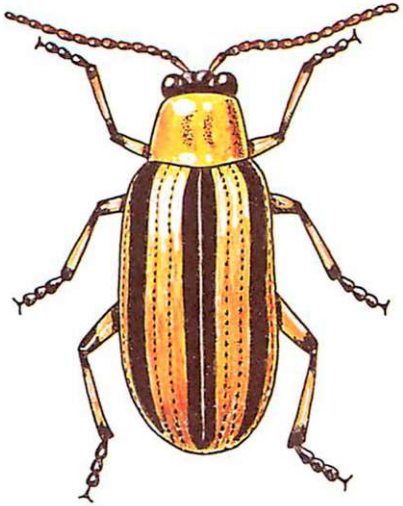
Biological Control of Cucumber Beetles



Molly Dieterich Mabin

Celeste Welty

Mary M. Gardiner

THE OHIO STATE UNIVERSITY

COLLEGE OF FOOD, AGRICULTURAL, AND ENVIRONMENTAL SCIENCES

Outline

- Biology and life cycle of cucumber beetles
- Natural enemies of cucumber beetles
- Results of recent studies on if we can encourage biological control in vine crops with habitat management practices that can benefit these natural enemies

Cucumber Beetles

Coleoptera: Chrysomelidae

Cucumber Beetles

Coleoptera: Chrysomelidae

Southern corn rootworm

Cucurbits

Cucumber Beetles

Bacterial Wilt
(Erwinia tracheiphila)

Other Cucumber Beetles

Northern corn rootworm
(*Diabrotica barberi*)


BugGuide: Stuart Tingley

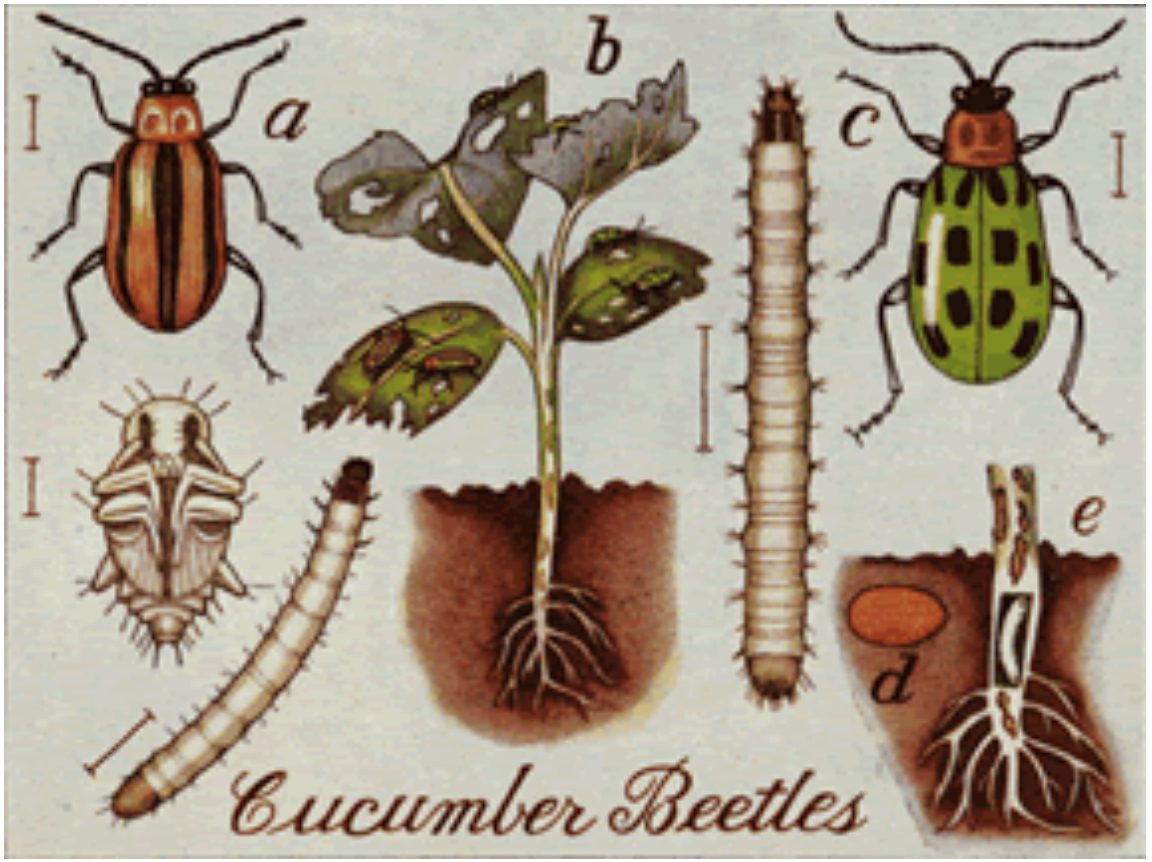

BugGuide: metrioptera

Western corn rootworm
(*Diabrotica virgifera virgifera*)

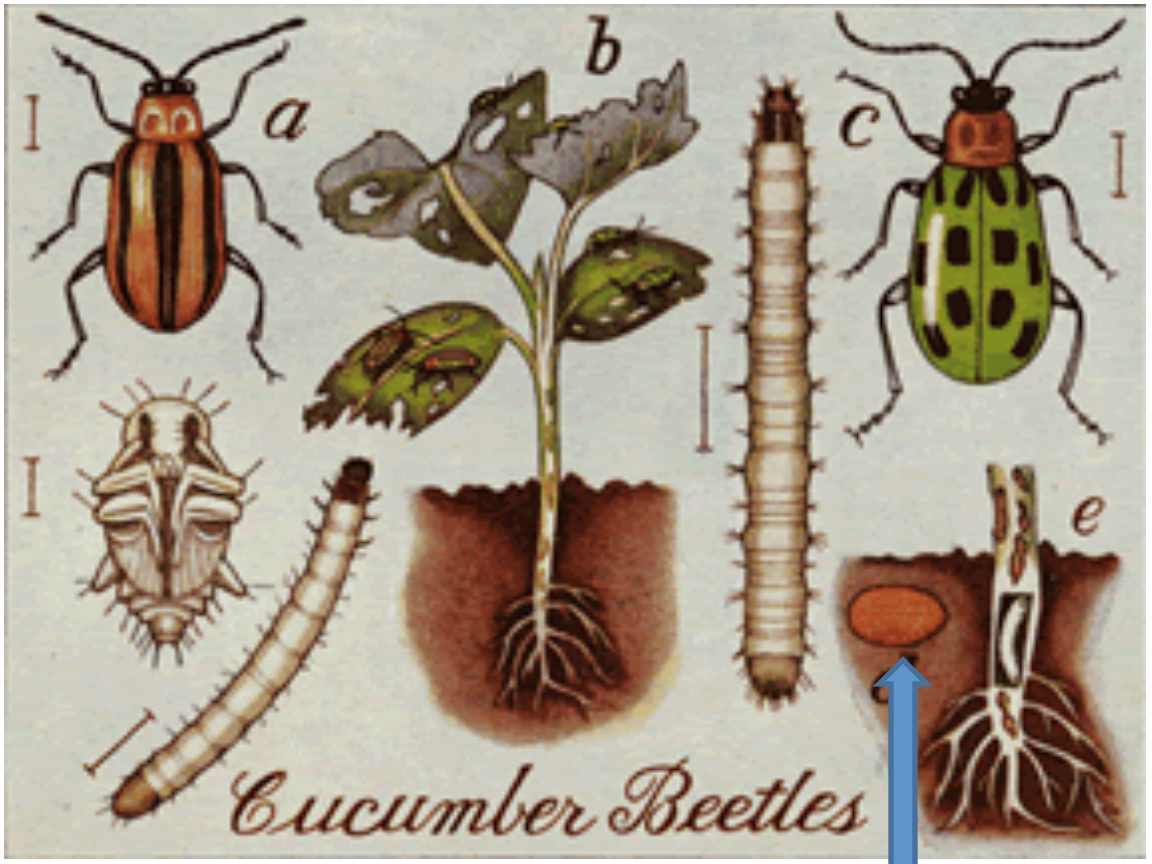

ca.uky.edu


Alex Wild

Cucumber Beetle Life Cycle

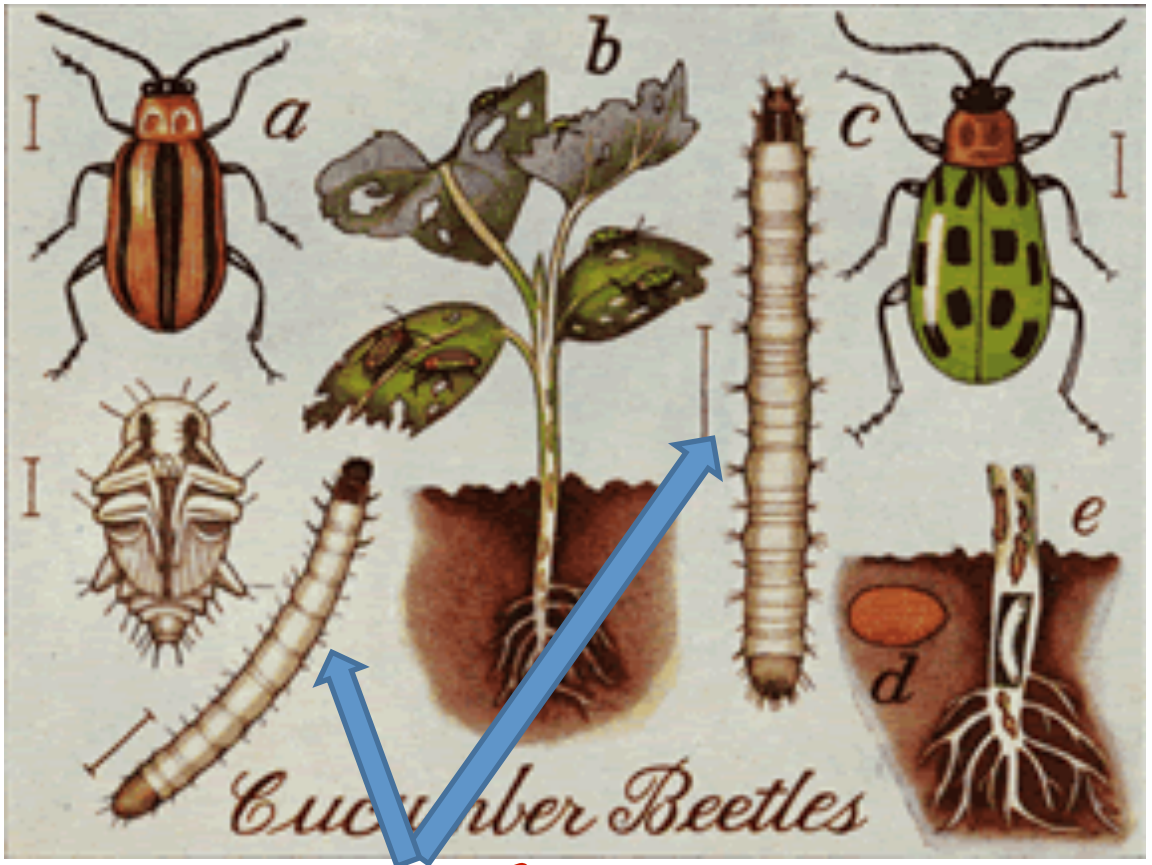


Cucumber Beetle Life Cycle



Egg

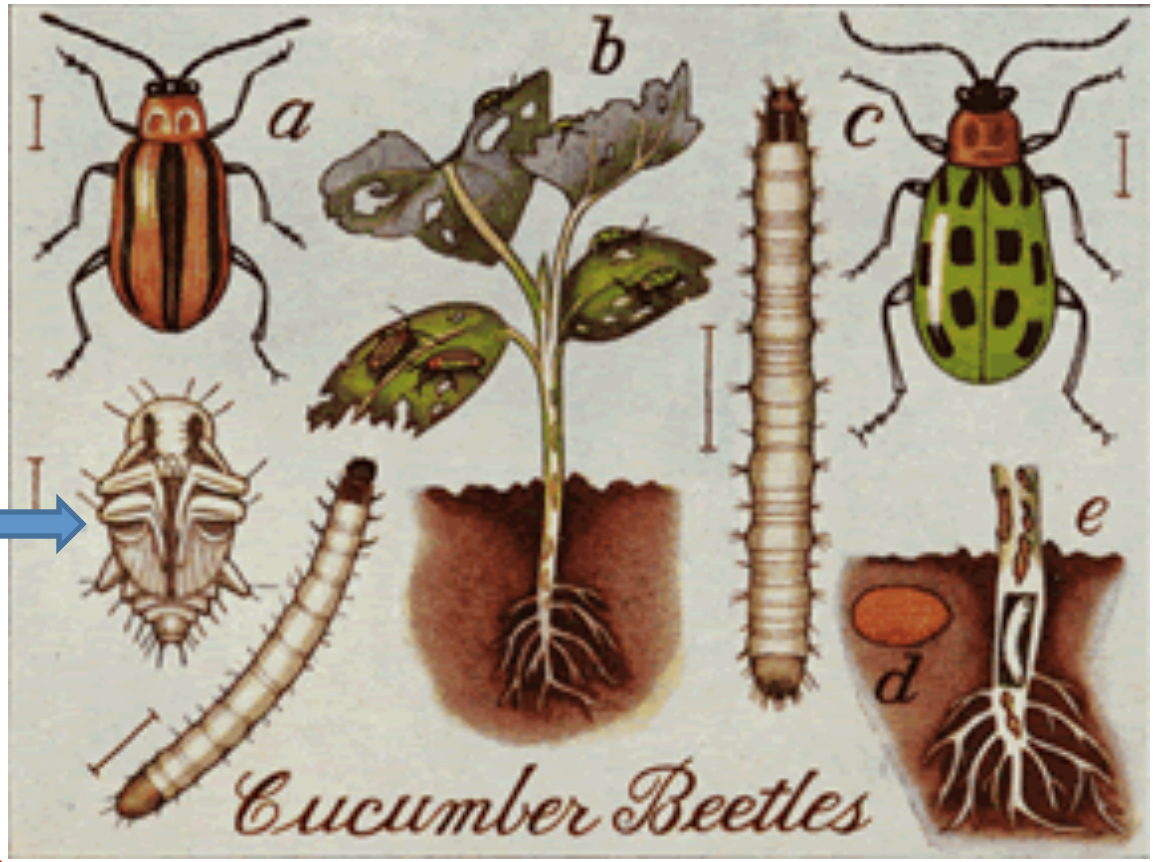
Cucumber Beetle Life Cycle



Larva

Egg

Cucumber Beetle Life Cycle

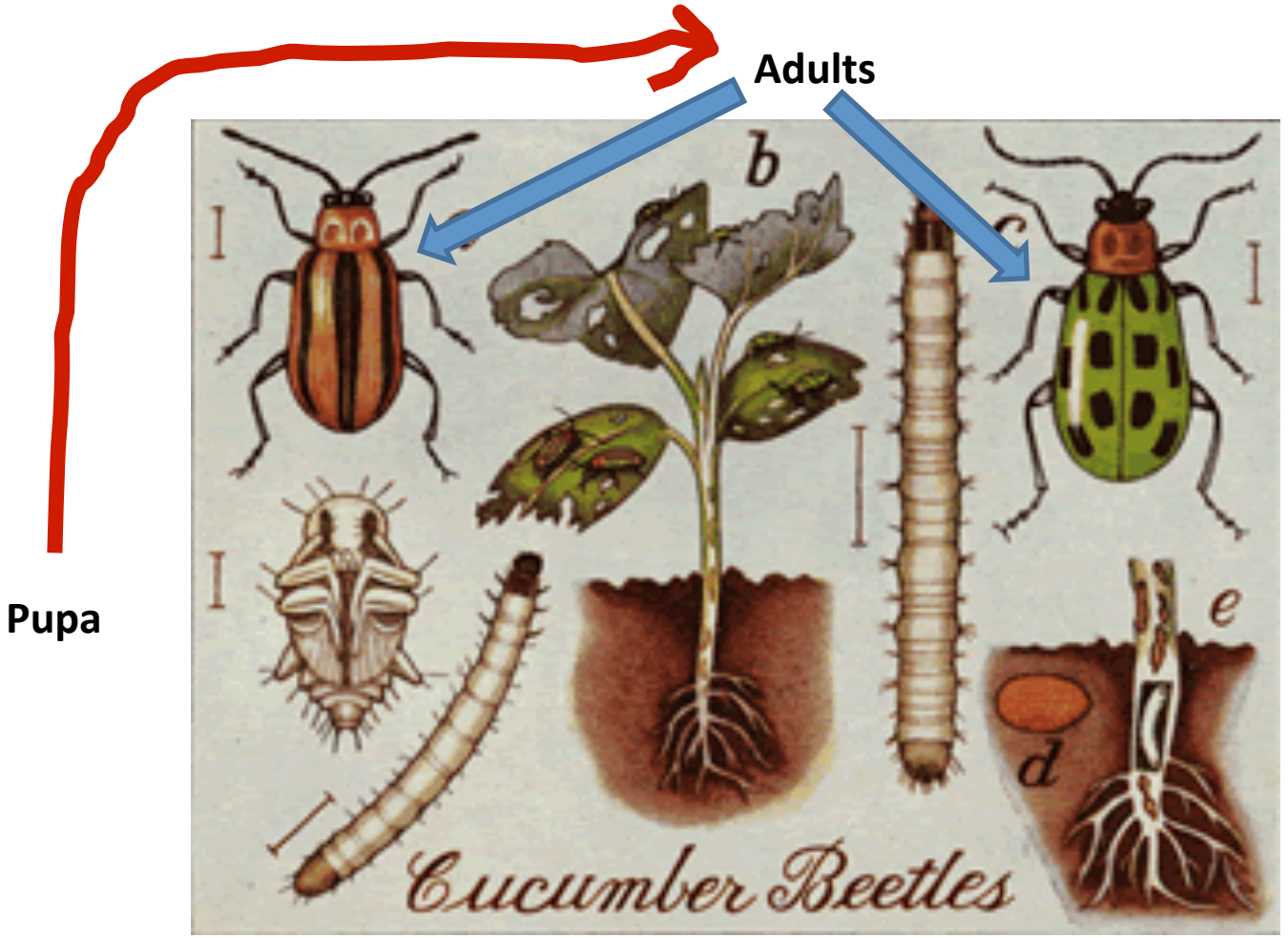


Pupa

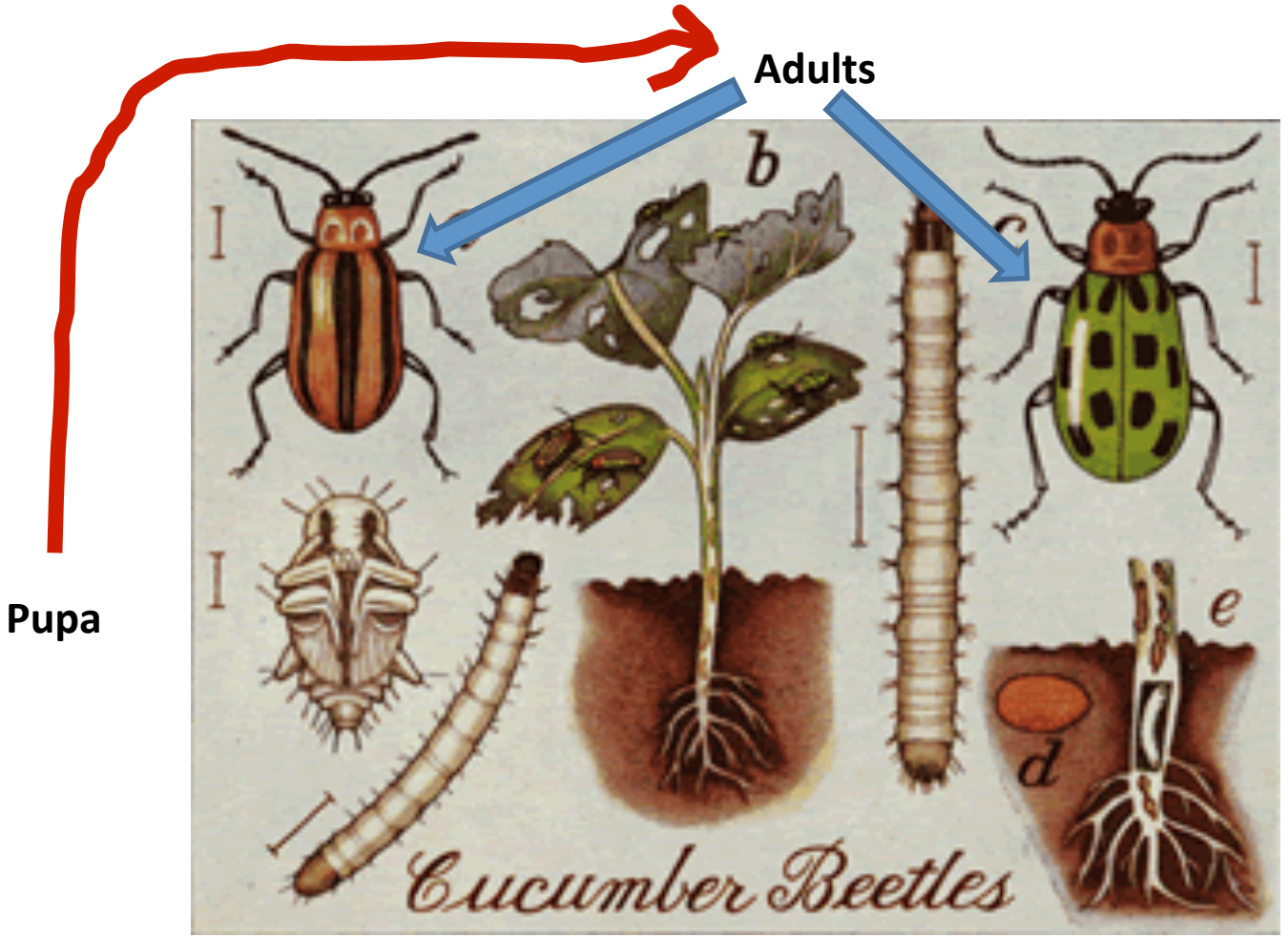
Larva

Egg

Cucumber Beetle Life Cycle



Cucumber Beetle Life Cycle



Bivoltine:
2 generations per growing season

Natural Enemies

- Top-down control
  - Predators
  - Parasitoids

Natural Enemies

- Parasitoids (tachinid fly)
  - *Celatoria diabroticae*
  - *Celatoria setosa*
  - 4 – 38% of adult beetles

Natural Enemies

- Parasitoids (braconid wasp)
  - *Centistes* wasp
  - ~14%, up to 54% parasitism

Predatory Natural Enemies

- Wolf spiders
  - Feed on adult beetles
    - Hunting spiders
  - Beetles avoid wolf spiders

  - Unmated females overwinter
    - Protected areas:
      shrubby fencerows, woodlots

Snyder et al. 2001, Williams & Wise 2003, Lundgren et al. 2009

Predatory Natural Enemies

- Ground beetles
  - Predatory as adults & larvae

Predatory Natural Enemies

- Rove beetles

Predatory Natural Enemies

- Harvestmen (Opiliones)
  - Daddy long-legs
  - (dehydration)

Predatory Natural Enemies

- Lady beetles
  - Aphids
  - Other prey

Predatory Natural Enemies

- Lady beetles






Predatory Natural Enemies

- Lacewings

Other Natural Enemies

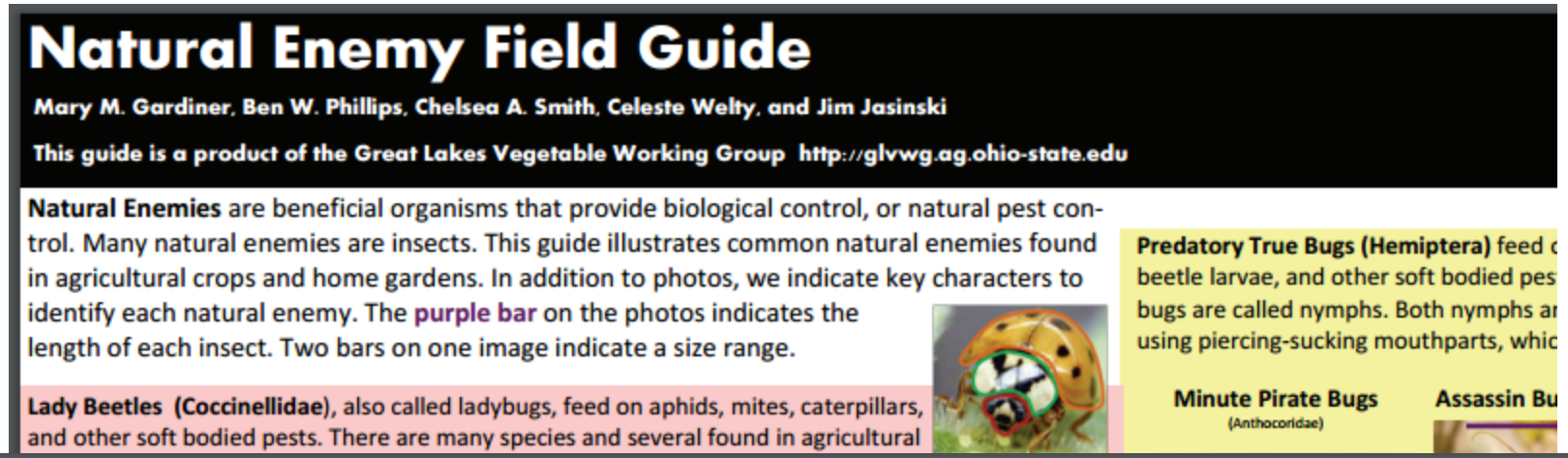
- Predatory True Bugs (Hemiptera)
  - Damsel bugs
  - Assassin bugs
  - Minute pirate bugs
  - Predatory stink bugs (spined soldier bug)

Predatory Natural Enemies

- Other spiders!
  - Jumping spiders
  - Crab spiders
  - Orb weavers

More information

- OSU > Gardiner Lab > Resources



Natural Enemy Field Guide

Mary M. Gardiner, Ben W. Phillips, Chelsea A. Smith, Celeste Welty, and Jim Jasinski

This guide is a product of the Great Lakes Vegetable Working Group http://glvwg.ag.ohio-state.edu

Natural Enemies are beneficial organisms that provide biological control, or natural pest control. Many natural enemies are insects. This guide illustrates common natural enemies found in agricultural crops and home gardens. In addition to photos, we indicate key characters to identify each natural enemy. The **purple bar** on the photos indicates the length of each insect. Two bars on one image indicate a size range.

Lady Beetles (Coccinellidae), also called ladybugs, feed on aphids, mites, caterpillars, and other soft bodied pests. There are many species and several found in agricultural

Predatory True Bugs (Hemiptera) feed
beetle larvae, and other soft bodied pes
bugs are called nymphs. Both nymphs ar
using piercing-sucking mouthparts, whic

Minute Pirate Bugs
(Anthocoridae)

Assassin Bu

OHIO STATE UNIVERSITY EXTENSION

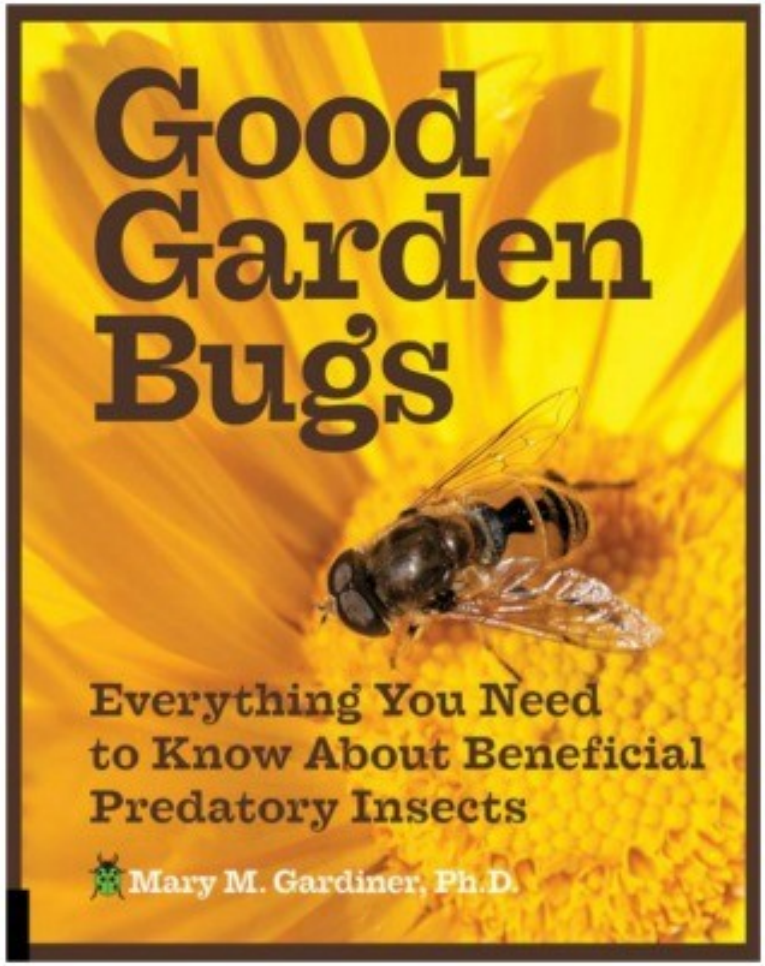
AGRICULTURE AND NATURAL RESOURCES FACT SHEET ENT-68-15

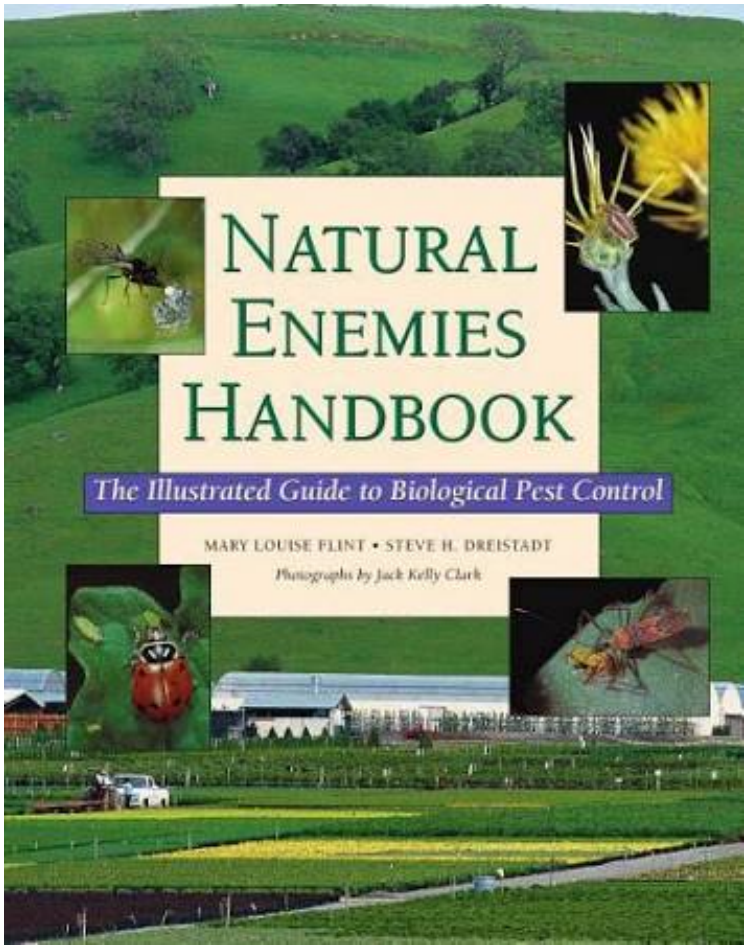
Ohio's Natural Enemies: Harvestmen

Also known as daddy longlegs

Mary Gardiner, Department of Entomology, and **Mary Griffith**, Ohio State University Extension

More information





Outline

- ✓ Biology and life cycle of cucumber beetles
- ✓ Natural enemies of cucumber beetles
- Results of recent studies on if we can encourage biological control in vine crops with habitat management practices that can benefit these natural enemies

Pest Insects

- Damage by pests is a main challenge to vegetable production
- To prevent yield losses, pests are often controlled with synthetic pesticides

Resistance

Non-target effects

Batra 1982; Okamoto & Amarasekare 2012; Toepfer et al. 2009
Landis et al. 2000; Hummel et al. 2002

Vegetable Production

- High input systems
  - Pesticides
  - Fertilizers
  - Water
  - Plastic mulch
  - Frequent tilling

Vegetable Production

- High input systems
  - Pesticides
  - Fertilizers
  - Water
  - Plastic m

unsustainable & expensive

Conservation Biological Control

Increase activity, abundance, & diversity of predatory natural enemies

- Vegetative habitats
- Overwintering sites
- Maximize edges

Batra 1982; Wissinger 1997;
Gardiner et al. 2009;
Maisonhaute et al. 2010

Conservation Biological Control

- Reduced tillage
- Crop rotations
- Cover crops
- Refuge habitats
  - Natural areas
  - Fallow fields

Hummel et al. 2002; Lee et al. 2001; Werling & Gratton 2008; Saska et al. 2007

Strip Tillage

- Reduced disturbance
- Organic matter
- Structural & species diversity of vegetation

Strip Tillage

- Reduced disturbance
- Organic matter
- Structural & species diversity of vegetation

Natural enemies

Bottenberg et al. 1999; Luna & Staben 2002; Brainard & Corey Noyes 2012
Stinner & House 1990; Marino & Landis 1996; Bryant et al. 2013

My Question

- Does this increase in natural enemy abundance and diversity result in greater biological control?

My Question

- Does this increase in natural enemy abundance and diversity result in greater biological control?
- Biodiversity-ecosystem function theory
  - Increased predator diversity should lead to greater biological control

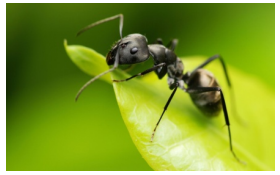
Cardinale et al. 2006

Hypothesis

Complex vegetative habitat

Abundant, diverse, & active NE community







Greater biological control of cucumber beetles

2014

Strip Tillage

Plastic Mulch

- organic & conventional management
- natural enemy community & biological control

Experiments

1. Pitfall traps
2. Sentinel egg study
3. Video surveillance
4. Molecular gut content analysis

Experiments

1. Pitfall traps
   - Diversity
2. Sentinel egg study

3. Video surveillance

4. Molecular gut content analysis

Experiments

1. Pitfall traps
   - Diversity
2. Sentinel egg study
   - Predation rates
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Experiments

1. Pitfall traps
   - Diversity
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   - Who's eating the eggs?
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Experiments

1. Pitfall traps
   - Diversity
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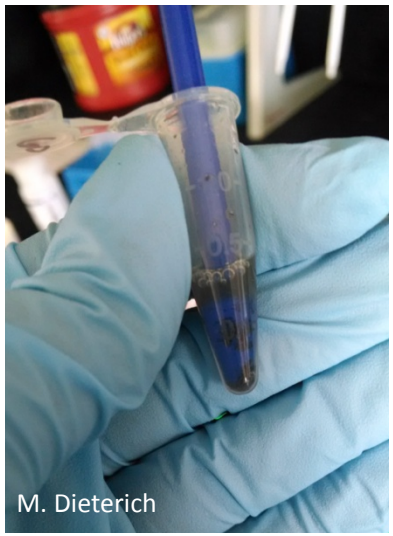
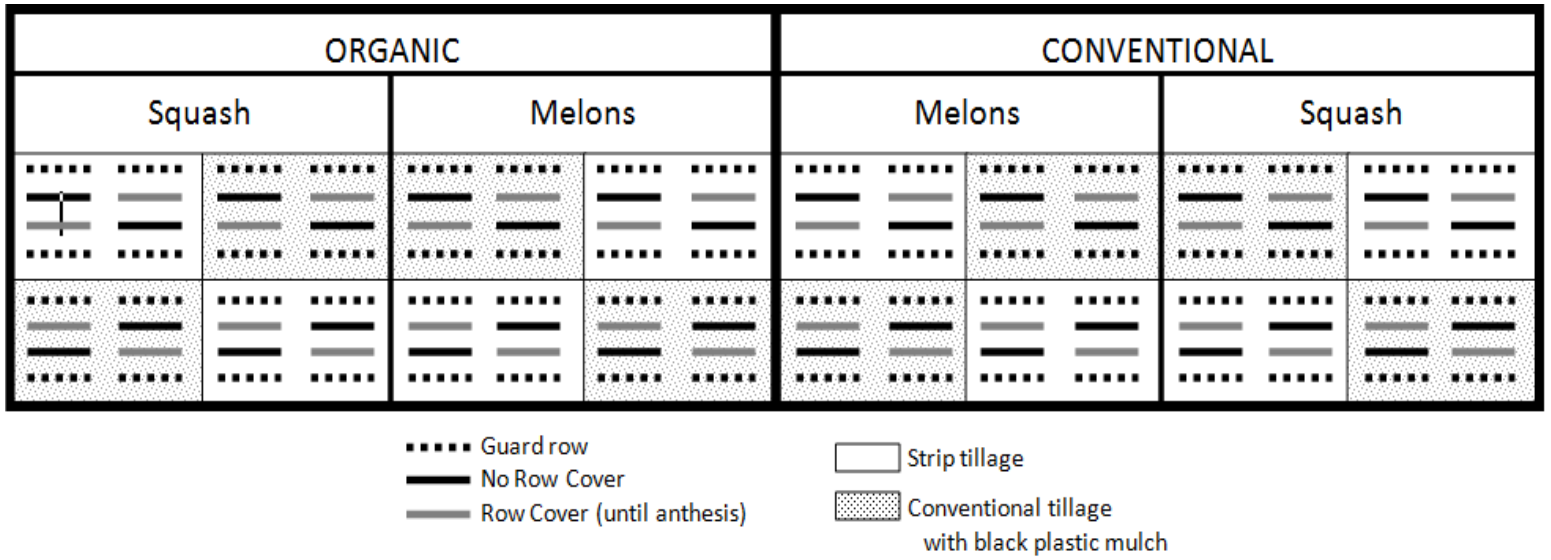
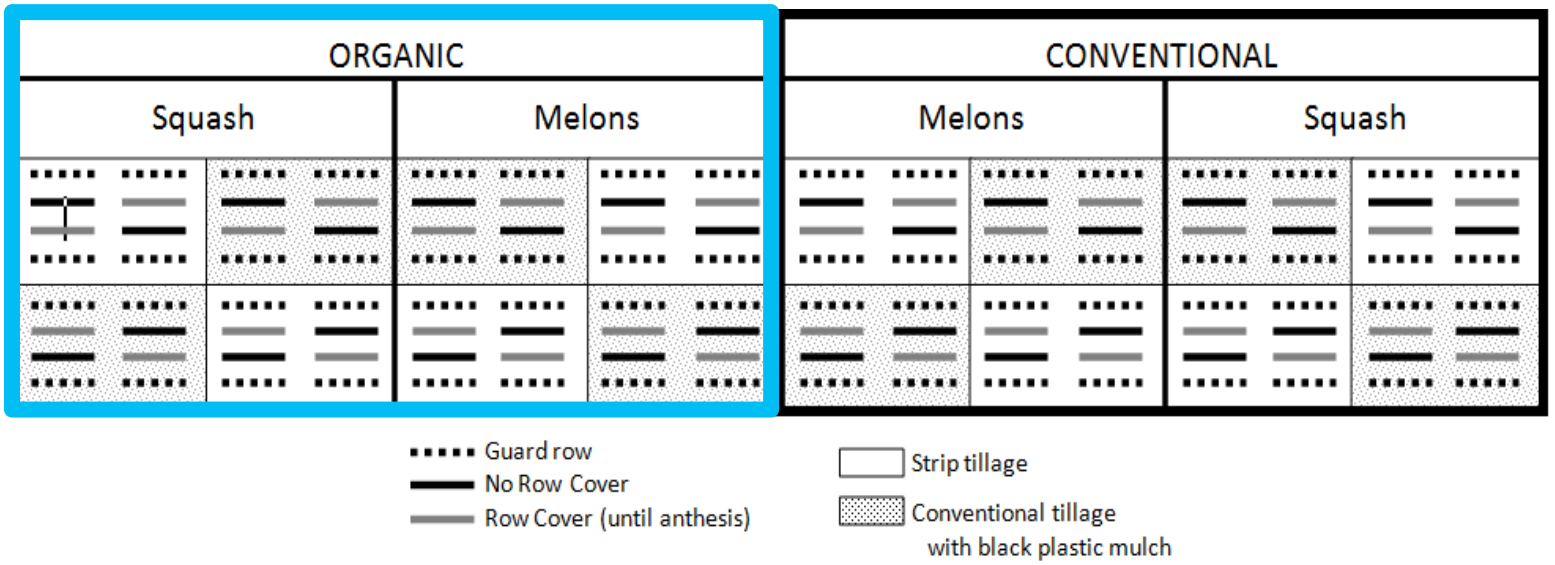
   - Who's eating the eggs?
4. Molecular gut content analysis
   - Who contributes to biocontrol


M. Dieterich

2014 Field Sites



2014 Field Sites



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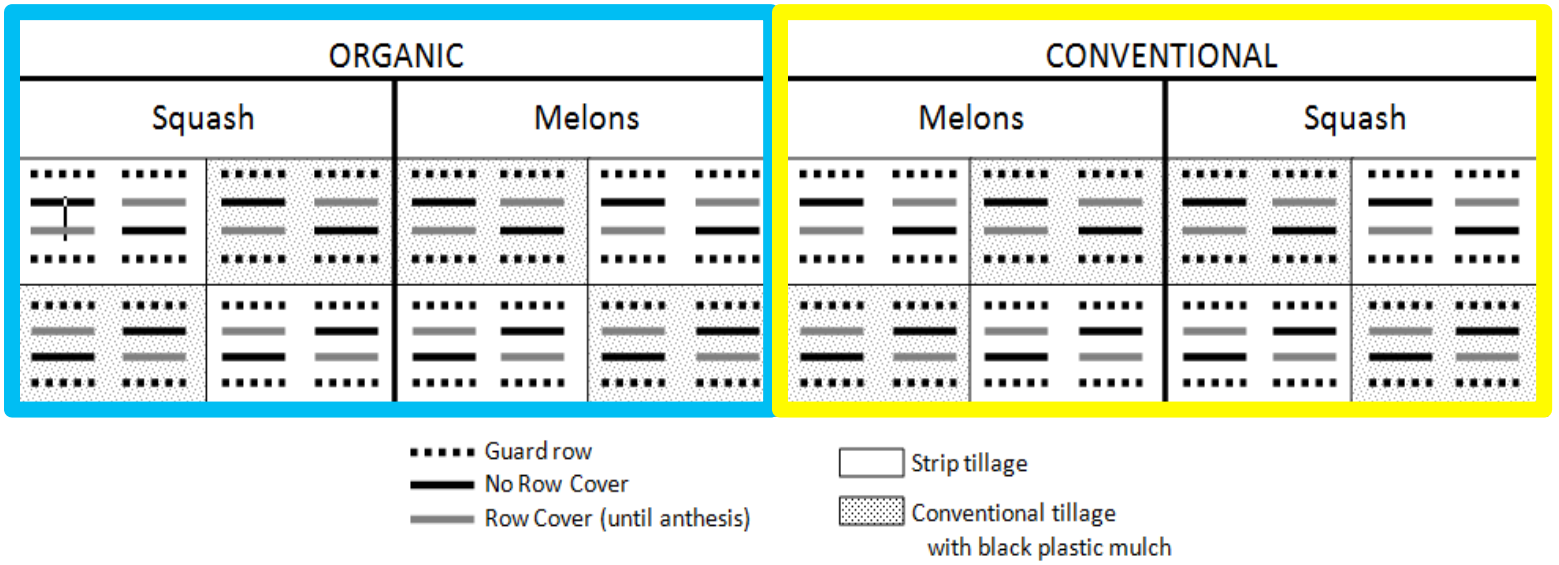

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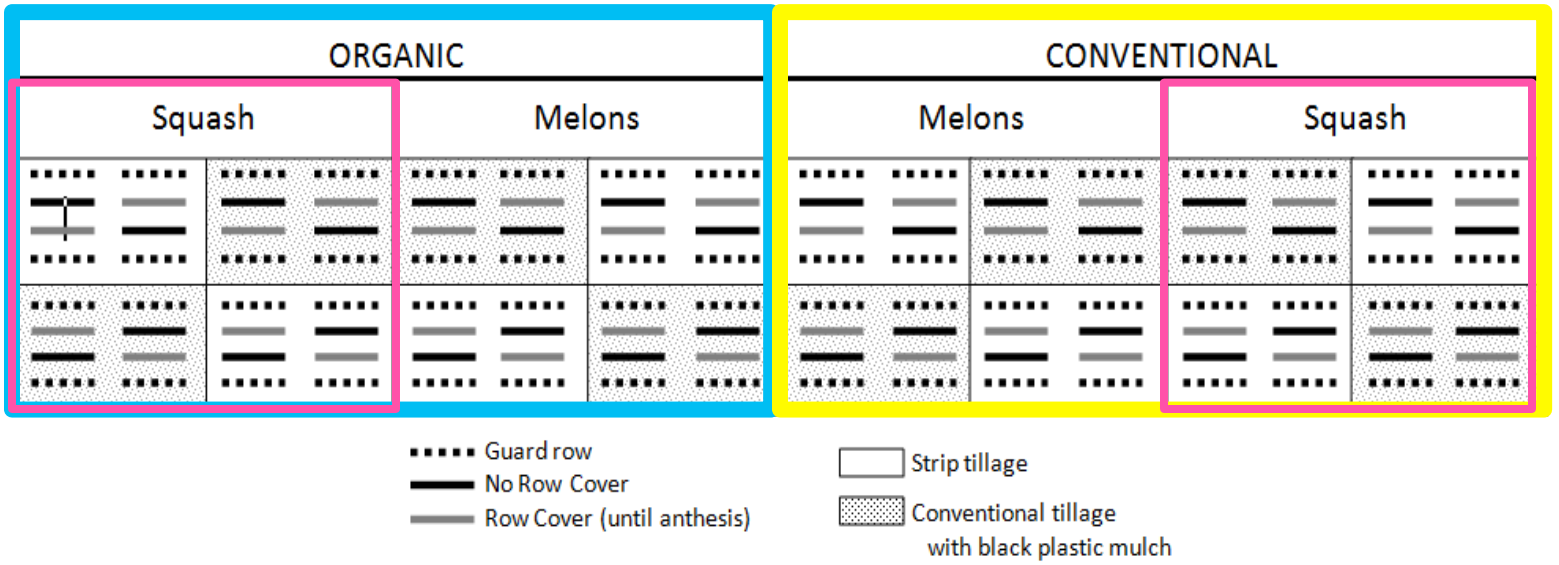

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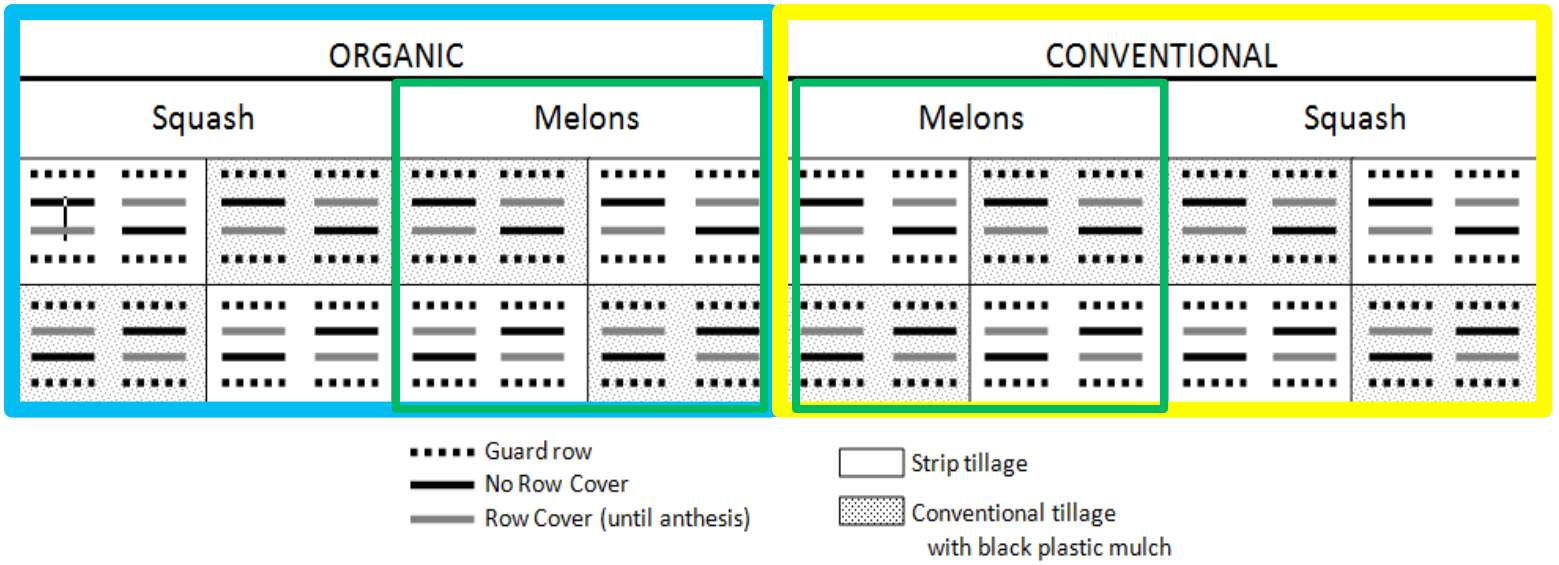

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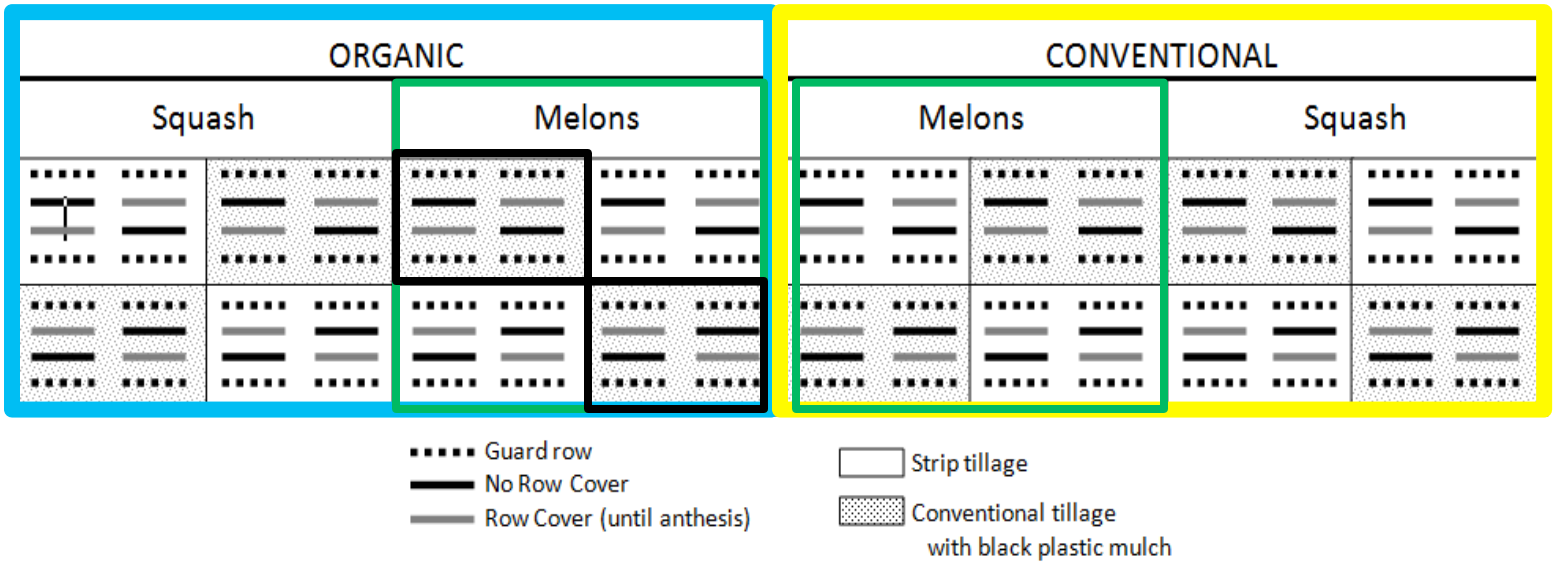

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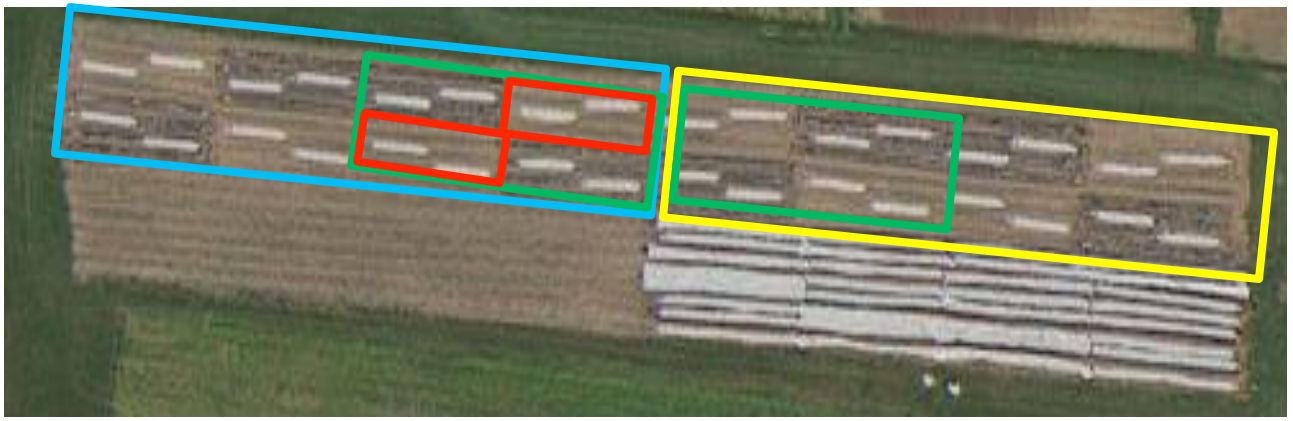
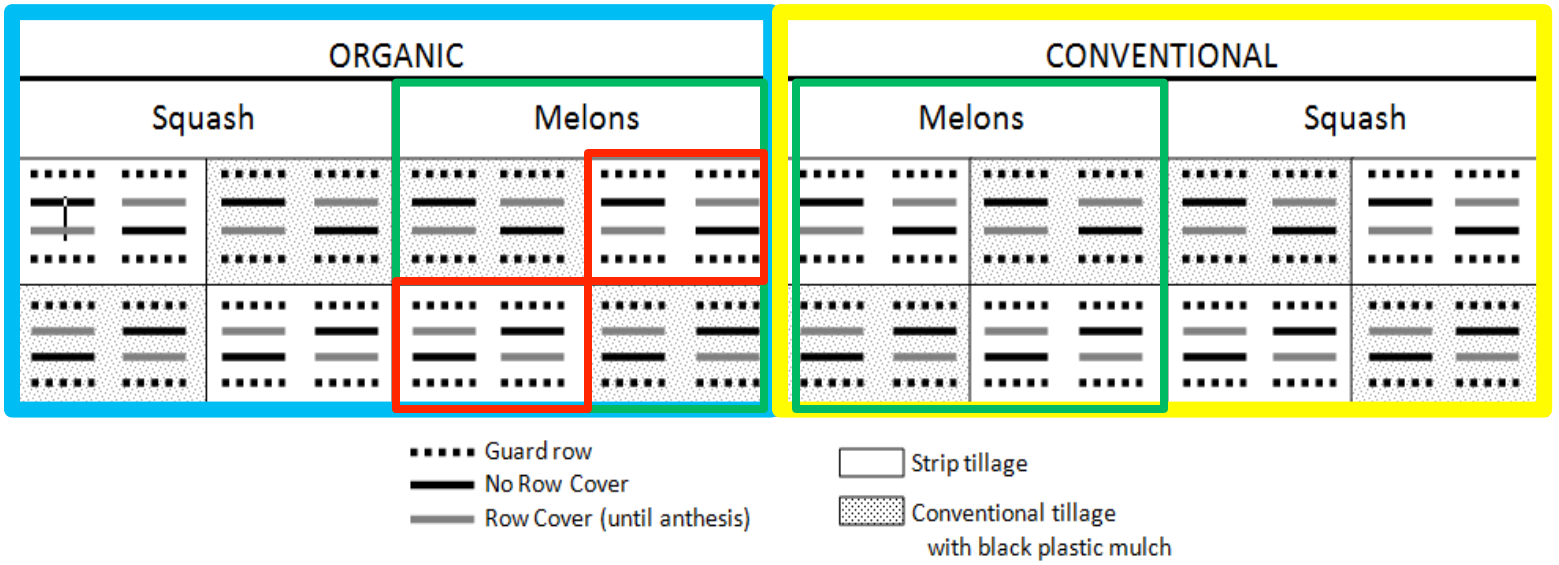
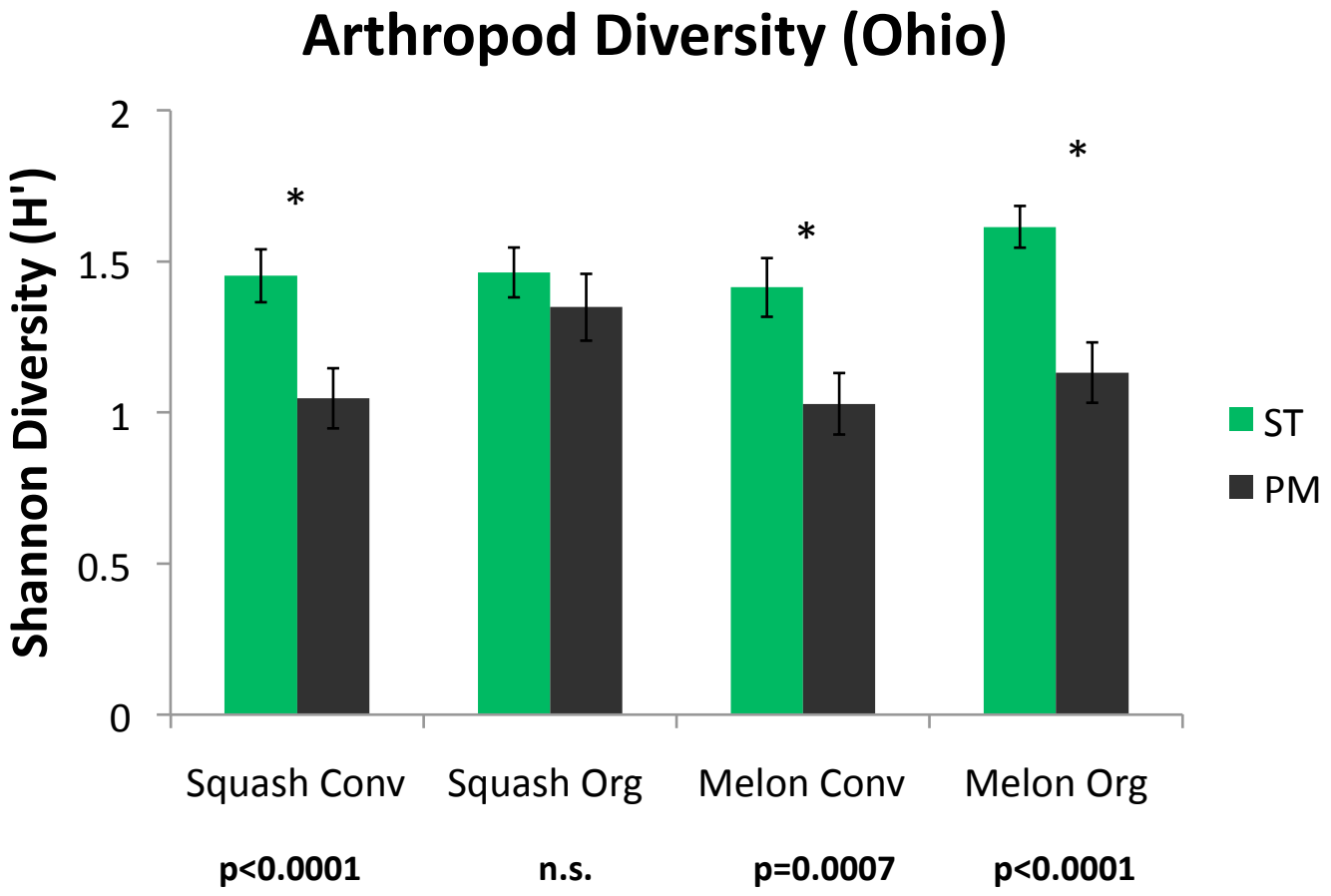
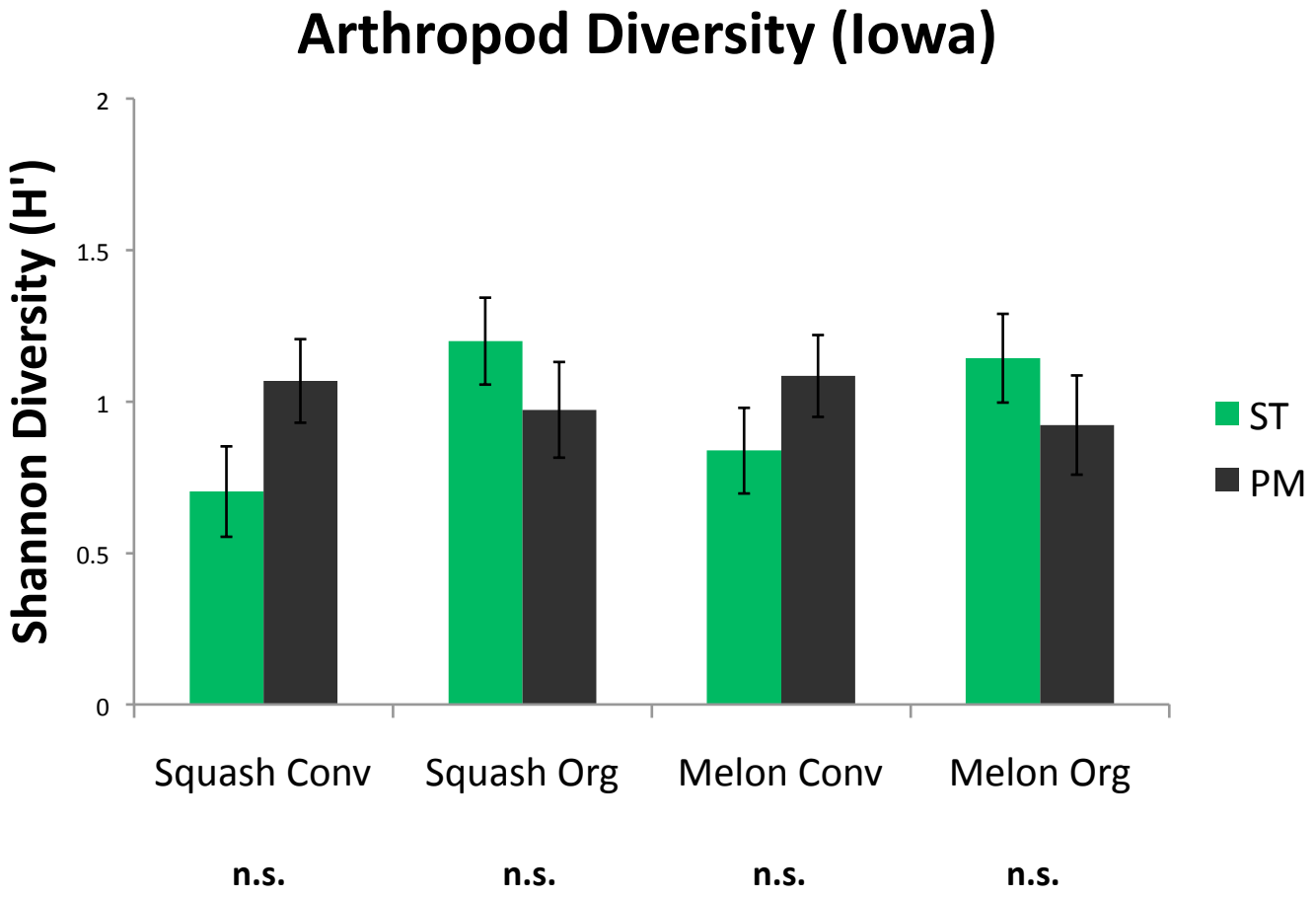




1. Arthropod Diversity



1. Arthropod Diversity



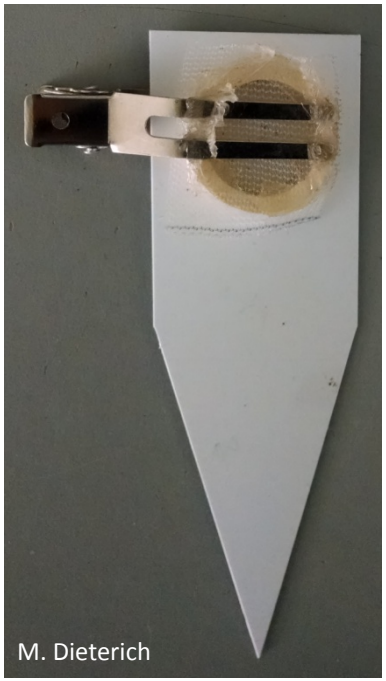
Experiments

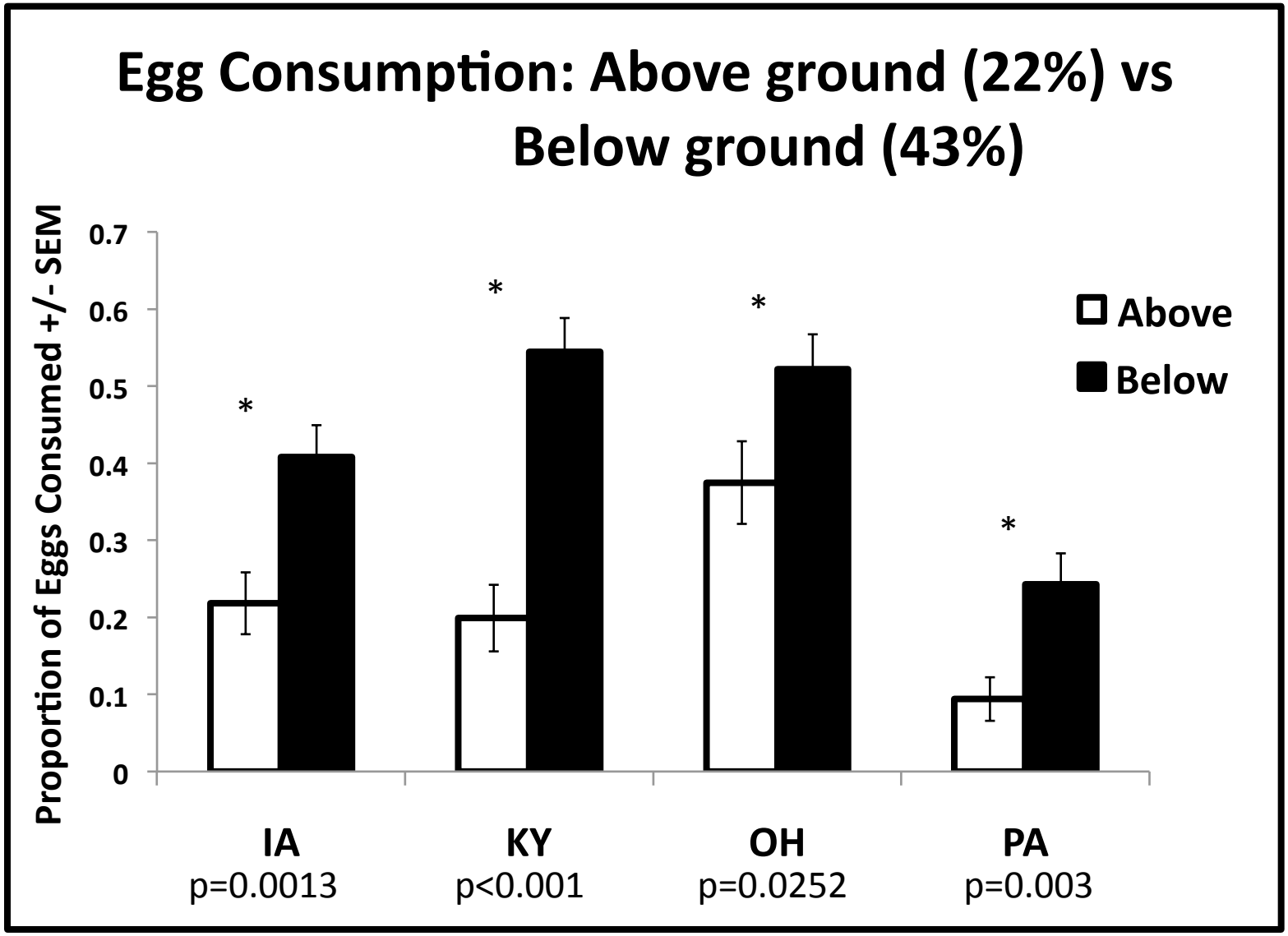
1. Pitfall traps
   - Diversity → (sometimes) greater in ST than PM
2. Sentinel egg study
3. Video surveillance
4. Molecular gut content analysis

2. Sentinel Egg Study

4 sites: Ohio, Kentucky, Iowa, Pennsylvania

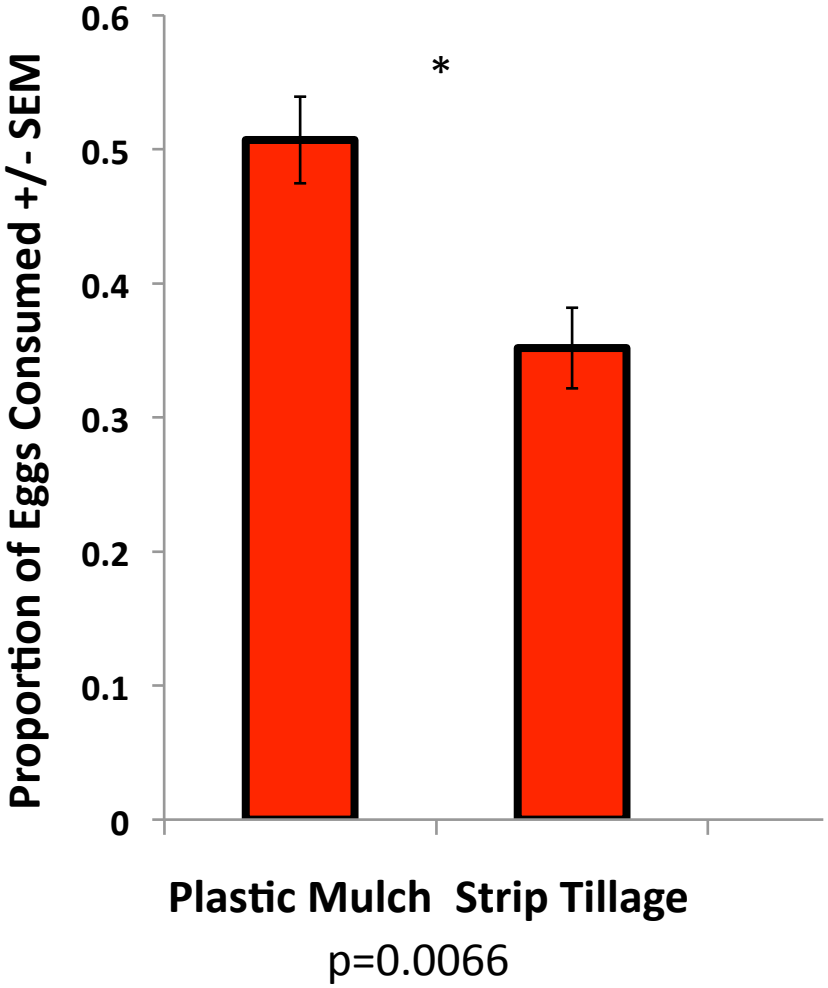
- 24 hours




Egg Consumption: Above ground (22%) vs Below ground (43%)
Proportion of Eggs Consumed +/- SEM
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Above
Below
*
*
*
*
IA
p=0.0013
KY
p<0.001
OH
p=0.0252
PA
p=0.003

Below Ground Egg Consumption:

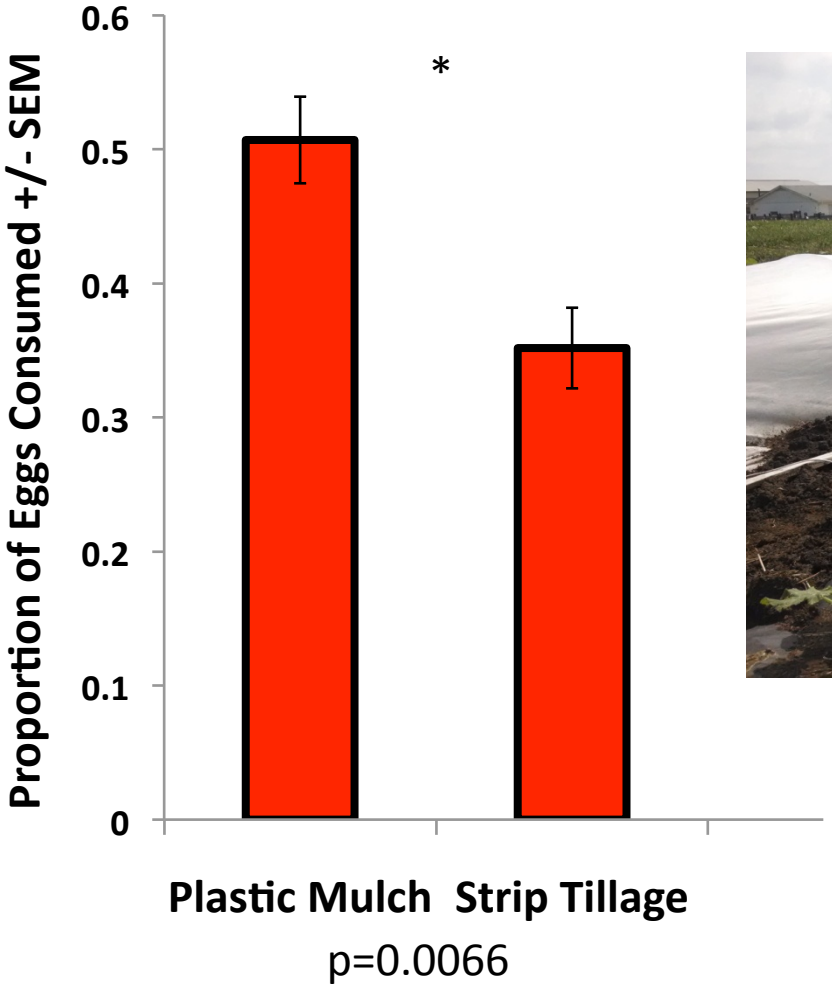
Plastic Mulch vs Strip Tillage



p=0.0066

Below Ground Egg Consumption:

Plastic Mulch vs Strip Tillage



p=0.0066

Experiments

1. Pitfall traps
   - Diversity → (sometimes) greater in ST than PM
2. Sentinel egg study
   - Predation rates → lower in ST than in PM
3. Video surveillance

4. Molecular gut content analysis

3. Video Surveillance

- Who is eating cucumber beetle eggs?
  - Video surveillance of above ground sentinel egg cards

3. Video Surveillance

- Ants
- Spiders
- Harvestmen
- Ground beetles, rove beetles, lady beetle larvae
- Crickets & Grasshoppers
- Centipedes
- Other: flies, lacewing larvae, mites, thrips, springtails

Experiments

1. Pitfall traps
   - Diversity → (sometimes) greater in ST than PM
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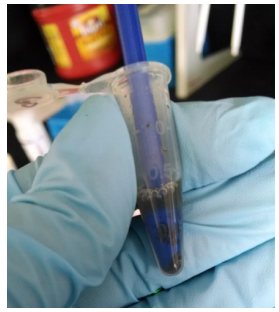
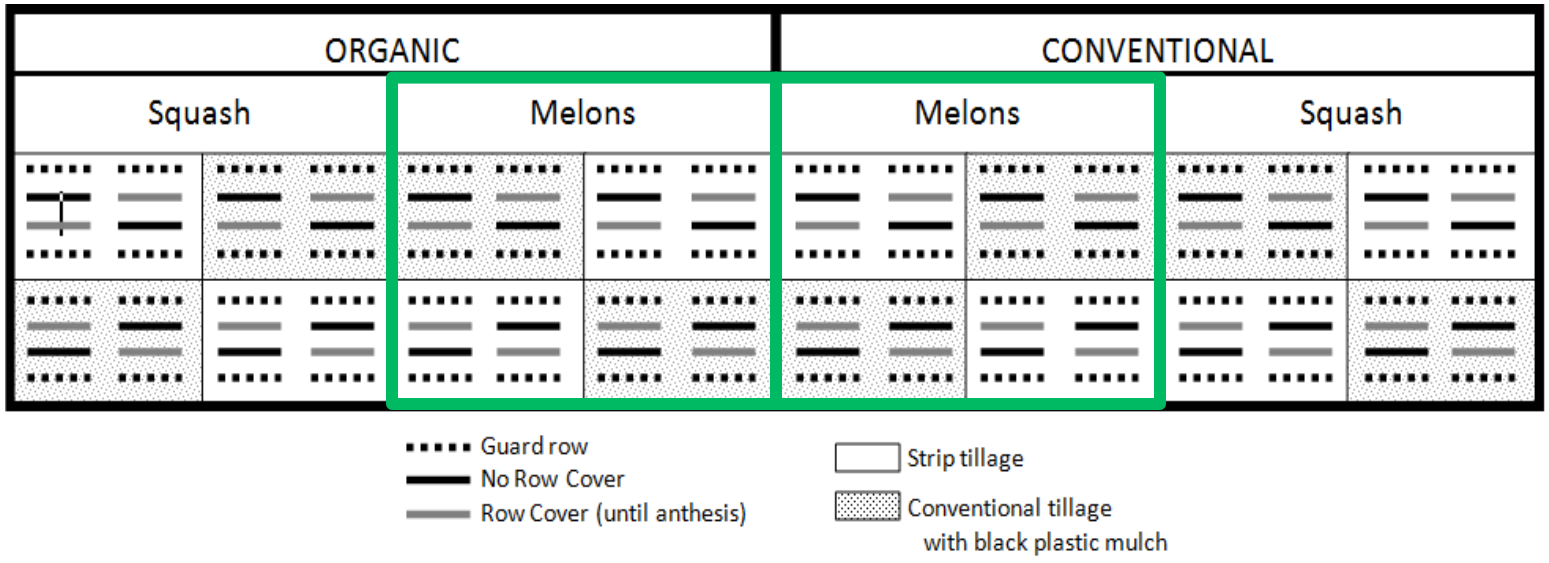
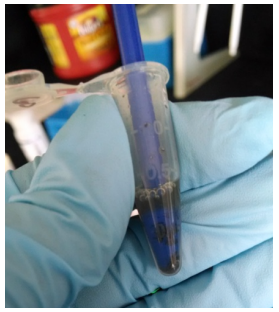
   - Who's eating the eggs? → as expected
4. Molecular gut content analysis

4. Molecular Gut Content Analysis



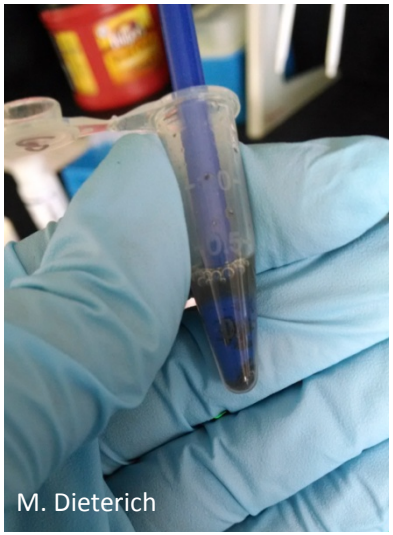


4. Molecular Gut Content Analysis



Collect NEs

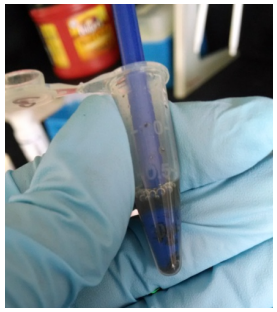
DNA extraction



Develop species-specific primers

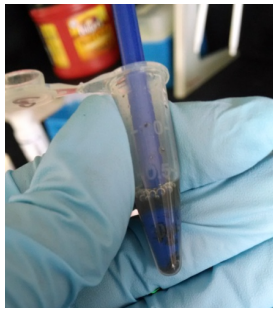
Chisholm et al. 2014, Rougerie et al. 2011, Harwood et al. 2009, Lundgren et al. 2009, Harwood et al. 2007, Schmidt et al. 2014

4. Molecular Gut Content Analysis



PCR & gel electrophoresis

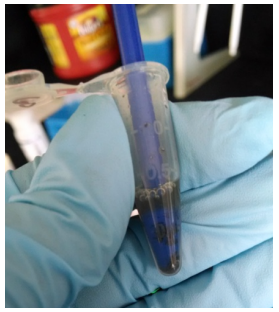
4. Molecular Gut Content Analysis



- 204 wolf spiders (Araneae: Lycosidae)

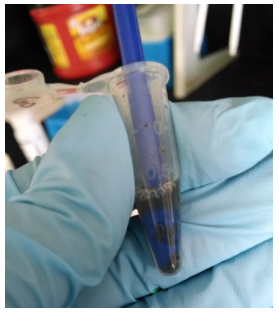
Pardosa milvina	*Pardosa pauxilla*	*Pardosa* immature
133	21	50

4. Molecular Gut Content Analysis



- 204 wolf spiders: 12.25%

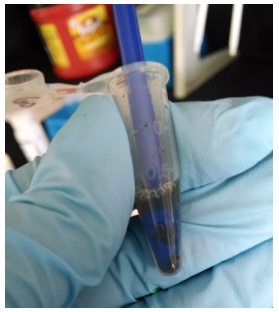
4. Molecular Gut Content Analysis



- 204 wolf spiders: 12.25%

No difference between: Organic & Conventional
Strip Till & Plastic Mulch

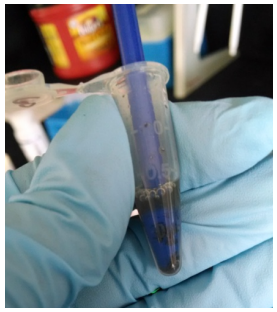
4. Molecular Gut Content Analysis



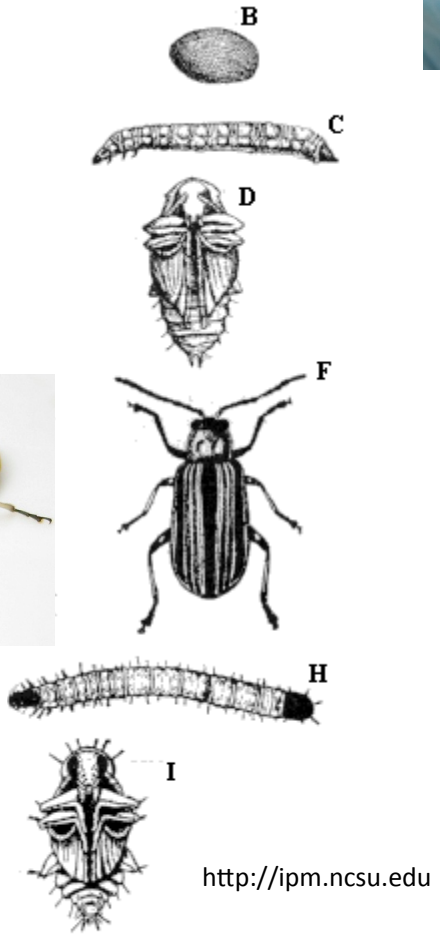
- 160 harvestmen (Opiliones)

Phalangium opilio	*Opilio parietinus*
53	**107**

4. Molecular Gut Content Analysis

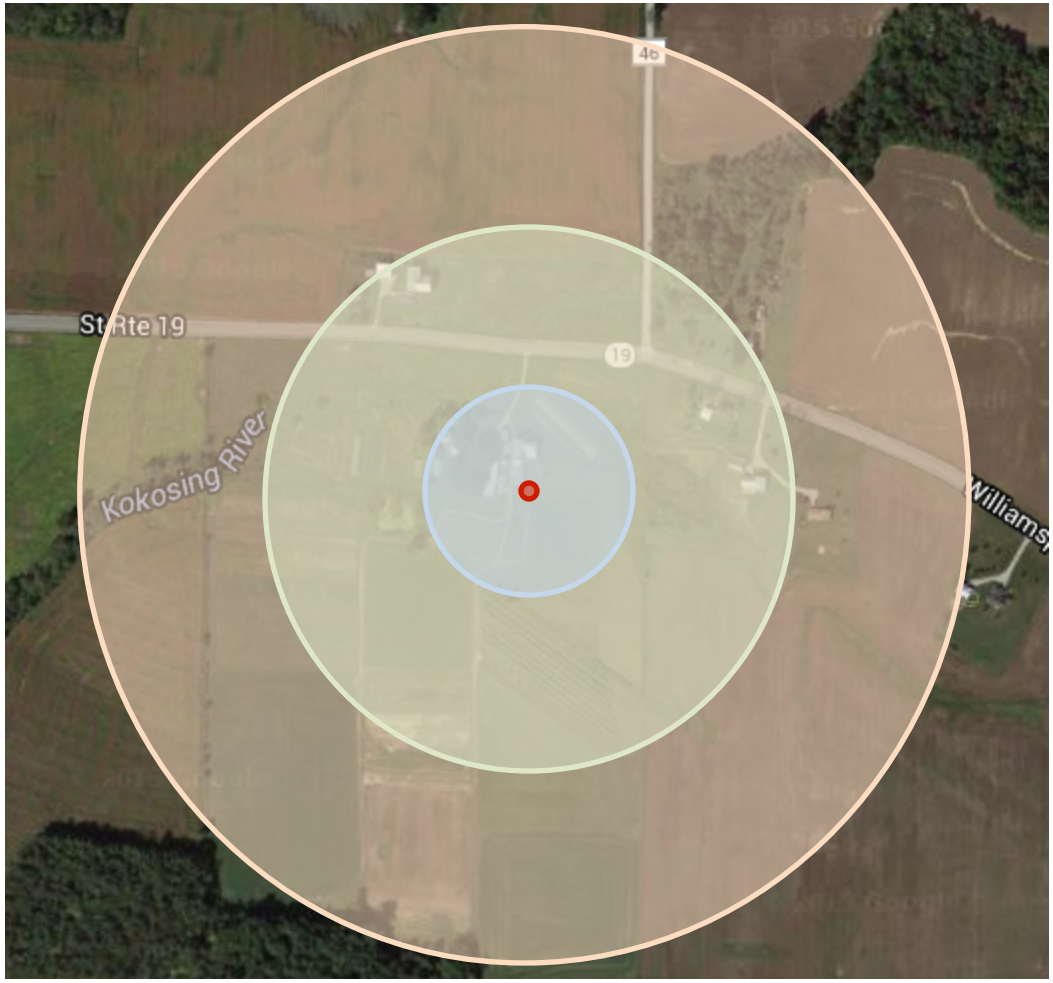


- 57 harvestmen: 17.5%



http://ipm.ncsu.edu

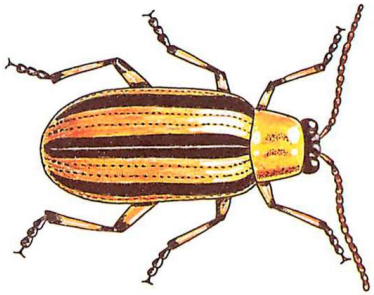
Implications



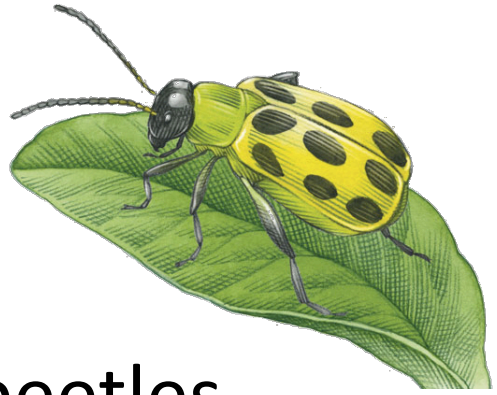
Chaplin-Kramer et al. 2011, Tscharntke et al. 2007, Crowder & Jabbour 2014

Experiments

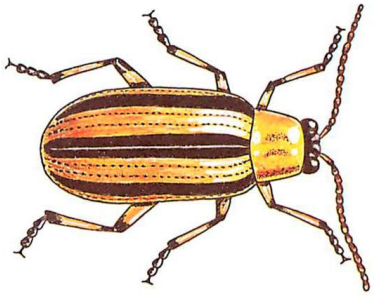
1. Pitfall traps ✓
   - Diversity → (sometimes) greater in ST than PM
2. Sentinel egg study ✓
   - Predation rates → lower in ST than in PM
3. Video surveillance ✓
   - Who's eating the eggs? → as expected
4. Molecular gut content analysis ✓
   - Who contributes to biocontrol → so far, WS & H



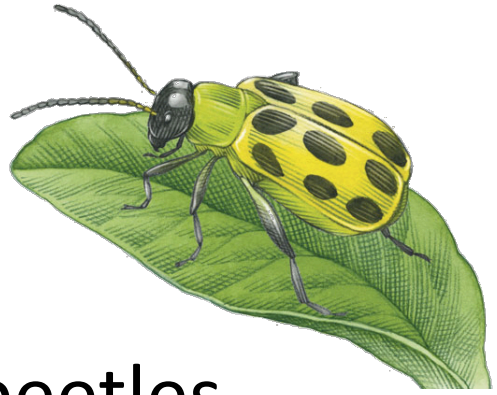
Summary



- Striped and spotted cucumber beetles
  - Abundant & damaging pests

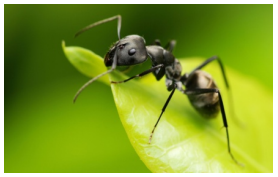


Summary



- Striped and spotted cucumber beetles
  - Abundant & damaging pests
- Will strip tillage result in greater biocontrol?
  - Arthropod diversity is (sometimes) greater in ST than PM
  - Biological control is not greater in ST







Recommendations

- Plastic mulch ~ strip tillage?
- Plant late
- Row covers
- Resistant varieties

Questions?

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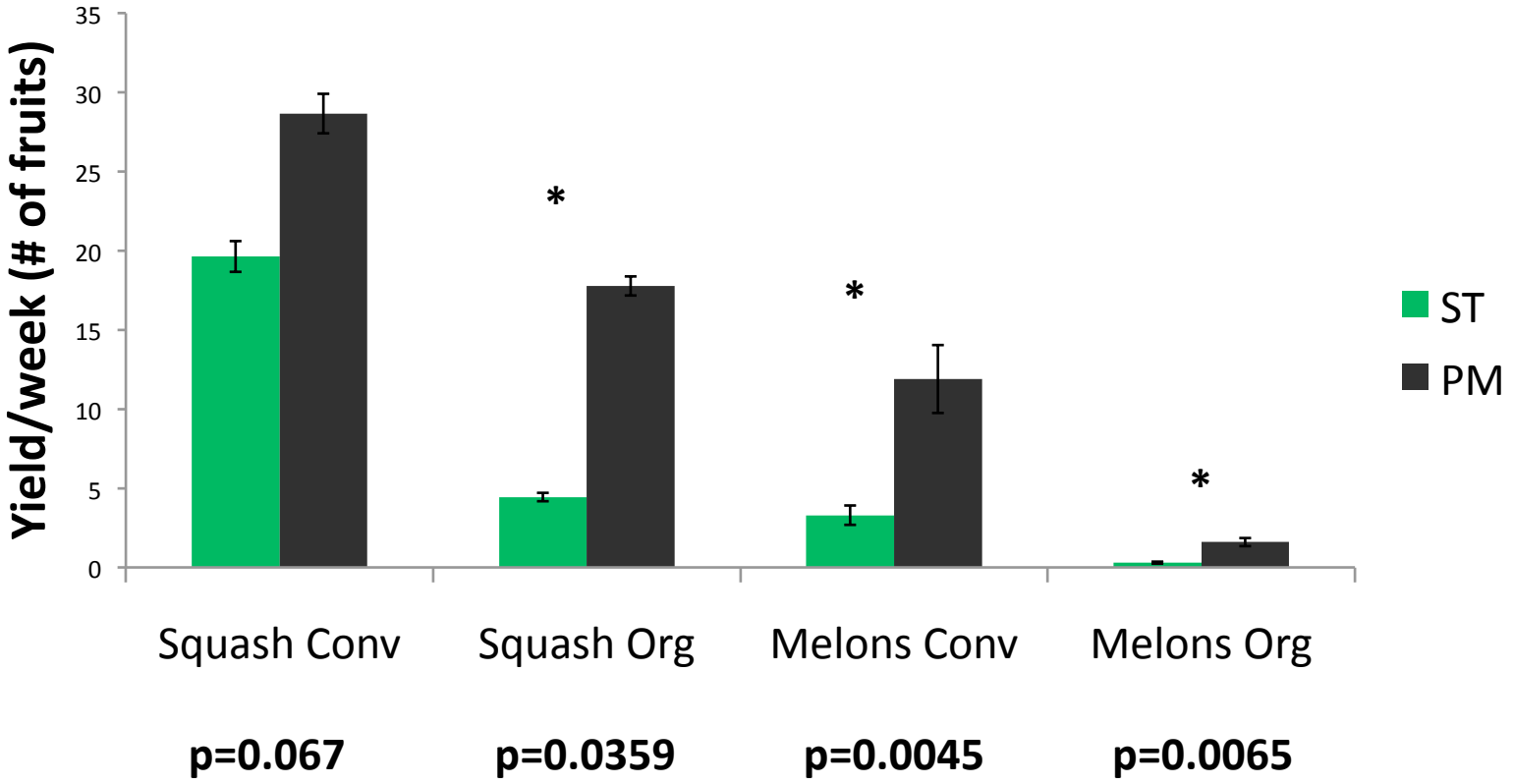
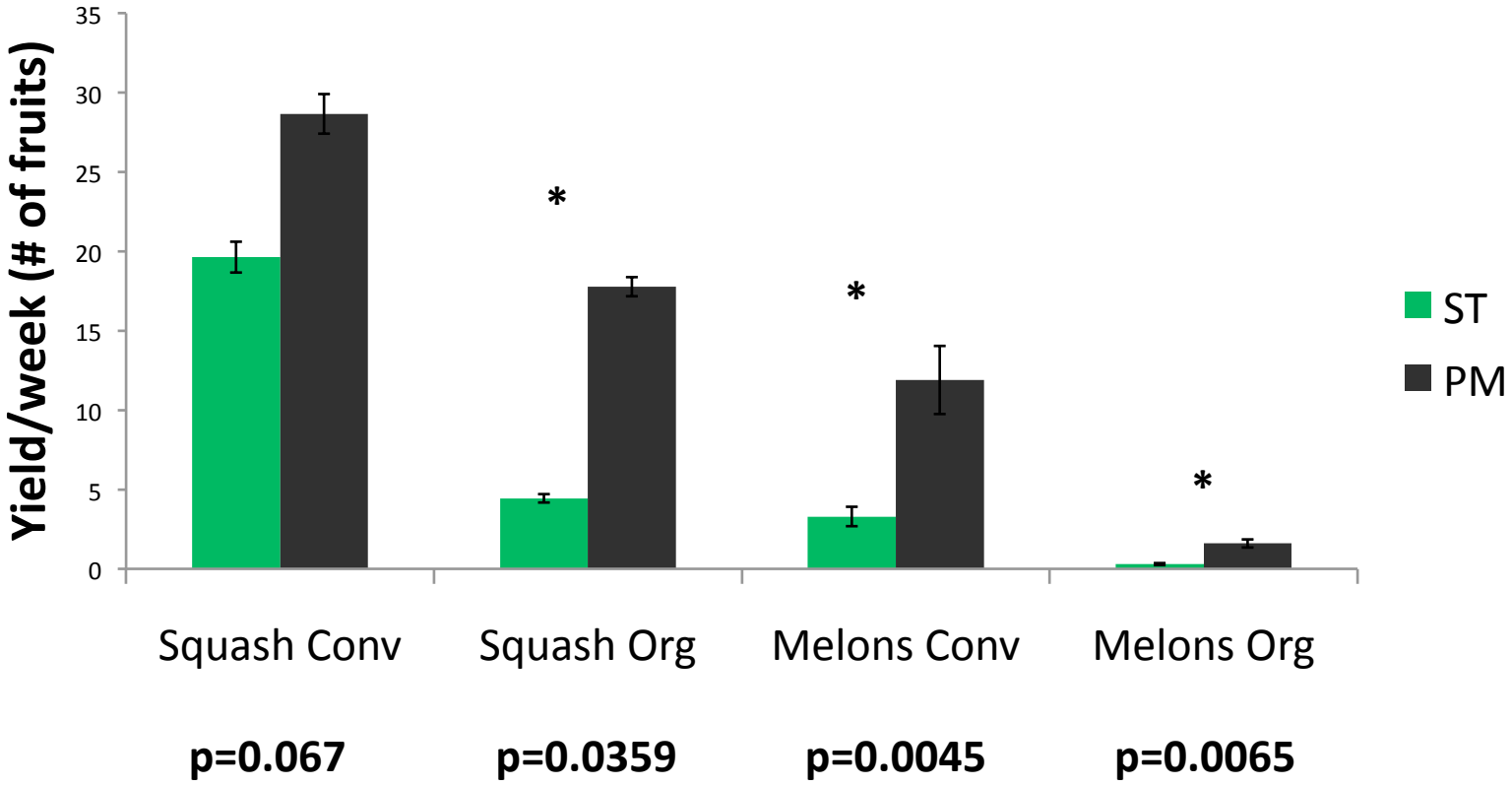
Yield (Ohio 2014)



Yield (Ohio 2014)



- Black plastic mulch reduces the survival rate of cucumber beetle larvae by as much as 50% (Penn State Extension).