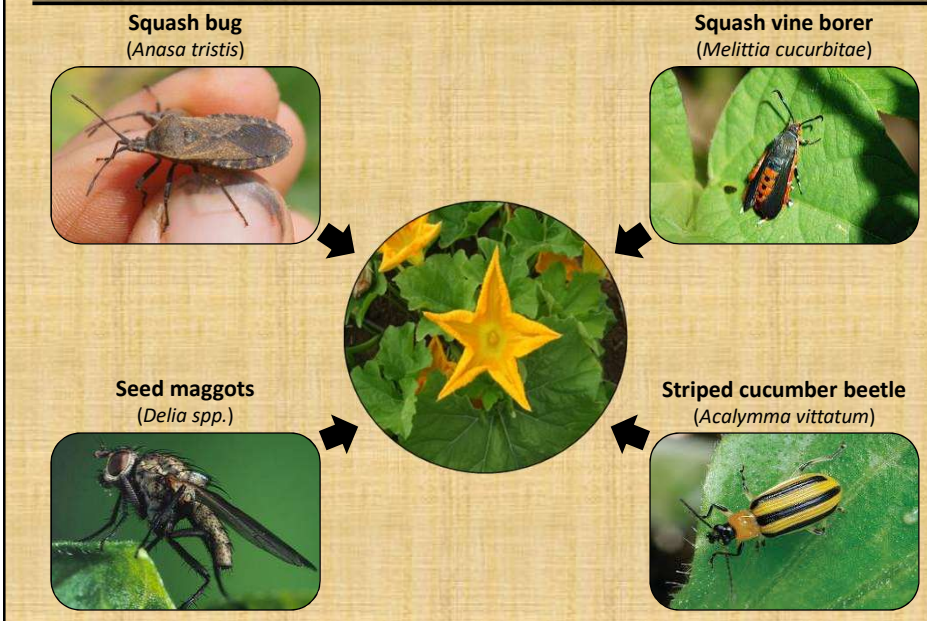
https://datcpservices.wisconsin.gov/pb/index.jsp

CUCURBIT PESTS

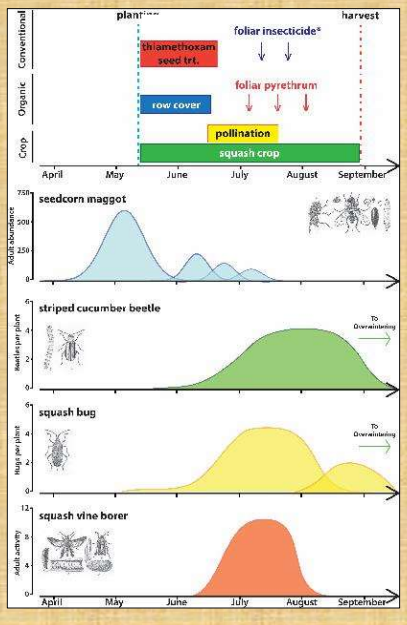


Agricultural Research Service

Key insect pests of cucurbits



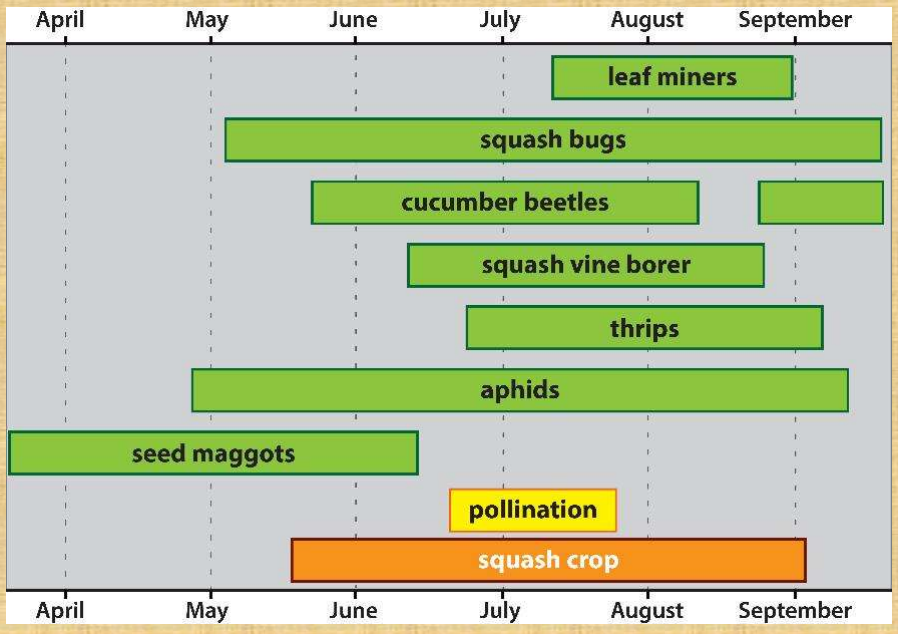
Season long management plans for cucurbits



- Early season control with seed treatment or cultural methods
- Timing of foliar applications (organic or not) dependent on flowering stage of the crop
- Scouting for pests will save money and reduce extra sprays
- Read labels and active ingredients

How does pest management fit into the broader sustainability picture?

Insect pests of cucurbits



Striped cucumber beetle – Lifecycle

- Overwinters as an adult in protected non-crop areas & colonizes in early spring
- Adults feed on plants and mate
- Lays eggs at base of host plant
- Become active when 'surrounding' air temp > 55° F.
- Micro-climatic variation influences timing of adult emergence

Field scouting is your best friend!!

Cucumber beetle – Sampling and thresholds (foliar)

Sampling

- Yellow sticky cards
- Plant counts (check at least 10 plants if you have that many)
- Colonization times critical

Action thresholds

- 1 beetle/plant for melons, cucumbers, and young pumpkins
- 5 beetles/plant for watermelon, squash, and older pumpkins

Cucumber beetle damage (4 types)

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Cucumber beetle – Bacterial wilt (most impt type)

- Most damage is from bacterial wilt, *Erwinia tracheiphila*
- Closely associated with the beetle, which is a vector
- No cure for bacteria, control through vector (beetle)

American Vegetable Grower
(www.meisterpro.com)

Vegetable Insect Management with Emphasis on the Midwest (Foster et al., 1995) lists susceptibility, from greatest to least as:
1. Cucumber
2. Cantaloupe
3. Honeydew
4. Casaba melon
5. Winter squash
6. Pumpkins
7. Summer squash
8. Watermelon

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Cucumber beetle – management

Cultural

- Later planting (second week of June)
- Transplants instead of direct seeding
- Early border trap crops
  (transplant Blue Hubbard squash)
- Aluminum plastic mulch

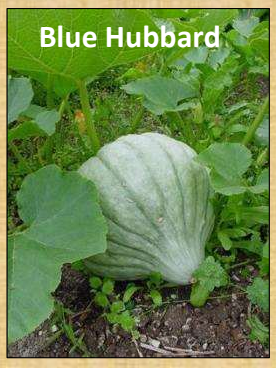

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Table 1 Ranking of Cucurbita by Cucumber Beetle Feeding Preference (Jarvis, 1994)

Yellow Summer Squash		**Winter Squash**	
Variety	**Ranking**	**Variety**	**Ranking**
Sunbar	1	Table Ace	6
Slender Gold	2	Carnival	7
Early Prolific Straightneck	20	Table King	12
Goldie Hybrid	32	Tay Belle	14
Sundance	33	———————	
Straightneck Summer Squash		**Butternuts**	
Seneca Prolific	4	Zenith	13
Goldbar	5	Butternut Supreme	16
Multipik	37	Early Butternut	25
———————		Waltham	28
Crooknecks		**Buttercups**	
Yellow Crookneck	8	Honey Delight	43
Sundance	34	Buttercup Burgess	44
———————		Ambercup	55
Scallops		———————	
Peter Pan	9	———————	
Zucchinis		**Pumpkins**	
Gold Rush	39	Baby Pam (pie pumpkin)	10
Zucchini Select	40	Munchkin	11
Ambassador	41	Seneca Harvest Moon	15
President	45	Jack Be Little	17
Black Jack	46	Jackpot	18
Green Eclipse	50	Tom Fox	19
Seneca Zucchini	51	Baby Bear	21
Senator	52	Howden	22
Super Select	54	Spirit	23
Dark Green Zucchini	56	Wizard	24
Embassy Dark Green Zucc.	57	Ghost Rider	26
———————		Big Autumn	27
———————		Autumn Gold	29
———————		Jack of All Trades	30
———————		Rocket	31
———————		Frosty	35

Note: Higher numbers are varieties preferred. Rank 1-14 not preferred, greater than 45 highly preferred

Other Summer Squash	
Scallop	3
Cocozelle	48
Caserta	58

Cucumber Beetles: Organic and Biorational Integrated Pest Management

ATTRA

https://attra.ncat.org/attra-pub/viewhtml.php?id=133

Some varieties of a cucurbit species are more attractive to cucumber beetles than others. For example, cucumber beetles preferentially feed on muskmelon varieties in the following order, from greatest to least (Foster et al., 1995):

1. Makdimon	6. Galia
2. Rocky Sweet	7. Pulsar
3. Cordele	8. Passport
4. Legend	9. Super Star
5. Caravelle	10. Rising Star

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Cucumber beetle – management

Cultural

- Eliminate weeds, weedy edges (non-crop sanitation)
- Crop rotation
- Early season row cover

- Row cover is only effective until plants begin to bloom, then pollinator access is needed

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Cucumber beetle – organic insecticides

- **Note: these will harm pollinators if they are present during application even though organic**
- kaolin clay (Surround WP) PyGanic
- broadcast foliar applications:
  - pyrethrum (Pyganic 1.4 and 5.0 EC) azera
  - pyrethrum + azadirachtin VENERATE
  - heat-killed Burkholderia (Venerate XC)
- Foliar sprays (thresholds) – "caution with pollinators"!!

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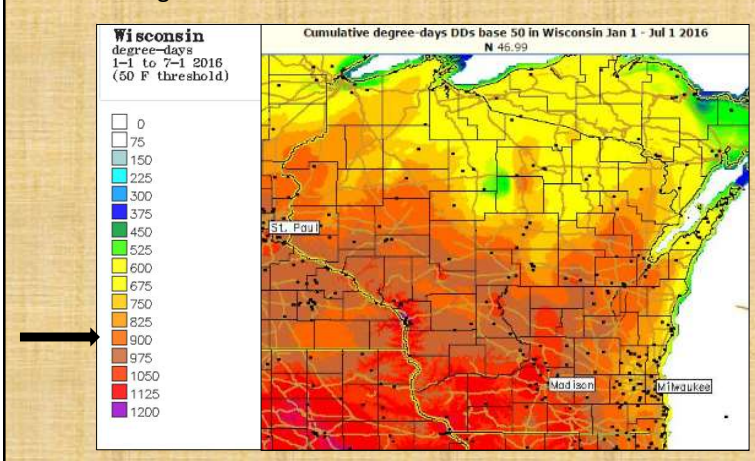
Squash vine borer, *Melittia cucurbitae*

Occurrence

- Daylight and dusk -flying clearwing moth
- Adults have rusty orange abdomens
- Wingspan ~ 1-1.5 inches
- Females can lay 150-200 eggs
- Larvae ¾ - 1 inch in length
- Appear around 900 growing degree days (base 50°F)
- One generation per year

US Degree Day Mapping Calculator http://uspest.org/cgi-bin/usmapmaker.pl

Squash vine borer
Base temperature = 50°F, Biofix – January 1
1st generation adult emergence DD_{50}
900 for 1st generation moths



Squash Vine Borer: phenological relationships with plants

Note: directed application to the first 12-16” of vine;
‘post-chicory bloom’

Manfred Heyde, OregonLive.com

Squash vine borer - management

Damage

- Single eggs laid at plant base
- Frass and entry hole very apparent
- Advanced damage may look like bacterial wilt

Squash vine borer - management

Pheromone trap

Monitoring

- Scout crop around 950 DD_{50} threshold
- Water pans for adults in crop
- Pheromone lures available through Great Lakes IPM

Control

- Rarely an issue in commercial production. Serious garden pest
- Insecticides often difficult to time & apply properly
- Pyrethrins & pyrethroids
- Bt

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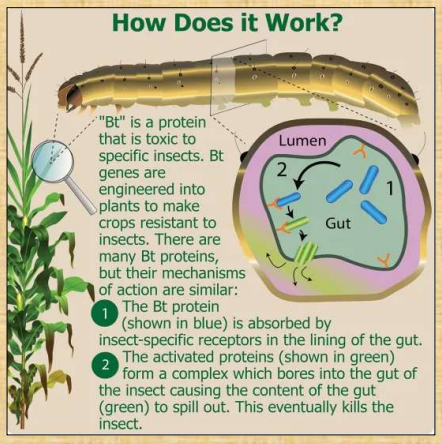
Btk (*Bacillus thuringiensis* subsp. *kurstaki*)



- *Bacillus thuringiensis* subsp. *kurstaki*
- Bt is a naturally occurring soil bacterium
- Need to use the correct strain for the pest (i.e. a strain for lepidopterans, mosquitoes, beetles, etc.
- It is used on vegetable crops as an organic insecticide and is OMRI-approved
- Applied to foliage, but must be applied when larvae are small or it is ineffective
- Is being bred into some crops to cut down on pesticide use

https://commons.wikimedia.org/wiki/User:Robert_Wetzlmayr

COLE CROP PESTS

Cole Crops – Key Pests

Diamond back moth

Imported cabbage worm

Cabbage looper

Managing Key Pests on Cole Crops

**Excellent example of potential for biological control (NCR Regional pub. 471, $8)
(https://learningstore.uwex.edu/Biological-Control-of-Insect-Pests-of-Cabbage-and-Other-Crucifers-P569.aspx)

History of problem

- Direct damage to crop by key pests
  - Worms on cabbage, broccoli, cauliflower heads
- Multiple insecticide applications used
- Resistance developed as threat to production

Solution

- IPM implementation based on biological control of key pests
- Pesticides switched to specific, 'soft' materials to preserve natural control

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Pest Specific Insecticides for Key Pests @ Threshold

- Control caterpillar pests at thresholds when needed
- Conserve beneficial organisms
- *Bacillus thuringiensis* subsp. *kurstaki* or spinosad

Crop	Growth stage	Threshold (% infestation)
Cabbage	Seed bed	10%
	Transplant-cupping	30%
	Cupping-early head	20%
	Mature head	10%
Broccoli/cauliflower	Seed bed	10%
	Transplant-first curd	50%
	Curd present	10%

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Spinosad

- Spinosad is a naturally occurring byproduct made by a soil bacterium that is toxic to insects.
- After ingesting Spinosad, insect pests die within 1 to 2 days.
- Does not persist in the environment.
- Classified as an organic substance by the USDA National Organic Program (NOP) and OMRI listed for use in organic production.
- Found in over 80 registered pesticide products. Used on crops, ornamentals, used in and around buildings, in aquatic settings, and as seed treatments. Also found in some drugs regulated by FDA for head lice on people and fleas on dogs and cats.
- Spinosad affects the nervous system of insects that eat or touch it.

Example product containing spinosad

Pest Specific Insecticides – Key Pests

Reduced-Risk Products

Bacillus thuringiensis (*kurstaki*; Btk, or *azaiwi*; Bta)

- many registered (e.g. Dipel, Xentari, Biobit, Cutlass, etc.)

spinosad (SpinTor 2SC & Entrust 2SC)

azadirachtin (Aza-Direct, AzaGuard, Azatin)

Chromobacterium subtsugae strain PRAA4-1^{T} (Grandevo)

Burkholderia spp, strain A396 (Venerate XC)

**Note: Avoid Broad Spectrum Insecticides!!

pyrethrum

- - Multiple applications
- - Resistance can be a problem
- - Eliminate biological controls

Pest Specific Insecticides – Key Pests

- Bio Control Organisms (parasites) for cole crop pests
  - Specific organisms for specific pests
- Cultural
  - Use clean transplants
- Biological Control Organisms
  - Good complex of parasites
    - Diamondback moth: (70-90%)
    - Imported Cabbage worm: (30-60%)
    - Cabbage looper: (10-30%)

Diadegma insulare

Cotesia glomerata

Pteromalus puparium

Trichogramma

Copidosoma floridanum

Cole Crops – Sporadic Pests

Cabbage maggot

Flea beetle

Onion thrips

Cabbage Maggot Lifecycle

Adult
- Small grey/black fly
- Similar to housefly

Eggs
- Small, white
- Laid in soil at base of plants

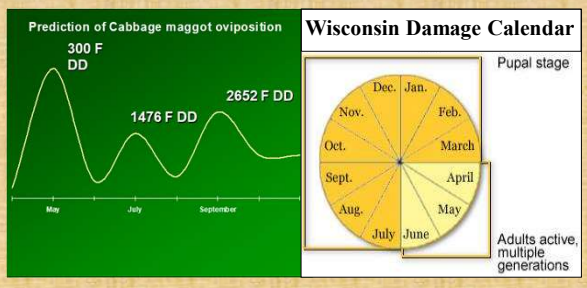
Larvae
- White, legless maggots
- 4 instars; up to 1/4”
- 3-4 weeks per generation
- 3 generations per year

Pupa
- Brown, oval shaped
- In or close to the roots

Cabbage maggot: prevalence and damage

Life Cycle

- Overwinter in soil as pupa
- Adults emerge in spring
- 4-5 generations/year. 2nd adult peak in May is usually most serious and occurs at 300 heat units or when lilacs bloom



Damage

- Tunnel into transplants
- Severely stunt plants, plants wilt.
- Cool weather, delays plant emergence increases severity

Cabbage maggot host range

- Moderate host range
- Can develop on organic matter
- Prevalent where brassicas reoccur, use crop rotation to help to control, keep brassica weeds out

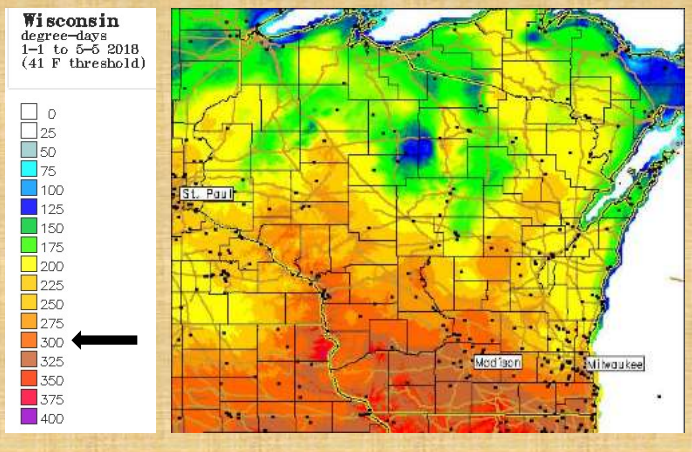
Crop Susceptibility

High	Moderate	Low
Brassica roots (cabbage, broccoli, cauliflower)	Peas (soy, kidney)	Corn
Brassica weeds	Brassica roots (radish, turnip)	

US Degree Day Mapping Calculator

http://uspest.org/cgi-bin/usmapmaker.pl

Cabbage maggot
Base temperature = 41°F
Biofix – January 1
1st generation adult emergence DD_{50}
300 for 1st generation moths



Cabbage Maggot Management

Cultural

- Rotate crop away from overwintering site (1/4-1/2 mile) may not be achievable in a garden setting
- Prevent egg laying with barrier, row cover
- Predict egg laying with heat units (300 DD_{43} ˚F base)
- Plant early or late to avoid eggs = fly free periods 'avoidance' using degree days to track development

Biological

- Some egg predation by beetles

Flea beetles

Crucifer flea beetle – *Phyllotreta cruciferae*
Potato flea beetle – *Epitrix cucumeris*
Corn flea beetle - *Chaetocnema ectypa*
Eggplant flea beetle – *E. fuscula*

- Flea beetles are small shiny and black and can cause serious damage to seedlings.
- They usually feed on the undersides of leaves leaving numerous small round or irregularly shaped holes.
- Because the beetle is small and active, it usually does not feed much in one spot.
- It is especially active during hot and sunny days.

Flea Beetle Management

- Cultural
  - Attract adults to alternate trap crop (Indian mustard, Chinese giant mustard, glossy-leaf collards) – perimeter trap crops
  - Delay planting to allow trap crops to emerge first
  - Crop rotation, avoid Brassicas in similar sites year to year
  - Sanitation of Brassica weeds
  - Row cover to protect from colonization
- Biological
  - Few effective controls
- Chemical
  - Repeat applications of pyrethrum, spinosad necessary (recolonization)
  - DO NOT disrupt biological controls for caterpillar pests

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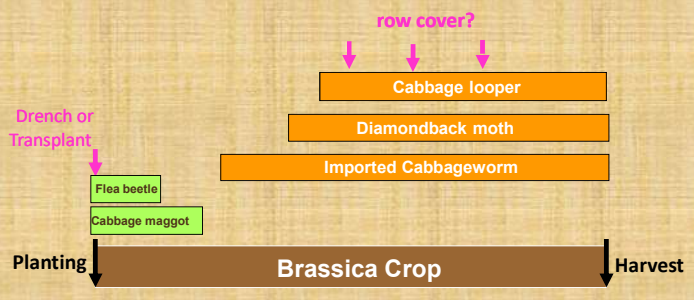
Cabbage Pest Management
Early and Mid-Season larval pests

- Need to protect crop early from flea beetle and maggot (14-21 days)
- Manage mid-season caterpillar pests based upon thresholds
  - Scout and pick,



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Rainer Haessner, Wiki Commons

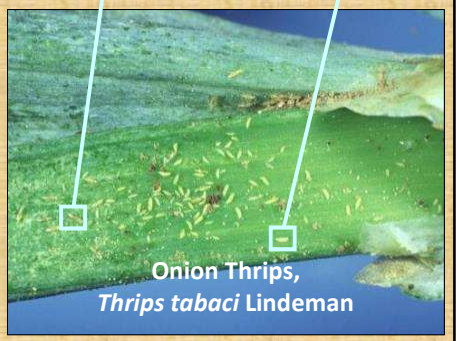
ONION PESTS

Onions and onion thrips – "anticipating a problem"

Damage from onion thrips

Adult

Larva



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Major Thrips Pests of Onion, *Allium cepa* in North America

Onion thrips
(*Thrips tabaci* Lindeman)

Western flower thrips
(*Frankliniella occidentalis* [Pergande])

Tobacco thrips
(*Frankliniella fusca* [Hinds])

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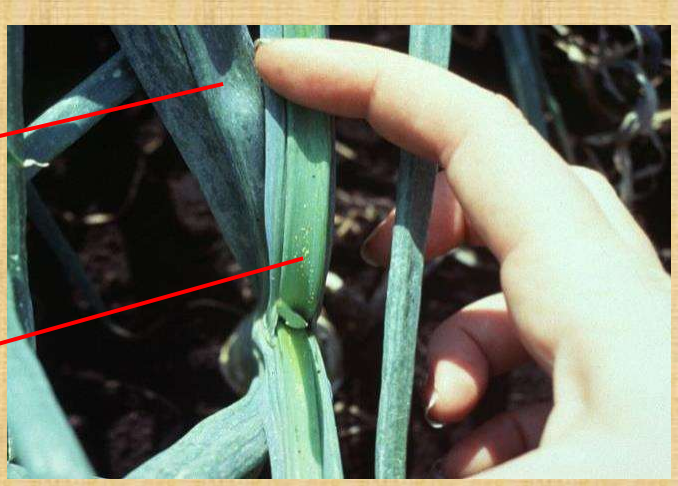
Onion Thrips, *Thrips tabaci* Lindeman

Adult

Larva



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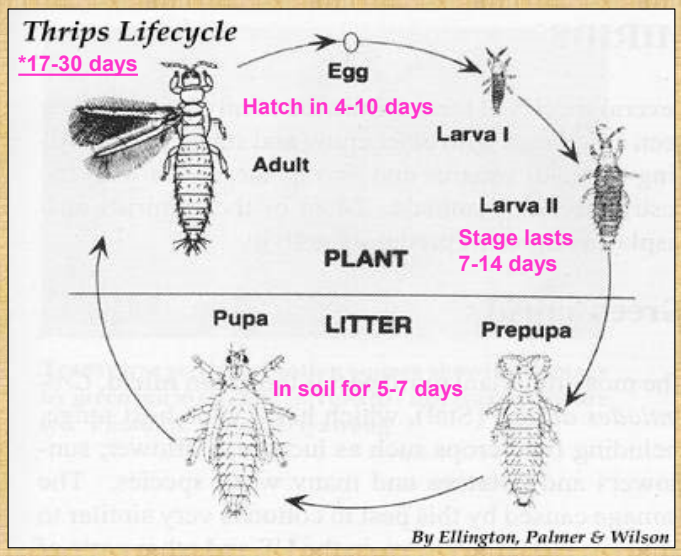
Onion Thrips Life Cycle (68°F)*

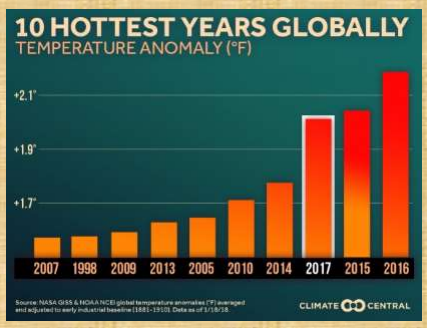


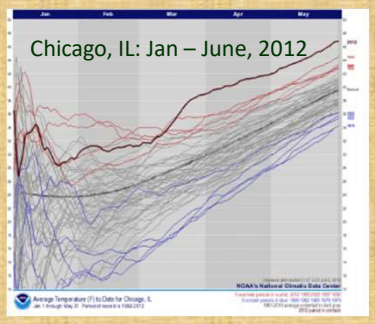
Onion thrips survival, fecundity, and generation time(s) at varying temperatures

	Days		
Factor	68^0 F	77^0 F	86^0 F
Survival	47	25	13
Eggs laid/ female	210	165	63
Generation time	48	30	17

Murai (2001)

Global and US Temps Warmest on Record: Thrips





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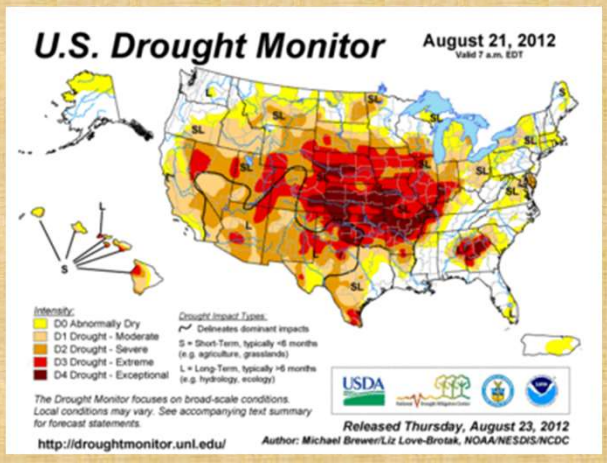
…And 2012 Was a Very Dry Year



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Biological attributes that make onion thrips a pest

- Short developmental time
- Parthenogenic (do not need to find a mate)
- Highly mobile
- Wide host range
- Overwinter adjacent to onion
- Capability of developing resistance to insecticides

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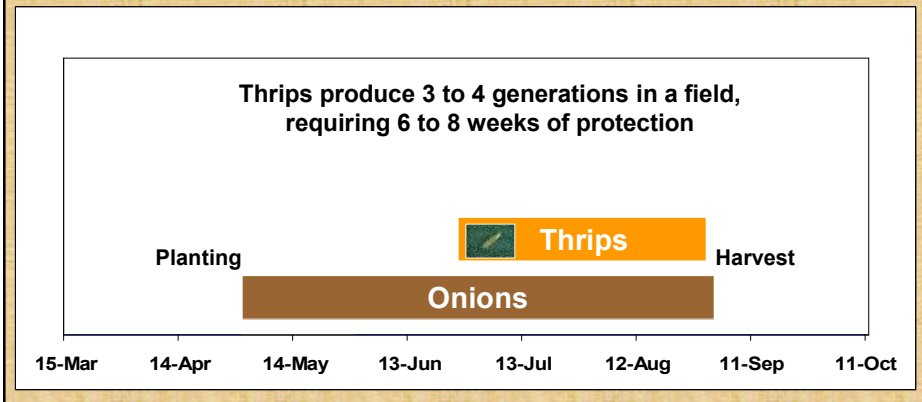
Example of Onion Thrips Occurrence in a Single Onion Field – 'temp based'

Example from Wisconsin



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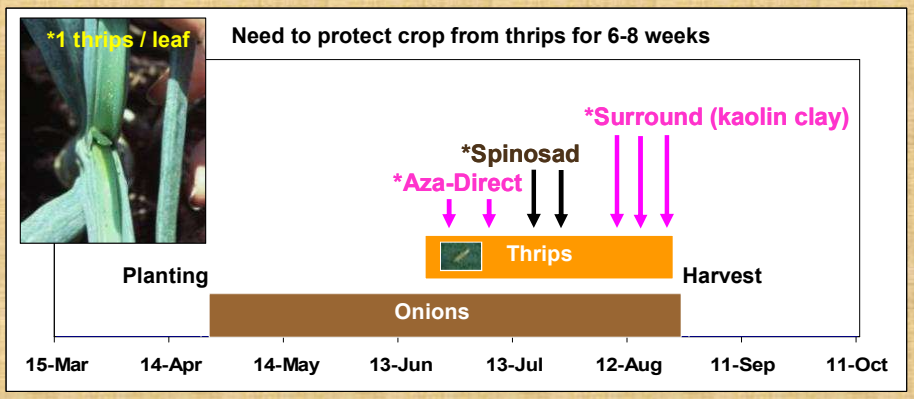
Combining Insecticide Sequences and Action Thresholds



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Onion thrips: Management

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Cultural

Crop rotation

Overhead irrigation

Sanitation (culls & field borders)Reflective mulch

Biological

Predacious thrips

Minute pirate bugs

Chemical

Foliar sprays (Surround, Entrust, Aza-Direct, PFR-97, Venerate)

Commercial seed treatments (Regard SC)

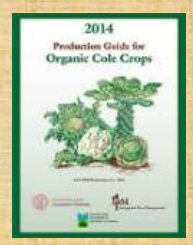
Insecticide Control Options

- Rotate insecticides (classes if possible)
  - e.g., azadirachtin, spinosad, kaolin, etc.
- Two successive applications of one product to control a generation
- Time applications based on most appropriate threshold (1-3 immature thrips / leaf)
- Avoid tank mixing insecticides

Vegetable IPM Resources

- Cornell University, Organic Guide for Vegetables

  http://nysipm.cornell.edu/organic_guide/veg_org_guide.asp



- Organic Materials Review Institute Web-page

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

- UWEX Learning Store

  http://learningstore.uwex.edu/

Vegetable IPM Resources

- Vegetable Insect Mgmt Web-page

http://labs.russell.wisc.edu/vegento/

- Vegetable Disease Mgmt Web-page

http://www.plantpath.wisc.edu/wivegdis

http://www.plantpath.wisc.edu/wivegdis/contents_pages/veg_crop_updates.html

- NCAT ATTRA

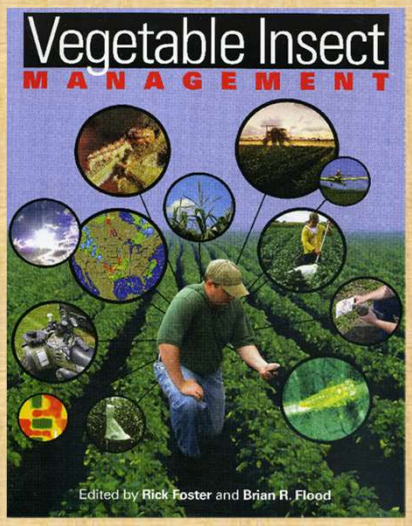
ATTRA
NATIONAL SUSTAINABLE AGRICULTURE INFORMATION SERVICE

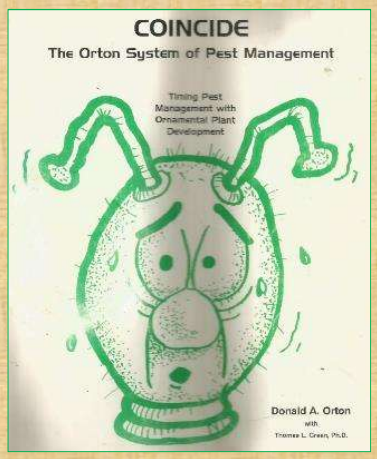
https://attra.ncat.org/publication.html

- Wisconsin Pest Bulletin

http://datcpservices.wisconsin.gov/pb/index.jsp

IPM Books





https://www.amazon.com/Coincide-Orton-system-pest-management/dp/B00071TVU2

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