Integrated Pest Management in Brassicas

NOFA MA Summer Conference
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Susan B. Scheufele
UMass Extension
Vegetable Program
Presentation Overview

• Insect Pests
  – Flea Beetle
  – Caterpillars
  – Root Maggot

• Diseases
  – Alternaria Leaf Spot
  – Black Rot
  – Downy Mildew

• Conclusions
Flea Beetle: Damage

**Shothole Feeding**
- Non-waxy leaves
- Feeding on entire surface
- Common on *Brassica juncea* and *B. rapa* types (e.g. bok choy, arugula, mustards, Chinese cabbage etc.)

**Marginal Feeding**
- Occurs on waxy leaves
- Mainly on *Brassica oleracea* crops (e.g. cabbage, broccoli, kale etc.)
- These crops become more waxy when older
Flea Beetle: Life Cycle

- **Above ground, on foliage**
  - Overwinter as adult
  - Become active in early-May
  - Eggs, larvae, pupae in soil
  - New adults emerge late-July to August
  - 3rd peak possible in fall, September
  - Feeding intensity drops off in September, unless 3rd peak

- **Underground, near plant roots**
  - Eggs, larva, pupae in soil
  - New adults emerge late-July to August
  - 3rd peak possible in fall, September
  - Feeding intensity drops off in September, unless 3rd peak

Image by Caryn Andersen
**Spring Emergence**

- Become active in May through late-June to early-July
- Feed on Brassica weeds
- Rapidly find new crops
- Can destroy seedlings
Flea Beetle: Management

Crop Rotation:
Rotate spring crop as far as possible from last fall’s crop

Fall Brassicas Year 1
Overwintering site for beetles
WOODS, ROADS, HOUSES, FIELDS

Spring Brassicas Year 2
Flea Beetle: Management

- Overwintered adults
  - Hungry!!
- Early Brassicas in field 1
  - Hungry!!
- Late Brassicas in field 2
- 1st Generation Summer adults
  - Very hungry!!
Flea Beetle: Management

Control Brassica Weeds

Shepherd’s Purse, Yellow rocket, Wild mustard, etc.

- Four-petaled flower (white or yellow)
- Narrow seed pod—small, round seeds
- Rosette at base, vegetative
- Tall upright stem, reproductive
- Annual or biennial
Flea Beetle: Management

Use Row Covers to Exclude Beetles

• Bed prep: stale seedbed or cultivate just before seeding/planting
• Seal edges immediately after seeding/planting
• Seal ends as well as edges
• Remove for weeding as needed, and re-cover on the same day.
• In all trials, row cover gives the best control!
Flea Beetle: Management

Trap Cropping

- Keep it simple
- *B. rapa, B. juncea/mix*
  - Komatsuna, mustard
  - cheap seed
- Borders *OR* In-field strips (e.g. 1 row in a field)
- Main crop: less preferred – *B. oleracea, B. napa.*
- Scout weekly
- Spray the trap crop only -- ‘Concentrate & kill’
## Flea Beetle: Management

<table>
<thead>
<tr>
<th>Most preferred</th>
<th>Least preferred</th>
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<tbody>
<tr>
<td><em>Brassica rapa</em></td>
<td><em>B. oleracea</em></td>
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<tr>
<td><strong>Bok choy</strong>, Komatsuna, Chinese Cabbage, Tatsoi</td>
<td><strong>Cabbage</strong>, Broccoli, Kale, Collards</td>
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<tr>
<td><em>Eruca vesicaria</em></td>
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<tr>
<td>Arugula</td>
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<tr>
<td><em>Raphanus sativus</em></td>
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<td>Radish, Daikon</td>
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<tr>
<td><em>B. juncea</em></td>
<td></td>
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<tr>
<td>Mustard</td>
<td></td>
</tr>
</tbody>
</table>

*Based on 2004 experiment, UMass Research Farm and other sources*
Full Bloom Farm trap crop study, 2013

- 2012 brassicas
- Kale & Collards 1
- Kale & Collards 2
- Bok Choy 1, 2, 3
- Border Trap Crop
- Border

[Map showing the farm layout with labeled crops and border trap crops]
Full Bloom Farm trap crop study, 2013

- **Trap crops:**
  - Brassica rapa, B. juncea border mix DS
  - ‘Sink’ crop (bok choy, napa) (2-4 A)

- **Main crop:**
  - kale, collard, lacinato, red Russian (8 A)

- **Thresholds:**
  - 1 to 2/plant, OR 10-25% damage

- **Product strategy:**
  - Pyganic for knockdown (rain coming)
  - Entrust for residual
  - mix if pressure is high
  - Use NuFilm adjuvant

+ successions of bok choy

<table>
<thead>
<tr>
<th>bok choy</th>
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<tbody>
<tr>
<td>kale</td>
</tr>
<tr>
<td>lacinato</td>
</tr>
<tr>
<td>red russian</td>
</tr>
<tr>
<td>border mix</td>
</tr>
<tr>
<td>kale</td>
</tr>
<tr>
<td>lacinato</td>
</tr>
<tr>
<td>red russian</td>
</tr>
<tr>
<td>border mix</td>
</tr>
<tr>
<td>road</td>
</tr>
</tbody>
</table>

| last year's brassicas |
Full Bloom Farm trap crop study, 2013

2012 brassicas

Kale & Collards 1
Kale & Collards 2
Bok Choy 1, 2, 3

Border Trap Crop

Results (FB sprays): (June 1 to Aug 1)
3 sprays on border (early)
2 sprays on kales (1 garlic, 1 mix P&E)
10 sprays on bok choy (weekly)
Save 8*8 acres = 64 acres spray
Late-planted field of mixed Brassica crops
Red Fire Farm, Granby, MA

Rotated 1/3 mile from early Brassica field
Single row of Komatsuna around main crop of mixed *B. oleracea*
One block of Chinese Cabbage (*B. napa*) in center
Average Number of Feeding Holes
Red Fire Farm (field 2) 2006

Number of Feeding Holes

Date

17-Jul
24-Jul
27-Jul
31-Jul
9-Aug

border & napa, 7/18
border & napa, 7/26
w hole field 8/2 (for thrips)

Border
Main Crop
Napa

Border
Main Crop
Napa

0
10
20
30
40
50
60
Flea Beetle: Management

**Push/Pull System**

- Plant trap crop border or in-field strips
- Use a repellent like kaolin clay (Surround) on main crop
- Use insecticide to kill beetles on “pull” crop
- Reduce overall pesticide used, time spraying etc.
Organic (OMRI listed) insecticides for flea beetle

- **kaolin (Surround WP\textsuperscript{OG})**: use on transplants, seedlings and young plants.
- **pyrethrin (PyGanic EC5.0\textsuperscript{OG})**: quick knockdown only
- **spinosad (Entrust\textsuperscript{OG})**: some residual, most effective
- **azadiractin (Neemix 4.5)**: efficacy rated fair to poor
UMass flea beetle insecticide trials, 2003-2004
Caryn Andersen et al

Weekly sprays on Komatsuna greens (*Brassica rapa*)

Results:

• Spinosad had significantly less feeding damage than control
• Pyganic was no different from unsprayed control
• Row cover was the most effective treatment
Flea beetle on Cabbage  
Abby Seaman, Cornell, 2011

- Crop: Cabbage “Farao F1”
- Planting date: 5/23
- Application dates: 5/31, 6/7, 6/14 (started as soon as flea beetles arrived)
- Evaluation date: 6/20

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rate</th>
<th>Mean Damage Rating*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entrust</td>
<td>2.5 oz/A</td>
<td>1.7 A</td>
</tr>
<tr>
<td>Pyganic 5.0</td>
<td>9 oz/A</td>
<td>2.7 B</td>
</tr>
<tr>
<td>Neemix 4.5</td>
<td>10 oz/A</td>
<td>2.5 B</td>
</tr>
<tr>
<td>Neemix + Pyganic</td>
<td>10 oz + 9 oz/A</td>
<td>2.7 B</td>
</tr>
<tr>
<td>Untreated control</td>
<td>--</td>
<td>2.5 B</td>
</tr>
</tbody>
</table>

*Rating 1-5 with 1 = no damage and 5 = plant almost dead
Flea Beetle: Management

**Scouting**

- Start in early May
- Look at most attractive crops first
- Field edges
- Count individuals and assess damage
- Consider crop stage, leafy vs heading, etc.
- Consider market tolerance
- Manage populations before they get out of control. Prevent buildup over seasons.
- Suggested thresholds: ~ 1 beetle/plant or 10-25% damage + adults present for greens
Sue Scheufele MS Mulch Study 2012

Randomized complete blocks design with four replications of 25’ x 5’

- Bare Ground Control
- Black Plastic Mulch
- Biodegradable Plastic Mulch (BioTelo)
- Wheat Straw Mulch (~2 tons/A)

Irrigated with trickle-line

Cover cropped field to keep down weeds and with-in field spore dispersal

- Disease Incidence
- Plant Height
- Total & Marketable Yields
Mulch Study: Results & Conclusions

- Mulching did have an effect on disease incidence
- Straw mulch significantly reduced disease incidence

![Graph showing disease incidence with control, plastic, BioTelo, and straw mulch categories.](image-url)
Mulch Study: Results & Conclusions

- All three mulches significantly increased plant height
- Plants grown under straw mulch grew the tallest
Mulch Study: Results & Conclusions

- None of the mulches significantly affected plant yield.

\( p = 0.1685 \)
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Caterpillars: Review

Imported Cabbageworm (ICW)

Cross Striped Cabbageworm (CSCW)

Cabbage Looper (CL)

Diamondback Moth (DBM)
Caterpillars in Brassicas

- Slow, fuzzy
- Wriggly when touched
- Pointy ends and forked butt
- Moves by inching or “looping”
- Eggs laid in clusters—feeding frenzy!!

- Overwinters in field edge
- Active earliest, early spring-fall (4-5 generations/season)
- Migratory
- Timing varies each year, overlapping generations
- Migratory – arrive later-mid-July to August
- Overwinter in soil
- Adults emerge in late-spring
- Damage concentrated in head
- Damage spread across leaves
- Cause large ragged holes across leaves
- Damage is severe, skeletonize plants
Caterpillars: Management

Scout weekly starting in June

- Critical times: mid-July (ICW build up, looper arrives) or crop starting to head up
- Early feeding damage is easy to spot if you look under the leaves!
- Look underneath the leaves to find caterpillars when they are small
- Frass also helpful in finding small larvae

Check 25 plants across the field

Note # plants with 1 or more = infested

Use threshold for spray decisions

- Leafy greens:
  - 15% infested (one or more/plant)
- Heading crops:
  - 35% before heading,
  - 15% after heading
Caterpillars: Management

**Organic Insecticides**

- *Bacillus thuringiensis* toxin (e.g. Dipel, Xentari)
- Entrust (good on FB also)
- Pyganic (contact only—not recommended)
- Neem (use on small larvae)

**Good coverage is important!!!!**

Use a spreader/sticker
- e.g. NuFilm P
ICW is parasitized by a wasp, *Cotesia rubecula*, introduced in 1990 and now well established. You may see their small white cocoons on brassica leaves.

DBM eggs are parasitized by the ichneumonid wasp, *Diadegma insulare*, which occurs naturally in Eastern North America. *D. insulare* females require sources of nectar to be effective DBM parasitoids, so maintain wildflower stands near brassica fields.
The chalcid wasp, *Trichogramma brassicae*, will lay its eggs in many species of caterpillar, including all of the brassica pests (as well as non-target caterpillars).

Purchased wasps arrive as pre-parasitized caterpillar eggs glued to cards that can be distributed throughout the crop. Each card costs around $16-$20, and contains about 100,000 wasps, which is enough for up to one acre.

*T. brassicae* are more effective against moth species that lay their eggs in clusters, so those species may be good options if cross-striped cabbage worm has been a particular problem.
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Cabbage Root Maggot: Damage

Symptoms include stunting, wilting, and discoloration of plants. These two pictures were taken the same day (left=untreated, right=verimark treated).
Symptoms include stunting, wilting, and discoloration of plants. These two pictures were taken the same day (left=untreated, right=verimark treated).
Cabbage Root Maggot: Damage

- Stunting
- Wilting
- Plant death
- Reduced Stands

Untreated plot (# 1 - left) Verimark treated plot (# 3 - right).
Cabbage Root Maggot: Damage

- Loss of secondary roots
- Elongation/callose of stem at hypocotyl
- Wounds allow entry of pathogens
Cabbage Root Maggot: Damage

- Root crops are also affected
- Larvae feed on root surface, causing tunnels and holes
- Secondary soft rot pathogens
- Unmarketable crop
- Worse in fall where CRM has built up over the season and turnips, radishes, and rutabagas are sizing up

http://ipm.illinois.edu/ifvn/contents.php?id=49
Cabbage Root Maggot: Life Cycle

**Adult CRM Fly**
Emerges in **early to mid-May** from pupa that survive in soil and leaf litter over the winter

**Eggs**
Are quite small but visible with the naked eye. Can be found **on plant stem** at or just below **soil line**

**Larvae**
Emerge from eggs in **late-May to early-June** and begin to feed on root and hypocotyl
Cabbage Root Maggot: Life Cycle

**Spring Emergence**

- Determined by time, weather
- Usually in early May

- **Monitoring**
  - Yellow sticky cards
  - Using biofixes (e.g. flowering of yellow rocket)

- **Predicting**
  - Pest models based on GDD
Cabbage Root Maggot: Management

Monitoring

- **Growing degree days (GDD):** Number of degrees above a base temperature per day, summed over time
  - Used to measure phenology traits of plants and insects
  - Base temperature is important
  - CRM models use a base of 40°F, colder than other insects
  - Peak flight of emerging adults occurs at ~450 GDD at base 40°F
Cabbage Root Maggot: Management

**Cultural Practices**

- **Crop rotation**: Overwinter right in field, rotate spring crop far from where fall crop was if CRM was present

- **Timing of Transplanting**: Avoid pest by delaying planting, OR put out larger transplants! They can take more damage

- **Row covers**: Exclude pest altogether, make sure you do not have any overwintering population though or you will just trap them in

- **Hilling and cultivation**: Throws soil up on stem, secondary roots may form above damage
Cabbage Root Maggot: Management

**Organic Insecticides**

- None labeled
- Entrust has shown some efficacy but is not labeled for this use
- We are pursuing a 2ee label for Entrust: fill out our survey!!
- UMass Extension is investigating other OMRI-approved products
<table>
<thead>
<tr>
<th>Treatment</th>
<th>Active Ingredient</th>
<th>Rate</th>
<th>Application Method</th>
</tr>
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<tbody>
<tr>
<td><strong>Cabbage (Farao) treatments</strong></td>
<td></td>
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<tr>
<td>Untreated</td>
<td>De-Ionized Water</td>
<td>na</td>
<td>Banded over row after transplant</td>
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<td>Lorsban</td>
<td>Chlorpyrifos</td>
<td>2.4 floz/A</td>
<td>Banded over row after transplant</td>
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<td>Verimark</td>
<td>Cyantraniliprole</td>
<td>13 fl oz/A</td>
<td>Tray drench in GH</td>
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<td>Coragen</td>
<td>Chlorantraniliprole</td>
<td>5 fl oz/A</td>
<td>Tray drench in GH</td>
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<td>Entrust SC-A</td>
<td><strong>Spinosad</strong></td>
<td>10 fl oz/A</td>
<td>Tray drench pre-plant; Banded at planting; Banded 14 days later</td>
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<td>Entrust SC-B</td>
<td><strong>Spinsoad</strong></td>
<td>10 fl oz/A</td>
<td>Banded at planting; Banded 14 days later</td>
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<td>Burkholderia spp. strain A396</td>
<td>1% solution</td>
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<td>9</td>
<td>Venerate XC</td>
<td>Burkholderia spp. strain A397</td>
<td>1% solution</td>
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</table>
UMass CRM Research: Methods

• Farao Cabbage
  – Early, small, fresh-eating variety

• Soil amended with 100-50-50 lbs N-P-K and 20 tons/acre manure-based compost

• Transplanted on May 2^{nd}: Two rows 18” apart, 12” in-row spacing

• RCBD with four replications of each treatment

• Adult CRM flies first observed May 5^{th}, 3 days after transplant
UMass CRM Research: Tray Drench

- One day before transplant
- 1.5-2 liters water
- Calculated material/plant
- Soaked 4 hours
UMass CRM Research: Soil Drench

- 200 gallons per acre
- Directed spray at soil/base of plant
- 4 – 6” band
- Applied one day after transplanting
UMass CRM Research: Sampling

Started Measurements at First Sign of Eggs (May 19th); Repeated Weekly

Plot Vigor (0-100%): Measured overall vigor and stand counts of each replicate plot.

Plant Vigor (0-100%): Measured vigor of ten randomly selected plants per plot.

**Destructive Sampling of 10 Plants per Plot**
- Measured root damage on scale of 1-5
- Counted # of larvae present
UMass CRM Research: Vigor Rating (0-100%)

Assessment Incorporated:

- Plant Stand (ie. # plants killed by CRM)
- Plant size/stunting
- Plant color
- Wilting
- Flea beetle damage
- Discoloration
UMass CRM Research: Damage Scale

1 = no damage/strong root development/lots of secondary roots
2 = Slight to very little root damage/still good secondary roots
3 = Moderate to severe root damage/not a lot of secondary roots
4 = Highly damaged/no secondary roots
5 = Dead
UMass CRM Research: Plot Vigor 2014

Vigor (%)

- Untreated
- Lorsban
- Verimark
- Coragen
- Entrust SC - A
- Entrust SC - B

p = 0.0004  p < 0.0001

5/19  5/27  6/2

50  60  70  80  90  100
UMass CRM Research: Root Damage 2014

Mean Damage on Scale 1-4

- Untreated
- Lorsban
- Verimark
- Coragen
- Entrust - A
- Entrust - B

p < 0.0001
UMass CRM Research: Cabbage Yield 2014
UMass CRM Research: Head Size 2014

Mean Head Diameter (inches)

- Untreated
- Lorsban
- Verimark
- Coragen
- Entrust SC - A
- Entrust SC - B

p < 0.0001
Cabbage Vigor (%) and Root Damage (0-4) at Final Timepoint

- **Untreated**
- **Lorsban**
- **Verimark**
- **Entrust-A**
- **Entrust-B**
- **Azatin O-A**
- **Azatin O-B**
- **Venerate-A**
- **Venerate-B**

Legend:
- **Vigor**
- **Root Damage**

Data points are marked with letters indicating significant differences.
UMass CRM Research: Head Size 201

Cabbage Harvest 2015

Average Head Diameter (in)

Average Head Weight (lbs)

- Untreated
- Lorsban
- Verimark
- Entrust SC-A
- Entrust SC-B
- Azatin O-A
- Azatin O-B
- Venerate XC-A
- Venerate XC-B

- Weight (lbs)
- Head Diameter (in)

Legend: different letters indicate significant differences at p < 0.05.
**Entrust** – A worked as well as Lorsban when transplants were drenched before planting

- We will continue to study Entrust and work with Dow to get a 2ee label for MA

**Not currently labeled in New England**

None of the other OMRI-approved materials tested showed any efficacy
Cabbage Root Maggot: Summary

- **Crop rotation**: Overwinter right in field, rotate spring crop far from where fall crop was if CRM was present.

- **Timing of Transplanting**: delay planting, OR put out larger transplants!

- **Row covers**: Exclude pest altogether, trap them inside covers!

- **Monitoring**: Use the NEWA model to know when emergence and peak flight will occur. Use sticky cards in field.

- **Insecticides**: Fill out our Entrust Label Expansion Survey!!!
Insect Questions?
Presentation Overview

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• Diseases
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  – Downy Mildew

• Conclusions
Alternaria Leaf Spot: Symptoms

- Small black dots enlarge to form target-like dark brown spots with “shot-hole” centers.
- Leaf chlorosis and necrosis
Alternaria Leaf Spot: Symptoms

- All plant parts – stems, foliage, seeds, florets, heads
- All *Brassica* crops are affected
- Symptoms and impact on marketability may differ
Alternaria Leaf Spot: Symptoms

- Spreads in storage
Alternaria Leaf Spot: Disease Cycle

- Primary Inoculum: infected seed or transplants, crop debris in soil (survives 2-3 years), or from nearby fields by wind
- Occurs regularly each year
- Thrives at 59-77°F but survives and grows at very wide temperature range
- Common in fall
Alternaria leaf spot: Disease Cycle

- Spores produced continually throughout season
- Spore production requires 12+ hours of 90% RH
- Spread by wind, rain, splash and by flea beetles

Spores of *Alternaria brassicicola*
S. Seemadua http://www.padil.gov.au/thai-bio/Pest/Main/140396/30061
Alternaria leaf spot: Management

Use Cultural Practices!!

- Use clean seed-hot water treatment
- 3 year crop rotations – Fall/Spring
- Residue management -- stalks last 2+ years
- WIDER SPACING!!
- Control *Brassica* weed hosts
- Control Flea beetles!!

Sporulating lesions on overwintered Brussels sprouts

Dillard et al, 1998
Alternaria leaf spot: Management

**Organic Fungicides**
- None have shown efficacy
- Studies ongoing at UMass
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Black Rot: Symptoms

- Characteristic V-shaped lesions form on leaf margins
- Caused by bacterium *Xanthomonas campestris*
- Bacteria enter plant through leaf hydathodes in guttation droplets
- Veins within lesions turn black, as vessels are clogged with Xantham gum
Black Rot: Disease Cycle

- **Primary Inoculum**: infected seed/seedlings or infected crop residue in soil (2-3 years)

- **Systemic infections** at the seedling stage cause lower leaves to yellow and drop and the plant eventually will collapse

- **Thrives at 75-95°F** and will not be spread or infect below 50°F or during dry weather.

- Also spread by workers/equipment and by insects like flea beetles.

- Bacterial cells are spread by water e.g. from rainsplash, surface runoff, aerosols in humid air.
Start with Clean Seed
• Bacteria are often seed-borne
• Major source of primary inoculum
• Greenhouse environment very conducive for bacterial growth and spread

Residue Management
• Prevent overwintering in field
Black Rot: Management

Reduce Humidity/Water
- No overhead irrigation
- Improve soil drainage
- Increase plant spacing
- Remove weeds from within row

Sanitation
- Bleach/Greenshield tools and equipment
- Rogue out infected plants
- Don’t work in wet fields
- Work in unaffected fields first to prevent spread
- Separate successions or locate younger plantings and direct-seeded fields upwind from older plantings

Control flea beetles!!

Control weed hosts
- E.g. mustards, Virginia pepperweed, shepher’d purse, wild radish

Dillard et al, 1998
Black Rot: Management

**Organic Bactericides**
- Coppers eg. Cueva, Champ
- Lots of others labeled
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Brassica Downy Mildew: Symptoms

- Yellow spots on seedlings
- Gray – black flecking within lesion
Brassica Downy Mildew: Symptoms

- Poor stand
- Yellowing cotyledons
- Yellowing cotyledons
- Tan-brown-gray flecking
- Dark spots/growth on leaf underside
Brassica Downy Mildew: Symptoms

- Diffuse yellowing of foliage, may be vein-delimited
- Dark sporulation may be seen on leaf undersides
- As lesions age they become tan, papery, necrotic
Brassica Downy Mildew: Symptoms

- All brassica crops affected (and many weeds!)
- Here a rutabaga crop is 100% affected and had to be plowed in...seed lot infested!!
Brassica Downy Mildew: Symptoms

**All crops affected:**
- On cauliflower, curds turn brown (like with Alternaria)
- On broccoli, gray streaks form below the beads
- Also affects taproots of turnip and radish, black blotches on surface and an internal discoloration.
Brassica Downy Mildew: Disease Cycle

- Caused by an oomycete (sporangia at right)
- Can overwinter in crop debris, unlike many DM’s
- Can also be seed-borne
- Infection can occur at any growth stage.
- Plants may be infected early and not show any symptoms until conditions are favorable, often late-season/fall
- Cool temperatures of 50°F– 59°F and prolonged periods of leaf wetness, dew or fog are required.
Brassica Downy Mildew: Management

Start with Clean Seed!
- Ask your seed supplier
- Hot water seed treatment
- Fungicide seed treatments??

Control brassica weeds!

Reduce humidity by:
- Increasing spacing
- Good weed control
- Don’t use overhead irrigation

Be diligent if doing brassicas over the winter—a conducive environment, living bridge!

Break down crop debris quickly!
Conclusions

Brassica IPM

• **Rotate**: 2 years long, as far apart in season as possible, separate fall/spring (FB, CRM, ALS, BR)

• **Hot water treat seeds** to eradicate common pathogens (BR, ALS, BDM)

• **Control brassica weeds**: Shepherd’s purse, rocket, radish, mustards, pepperweed etc.

• **Insects**:
  • Don’t let populations get out of control, either in 1 season or over many.
  • Scout weekly for FB, caterpillars, disease symptoms

• **Increase plant spacing**: healthier crops, less disease, higher yields

• **Manage Residues**: Mow, disc, plow fields as soon as possible to start residue breaking down immediately—can last 2+ years in soil.
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Resources

New England Vegetable Management Guide
http://nevegetable.org/
• Answers to all questions relating to crop production including chemical recommendations for every crop/pest

Vegetable Notes Newsletter
https://ag.umass.edu/vegetable/newsletters
• Weekly pest alerts warn you of pest arrival or outbreaks, and articles on crop production and farm issues

Production Guide for Organic Cole Crops
http://nysipm.cornell.edu/organic_guide/cole_crops.pdf
• Another useful guide specifically for organic brassicas from NYSIPM

Network for Environmental and Weather Applications (NEWA)
http://newa.cornell.edu/
• Pest models/forecasts for veg crops including brassicas, onions, potato and tomato
Questions?