Onion maggot control in onion: can we get off the insecticide treadmill?

Riley Harding and Brian Nault
Cornell University

Cornell AgriTech NEW YORK STATE AGRICULTURAL EXPERIMENT STATION
Onion production on muck in NYS
Onion production on muck in NYS

HIGH IN ORGANIC MATTER
Muck field in production
Onion maggot (*Delia antiqua* Meigen)  
*Diptera: Anthomyiiidae*

- Overwinters as pupa
- Adults emerge springtime
- ≥3 generations per year
- First generation larvae most catastrophic, up to 100% crop loss
- Feed near base onion
Muck field in production
In 2018 a reported 30% loss in yield on one farm
IPM toolbox

CHEMICAL CONTROL

NOVEL TECHNOQUES

CULTURAL CONTROL

IPM

PLANT RESISTANCE

BIOLOGICAL CONTROL
Current Insecticides Labelled

Seed treatments
- FarMore FI500 (thiamethoxam and spinosad)
- Trigard (cyromazine)
- Sepresto 75 WS (clothianidin + imidicoloild)

Drench treatments
- Lorsban (chlorpyrifos)
- Diazinon AG500 (diazinon)
Current Insecticides Labelled

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Do growers need Lorsban?
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- Criticism of broad spectrum insecticides
Do growers need Lorsban?

†Criticism of broad spectrum insecticides

Review
Worldwide decline of the entomofauna: A review of its drivers
Francisco Sánchez-Bayo†‖, Kris A.G. Wyckhuys††

† School of Life & Environmental Sciences, Sydney Institute of Agriculture, The University of Sydney, Sydney, NSW 2006, Australia
‖ School of Biological Sciences, University of Queensland, Brisbane, Australia
†† Chrysalis, House, Viet Nam
‡ Institute of Plant Protection, China Academy of Agricultural Sciences, Beijing, China
Do growers need Lorsban?

- Criticism of broad spectrum insecticides
- Documented resistance in onion maggot
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Francisco Sánchez-Bayo\textsuperscript{*,1}, Kris A.G. Wyckhuys\textsuperscript{2,3,4}
\textsuperscript{1} School of Life & Environmental Sciences, Sydney Institute of Agriculture, The University of Sydney, Sydney, NSW 2006, Australia
\textsuperscript{2} School of Biological Sciences, University of Queensland, Brisbane, Australia
\textsuperscript{3} CIIR-IF, Hanoi, Vietnam
\textsuperscript{4} Institute of Plant Protection, China Academy of Agricultural Sciences, Beijing, China

Onion Maggot (Diptera: Anthomyiidae) Resistance to Chlorpyrifos in New York Onion Fields
Brian A. Nault \textsuperscript{3}, Jian-Zhou Zhao \textsuperscript{4}, Richard W. Straub \textsuperscript{3},
Jan P. Nyrop \textsuperscript{3}, Mary Lou Hessney \textsuperscript{3}
Do growers need Lorsban?

- Criticism of broad spectrum insecticides
- Documented resistance in onion maggot
- Threatened with EPA ban
Do growers need Lorsban?

◊ Criticism of broad spectrum insecticides
◊ Documented resistance in onion maggot
◊ Threatened with EPA ban
Objective

To evaluate onion maggot control using insecticide seed treatments alone or in combination with Lorsban
Objective
Objective

 önemli: patlıcan magot kontrolü, Lorsban drenç eklenmesiyle iyileştirebilir.
## Materials & Methods

<table>
<thead>
<tr>
<th>Seed Treatment</th>
<th>Lorsban Drench</th>
<th>$n=\pm$ (datasets)</th>
<th>Year</th>
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### Materials & Methods

- Plants assessed weekly/bi-weekly for damage by maggot

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**Materials & Methods**

- Plants assessed weekly/bi-weekly for damage by maggot
- Cumulative % plants killed determined at the end of the 1\textsuperscript{st} generation

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Summary of onion maggot control with **FarMore ± Lorsban** (n=5 data sets from 2012-2016)

Proc MIXED (SAS)  
Fixed: TRT  
Random: YEAR REP  
F = 66.5; df=3, 92; p <0.0001
Summary of onion maggot control with **FarMore±Lorsban** (n=5 data sets from 2012-2016)

Mean % plants killed by maggots

- Untreated
- Lorsban
- FarMore
- FarMore + Lorsban

*No benefit of adding Lorsban*

Proc MIXED (SAS)
Fixed: TRT
Random: YEAR, REP
F = 66.5; df=3, 92; p < 0.0001
Summary of onion maggot control with **Trigard±Lorsban** (n= 26 data sets from 2002-2016)

Proc MIXED (SAS)
Fixed: TRT
Random: YEAR REP
F= 101.4; df=3, 451; p <0.0001
Summary of onion maggot control with Trigard±Lorsban (n= 26 data sets from 2002-2016)

Proc MIXED (SAS)
Fixed: TRT
Random: YEAR REP
F= 101.4; df=3, 451; p <0.0001
Lorsban is not necessary for FarMore

Lorsban increases efficacy of Trigard
Plan for the future

- We have chemicals that work, but for how long?
- No reported new chemistries in the pipeline from chemical companies
- Re-evaluate other options in case of future control failures
IPM toolbox

CHEMICAL CONTROL

IPM

PLANT RESISTANCE
IPM toolbox

CHEMICAL CONTROL

IPM

PLANT RESISTANCE
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CHEMICAL CONTROL

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CULTURAL CONTROL
IPM toolbox

- Chemical Control
- Cultural Control
- IPM
- Biological Control
- Plant Resistance
- Cultural Control
IPM toolbox

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NOVEL TECHNIQUES

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IPM

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Plant Resistance: Other Allium *spp.*

- No known cultivars of bulb onion to confer resistance
- Study in 1996 demonstrated other Allium *spp.* (wild leeks and scallions) to confer resistance to OM damage
- Potential for genetic engineering
Biological control

- Entomopathogenic fungi
  - *Beauvaria bassiana*
- Entomopathogenic nematodes
- Parasitoids (Tomlin et al. 1985)

Repressed *Beauveria bassiana* infections in *Delia antiqua* due to associated microbiota

Fangyuan Zhou, Xiaqing Wu, Letian Xu, Shuhai Guo, Guanhong Chen and Xinjian Zhang

Arthropod Parasitoids and Predators of the Onion Maggot (Diptera: Anthomyiidae) in Southwestern Ontario

A. D. Tomlin, J. J. Miller, C. R. Harris, and J. H. Tolman
Research Centre, Agriculture Canada, University Sub Post Office, London, Ontario N6A 5B7, Canada
### Cultural control:

**Crop rotation**

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Cultural control:
Crop rotation
Cultural control: Crop rotation

- Study found adoption of a rotation out of Allium decreased damage by onion maggot significantly.

  (Walters et al. 1996)
Cultural control:
  Delay planting

- Moderate (2wk) delay in onion planting reduces damage by onion maggot
- Onion yield not impacted
- Still need to supplement with insecticide
Delaying Onion Planting to Control Onion Maggot (Diptera: Anthomyiidae): Efficacy and Underlying Mechanisms

Brian A. Nault, Benjamin P. Werling, Richard W. Straub, Jan P. Nyrop

Author Notes

Other techniques:
Sterile Insect Technique

- Reduced risk approach implemented in Quebec
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Sterile Insect Technique

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Other techniques: Sterile Insect Technique

- Reduced risk approach implemented in Quebec
- Male flies are sterilized via irradiation
- Males released to “mate” with wild females and inhibit resident population growths
- 6 yr study, have seen a reduction in onion maggot
Challenges of adopting new tactics

- High value crop; risk of losing crop without insecticidies
Challenges of adopting new tactics

- High value crop; risk of losing crop without insecticides
- Using biologicals in a pesticide intensive system
Challenges of adopting new tactics

- High value crop; risk of losing crop without insecticides
- Using biologicals in a pesticide intensive system
- Cost-effectiveness of novel techniques
Current IPM Strategy

- **Chemical Control**
- **Cultural Control**
- **IPM**
- **Novel Techniques**
- **Plant Resistance**
- **Biological Control**
Goal for IPM in the future

**CHEMICAL CONTROL**
- Seed treatment options
- Decreased use of broadspectrums

**NOVEL TECHNIQUES**
- Sterile insect technique

**CULTURAL CONTROL**
- Crop rotation
- Delay planting

**IPM**

**PLANT RESISTANCE**
- GE of bulb onion with traits from scallion and leek

**BIOLOGICAL CONTROL**
- EPNs
- EPVs
- Parasitoids
Summary

- Reduced chemical options and control
- Criticism of broad-spectrums and decline in entomofauna
- Novel techniques must be employed
- IPM
Zhou et al
Sanchez-Bayo et al
https://www.researchgate.net/publication/291302201_Entomopathogenic_fungi_and_their_role_in_regulation_of_insect_populations
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Worldwide decline of the entomofauna: A review of its drivers

Francisco Sánchez-Bayo\textsuperscript{a*}, Kris A.G. Wyckhuys\textsuperscript{b, c, d, e, f, g, h, i, j, k, l, m, n, o, p, q, r, s, t, u, v, w, x, y, z}
Decline in entomofauna

Review

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### Table 4. Host–parasitoid relationships for several species of Diptera associated with Ontario onion fields

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<td><em>Aleochara bilineata</em> (Gyllenhal)</td>
<td><em>Delta platura</em> (Meigen)</td>
<td>30/271</td>
<td>B, K, L</td>
<td>11.1</td>
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<tr>
<td>(Coleoptera: Staphylinidae)</td>
<td><em>(Diptera: Anthomyiidae)</em></td>
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<tr>
<td><em>A. curtula</em> (Goeze)</td>
<td><em>D. antiqua</em> (Meigen)</td>
<td>0/2,438&lt;sup&gt;a&lt;/sup&gt;</td>
<td>—</td>
<td>0</td>
</tr>
<tr>
<td><em>A. bipustulata</em> (L.)</td>
<td><em>D. antiqua</em></td>
<td>1/1,491&lt;sup&gt;a&lt;/sup&gt;</td>
<td>L</td>
<td>0.07</td>
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<tr>
<td><em>Aphaereta pallipes</em> (Say)</td>
<td><em>D. platura</em></td>
<td>32/271</td>
<td>B, K, L, T</td>
<td>11.8</td>
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<td>(Hymenoptera: Braconidae)</td>
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<tr>
<td><em>A. pallipes</em></td>
<td><em>Fannta canicularis</em> (L.)</td>
<td>2/660</td>
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<td>(Diptera: Muscidae)</td>
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<td><em>M. assimilis</em></td>
<td>1/979</td>
<td>B</td>
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<sup>a</sup> These relationships were only scored from July to Sept. of 1981.
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<td><em>A. bipustulata</em> (L.)</td>
<td><em>D. antiqua</em></td>
<td>1/1,491&lt;sup&gt;a&lt;/sup&gt;</td>
<td>L</td>
<td>0.07</td>
</tr>
<tr>
<td><em>Aphaeeta pallipes</em> (Say)</td>
<td><em>D. platura</em></td>
<td>32/271</td>
<td>B, K, L, T</td>
<td>11.8</td>
</tr>
<tr>
<td>(Hymenoptera: Braconidae)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>A. pallipes</em></td>
<td><em>Fannia canicularis</em> (L.)</td>
<td>2/660</td>
<td>L</td>
<td>0.3</td>
</tr>
<tr>
<td>(Diptera: Muscidae)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>A. pallipes</em></td>
<td><em>Muscina assimilis</em> (Fallén)</td>
<td>9/173</td>
<td>K, L, T</td>
<td>5.2</td>
</tr>
<tr>
<td>(Diptera: Muscidae)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Figitas</em> sp. (Hymenoptera: Figitidae)</td>
<td><em>F. canicularis</em></td>
<td>61/660</td>
<td>B, K, L, T</td>
<td>9.2</td>
</tr>
<tr>
<td><em>Phygadeon</em> sp. (Hymenoptera: Ichneumonidae)</td>
<td><em>M. assimilis</em></td>
<td>1/979</td>
<td>B</td>
<td>0.1</td>
</tr>
<tr>
<td><em>Sphegigaster</em> sp. (Hymenoptera: Pteromalidae)</td>
<td><em>D. antiqua</em></td>
<td>1/1,491&lt;sup&gt;a&lt;/sup&gt;</td>
<td>L</td>
<td>0.07</td>
</tr>
<tr>
<td><em>Stilpnus</em> sp. (Hymenoptera: Ichneumonidae)</td>
<td><em>F. canicularis</em></td>
<td>3/660</td>
<td>B, L, T</td>
<td>0.5</td>
</tr>
</tbody>
</table>

<sup>a</sup> These relationships were only scored from July to Sept. of 1981.
Decline in entomofauna: Hymenoptera taking the hit in NA
Background on dry bulb onion in NYS

- $56 million industry NYS
- 7,000 acres planted in 2018
- Predominately grown on muck soils
- Direct-seeded late April
What are other options besides chemical?

- Entomopathogenic viruses (EPVs)
- Sterile Insect Technique, SIT (Fournier unpublished)
- Crop rotation
- Entomopathogenic nematodes (EPNs)
Introduction
Materials & Methods

- Evaluated products in **small plot field trials** throughout NYS from 2002-2016

- 5 data sets that included FarMore FI500 with and w/o Lorsban 26
  data sets that included Trigard with and w/o Lorsban

- Recorded **# plants killed by onion maggot** during first generation

- **Cumulative % damaged plants** determined at the end of the first generation

- Data analyzed using a mixed model in **SAS** with insecticide treatment as a fixed effect and year and rep as random factors
Current Insecticides Labelled

Seed treatments

- FarMore FI500 (thiamethoxam and spinosad)
- Trigard (cyromazine)
- Sepresto 75 WS (clothianidin + imidicicolprid)

Drench treatments

- Lorsban (chlorpyryrifos)
- Diazinon AG500 (diazinon)