Managing the interactions of insects with other pests in agricultural fields

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Interactions in agricultural fields

Interactions between two pests

- arthropods
- pathogens
- weeds

positive
negative
Interactions in the agroecosystem

Interactions among three pests
Aphids transmit the majority (~55%) of plant viruses - partly due to the shape of their mouth!
How do aphids feed?

http://vimeo.com/64269766
Vector - pathogen interactions

Types of Vector Transmission (e.g. aphid)

- Nonpersistent
  - noncirculative
  - ‘stylet-borne’
- Semipersistent
  - ‘foregut-borne’

Persistent Circulative
- Moves inside vector
- Replenished from host

Persistent Propagative
- Replicates inside vector
- Some transovarial
  - Produce infected eggs and nymphs

Pathogen transmission by vector
What kind of virus transmission is this?

Vector - pathogen interactions

How should IPM tactics differ for non/semipersistent vs. persistent viruses?
Vector - pathogen interactions

Pathogen transmission by vector

**Non-persistent** ➔ Needs immediate management action! MONITORING!!!

**Persistent** ➔ Needs to stop subsequent generations to emerge and spread to new areas.
VECTOR IPM

1. prevent pathogen acquisition and transmission by vector
   a. prevent vector from landing on host plant (repellents, mulches)
   b. prevent landing vector from probing/feeding (feeding deterrents, oils)

2. reduce the population density of vector
   a. insecticides
   b. natural enemies
### Aphid transmission of viruses on cucurbitis

<table>
<thead>
<tr>
<th>Common Cucurbit Viruses and Transmission Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Virus</td>
</tr>
<tr>
<td>Cucumber Mosaic Virus</td>
</tr>
<tr>
<td>Papaya Ring Spot Virus</td>
</tr>
<tr>
<td>Squash Mosaic Virus</td>
</tr>
<tr>
<td>Watermelon Mosaic Virus</td>
</tr>
<tr>
<td>Zucchini YellowMosaic Virus</td>
</tr>
</tbody>
</table>

\(^1\) Aphidborne viruses are non-persistent, thus aphids can begin transmitting the virus after seconds of feeding, and may transmit the virus for only a few hours.

Most viruses that occur in the Midwest are transmitted by aphids (see Common Cucurbit Viruses and Transmission Sources table above). However, insect control will not effectively reduce virus incidence in late-season cucurbitis. Early planting will best control pumpkin viruses so fruit can set before virus diseases become apparent. For example, southern Indiana growers should plant by June 20. Proper virus diagnosis is critical. Chemical drift sometimes mimics virus symptoms.
Aphid management with border crops

Aphid management with border crops

contrast between brown and green attracts aphids to land

potato

a border crop that does not harbor the virus

DiFonzo et al., 1996
Fewer aphids landed on the outer edge of the potato when it had a crop border.

Aphids “clean” virus off on border crop.

DiFonzo et al., 1996
Cucumber beetle and bacterial wilt

Pathogen transmission by vector
Cucumber beetle and bacterial wilt

**cucumber or muskmelon**

**BORDER:**
- squash with imidacloprid drench
- planted 2 weeks prior to main crop

*Trap crops, the basics:* [http://www.youtube.com/watch?v=ELP1ylYJxco](http://www.youtube.com/watch?v=ELP1ylYJxco)

*Pathogen transmission by vector*
MAIN CROP: Muskmelon

TRAP CROP: Buttercup squash

Vector - pathogen interactions

**IMMEDIATE**
pathogen changes
vector behavior
non-persistent

**DELAYED**
pathogen changes
host plant suitability
for the vector
persistent

The effect of potato leafroll virus on *Myzus persicae* adult longevity on potato.
Srinivasan et al. 2008 Env. Entomol.
Non-vector pathogen interactions

Most insect herbivores are not vectors of plant pathogens!

53 bean arthropod pests $\rightarrow 94\%$ non-vector

54 tomato arthropod pests $\rightarrow 83\%$ non-vector

Hatcher & Paul, 2001
Non-vector pathogen interactions

Non-vector herbivores

Examples: physical wounding allows pathogen entry, honeydew provides nutrients for pathogen growth

Feeding on plant causes changes

Examples:
1. *induced susceptibility*: above ground insects cause increase in crown rot severity

2. *induced resistance*: induced immunization of plants against pathogens, hypersensitive response, lignification

Hatcher, Biol. Rev. 1995
These types of interactions are likely to be variable!

Figure 1. Incidence of cabbage tissue colonization by *Sclerotinia sclerotiorum* in feeding sites caused by lepidopterous insects in greenhouse studies. Numbers in parentheses indicate the experiment number (experiment was conducted three times). Data points indicate mean percentage of infected feeding sites and standard error of the mean for each insect species.

Dillard & Cobb, Crop Protection 1995
Question

You are the owner of an asparagus farm. You notice that the occurrence of the asparagus miner is associated with asparagus stem & crown rot. It seems likely that this positive correlation is due to the fact that the mines provide ideal infection sites for the fungus.

What integrated pest management methods would you use?
Question

You are the owner of an asparagus farm. You notice that the occurrence of the asparagus miner is associated with asparagus stem & crown rot. It seems likely that this positive correlation is due to the fact that the mines provide ideal infection sites for the fungus.

What integrated pest management methods would you use?

• removal of plant debris
• pre-plant soil fumigation
• insecticides/fungicides
Interactions in the agroecosystem

Interactions among three organisms

Weed arthropod interaction
Interactions in the agroecosystem

Interactions among three organisms

Weed pathogen interaction
Impact of weeds on pests

Weeds can serve as alternate hosts for pests when the crop is absent or when it is not in a suitable phenological stage for the pest.
Weeds can alter within field microclimate which in turn may favor pest survival/abundance when the crop canopy is suboptimal.
Impact of weeds on arthropods

Weeds can serve as cues or provide resources for pests, thus recruiting pests to the cash crop.
Indirect impact of weeds on crop through herbivores

Increased herbivore pressure on crop reduces its competitive ability, which in turn leads to increased weed growth.
Indirect impact of weeds on crop through herbivores

Pests move to feeding on weeds...
Impact of weeds on crop pest abundance

Average ±SEM cabbage aphids per plot:
- Weeds present
- Weeds absent

A vs B: Significantly different.
Interaction based on provision of oviposition substrate

Weed-pest interaction

Beet armyworm, *Spodoptera exigua*

Pigweed, *Amaranthus sp.*

Fig. 1. Mean ± SE proportions of the total number of beet armyworm eggs laid that were deposited on the surfaces of excised leaves in a floral aquapic (laboratory) or on potted plants (greenhouse) in no-choice tests. Means accompanied by the same letter within tests (lower case, laboratory; upper case, greenhouse) are not significantly different ($P > 0.05$; Tukey's HSD). Greenberg et al. 2002 Env. Entomol.
Type of weed matters!

Weed-pest interaction

average (±SEM) aster leafhoppers per yellow sticky trap

<table>
<thead>
<tr>
<th>% weediness</th>
<th>38% broad leaves</th>
<th>75% grasses</th>
<th>39% mix of grasses and broad leaves</th>
<th>&lt;1%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select (twice)</td>
<td>B</td>
<td>A</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>Select (3 times)</td>
<td>B</td>
<td>A</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>Lorox (twice)</td>
<td></td>
<td>A</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>Lorox (3 times)</td>
<td></td>
<td>A</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>Select+Lorox (twice)</td>
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<tr>
<td>Select+Lorox (3 times)</td>
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<td>A</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>Select+Lorox hand weeded (twice)</td>
<td></td>
<td>A</td>
<td>A</td>
<td>A</td>
</tr>
</tbody>
</table>

Aster leafhoppers are averaged across yellow sticky traps with error bars indicating ±SEM.
Grassy weeds increase aster leafhopper abundance

Broadleaf - weeds decrease aster leafhopper abundance
Weed-pest interaction

grassy weeds increase aster leafhopper abundance

broadleaf - weeds decrease aster leafhopper abundance
Interactions between weeds and arthropods

Temporal considerations of weed management

Managing weeds outside the field
Interactions in the agroecosystem

Interactions among four organisms
Green peach aphid

Leafroll (PLRV) persistent

Symptoms on potato

Symptoms on tomato

‘Net-necrosis’
Effect of an alternate weed host on the biology of the two important potato leafroll virus (Luteoviridae: Polerovirus) vectors.
Effect of an alternate weed host on the biology of the two important potato leafroll virus (Luteoviridae: Polerovirus) vectors

Longevity of aphids

Srinivasan et al. 2008 Env. Entomol.
Recommendation from the Midwest Vegetable Production Guide for management of aphids that transmit viruses on peppers

| Grow resistant varieties. Plant disease-free transplants. Eliminate broadleaf weeds within 150 feet of field before crops are established. | Some broadleaf weeds may be reservoirs for pepper viruses. Aphids may spread virus diseases from weeds to peppers and from diseased peppers to healthy peppers. Oil sprays timed with aphid flight periods may prevent virus transmission by aphids but have short-term residual effectiveness. Light-colored and reflective mulches may deter aphids from landing on plants and transmitting the virus. |
IPM to minimize pest interactions

Emphasis on preventive measures:
- Intensive monitoring
- Sanitation: weed control, removal of plant debris
- Quarantine measures
- Virus transmission by arthropod agents

Crop:
- plant resistant varieties
- proper fertilization, irrigation, pruning, drainage, plant spacing

Pathogen:
- virus free seeds, cuttings and other propagation materials

Vector:
- insecticides
- preserve beneficial organisms
- cultural control: i.e. trap crops
- physical/mechanical controls, i.e.: removal of debris