Use of Entomopathogenic Nematodes for Borer Control

John Halbrendt
Greg Krawczyk
Travis Enyeart
Biology:
Hosts: peach, plum, nectarine, cherry, apricots, almond.

• One generation / season. Adults emerge from May to October.

• Eggs are laid on the lower 15 cm of the trunk and nearby soil. Eggs hatch in about one week.

• Larvae chew through the bark to the cambium at the ground level. Wounds or breaks are not needed for the entry.

• Female can lay from 200 to 800 eggs. Larval stages overwinter under the bark.
Peachtree borer

**Injury:**
- Larvae feed on the cambium, and inner bark of the tree from a few inches above to 6 inches below the ground line. Trees exude gum with frass.
- Feeding can girdle older trees and injury can serve as an entrance to pathogenic fungi.

Peachtree borers kill more peach trees in the United States than any other insect.
Peachtree borer control

* Handgun application of insecticides to lower part of trunk to reduce infestation.

**Issues:**
  - Insecticide should be timed to coincide with egg hatch – once under the bark, chemical control is not effective.
  - Insecticides have re-entry and pre-harvest intervals.

* Mating Disruption

**Issues:**
  - Works best on blocks 5 acres or larger.
  - Infestation of edge rows may occur, especially near woods.

* Need for additional / alternative methods
Biology:

Hosts: apple, ornamental trees.

- One generation /season. Adults active from June to August.

- Eggs are typically laid on or near burl knots

- Larvae bore into tissue between the root initials and begin feeding.

- Larvae may take 13-22 months to complete development.
Dogwood borer

**Injury:**
- Feeding is initially confined to the burr knot but may spread to healthy bark.
- Consecutive years of infestation may reduce yields, girdle the tree, and/or eventually kill the tree.
- Reddish frass is usually visible.
Dogwood Borer Management

**Monitoring:**
- Check under tree guards for active infestations.
- Pheromone traps

**Control:**
- Prior to egg laying, apply undiluted white latex paint to lower part of trunk to reduce infestation.
- Trunk sprays with insecticides:

**Additional / Alternative Controls Desirable:**
- Mating disruption
Biological Control of Borers

Entomopathogenic Nematodes (A.K.A. Insect Parasitic Nematodes)

*Steinernema* spp. and *Heterorhabditis* spp.

- Lethal to many important soil insect pests.
- Totally safe for plants and animals.
- Rapid kill: 24 - 48 hours
- Many species are commercially available
Packet containing 25 million live nematodes. They must remain viable until time of application.
Examples: Nematodes as Biological Insecticides in Commercial Crops

<table>
<thead>
<tr>
<th>Crop</th>
<th>Pest</th>
<th>Nematode</th>
</tr>
</thead>
<tbody>
<tr>
<td>Artichokes</td>
<td>Plume moth</td>
<td>S. carpocapsae</td>
</tr>
<tr>
<td>Berries</td>
<td>Root weevil</td>
<td>H. bacteriophora</td>
</tr>
<tr>
<td>Citrus</td>
<td>Root weevil</td>
<td>S. riobravis</td>
</tr>
<tr>
<td>Cranberry</td>
<td>Root weevil</td>
<td>S. carpocapsae</td>
</tr>
<tr>
<td>Mushroom</td>
<td>Sciarid fly</td>
<td>S. carpocapsae</td>
</tr>
<tr>
<td>Ornamentals</td>
<td>Root weevil</td>
<td>H. bacteriophora</td>
</tr>
<tr>
<td></td>
<td>Wood borers</td>
<td>S. carpocapsae</td>
</tr>
<tr>
<td>Turf</td>
<td>Fungus gnats</td>
<td>S. feltiae</td>
</tr>
<tr>
<td></td>
<td>Scarabs</td>
<td>H. bacteriophora</td>
</tr>
<tr>
<td></td>
<td>Mole crickets</td>
<td>S. riobravis</td>
</tr>
</tbody>
</table>
“It is quite simple to apply a pesticide or utilize a high-yielding resistant variety to manage plant diseases, but one has to know a great deal about the biology of a situation in order to use cultural management.” - Thurston (1992)

This is also applies to the use of biological control methods.

“The user needs to understand the biology and ecology of these nematodes as the first step to an effective pest control program.” – H. Kaya
Entomopathogenic Nematode Biology / Life Cycle

• Non-feeding infective juvenile seeks out an insect host. (Only stage found free in soil)

• Enter insect through body opening or thin part of cuticle.

• Release symbiotic bacteria: The bacteria multiply rapidly causing death of the insect and produce antibiotics that suppress secondary invaders of the cadaver.

• Nematodes feed on bacteria and liquefying insect. Nematodes pass through 3rd and 4th juvenile stage to become adults.
Entomopathogenic Nematode Biology / Life Cycle

- Adult nematodes reproduce. One or multiple generations depending on the size of the host.

- The life cycle is complete within a few weeks.

- Infective juveniles retain a supply of symbiotic bacteria before they leave the insect cadaver.

- Infective juveniles are remarkably hardy and depending on storage conditions can remain alive for months or up to a year.

- However, nematodes can not survive desiccation and / or ultraviolet light.
Sclarid fly maggot infected with entomopathogenic nematodes
Adult female Steinernema

Adult male Steinernema
Parasitized wax moth larva releasing infective juvenile stage of an entomopathogenic nematode.
Black current Borer infected with *Steinernema feltiae*

Juveniles are mobile and can infect boring insects within their galleries.
EPN for control of PTB

Previous research has documented the efficacy of Entomopathogenic nematodes to control PTB and LPTB (Kain and Agnelo, 1999; Shapiro-Ilan et al. 2006)

Sterneinema carpocapse and S. feltiae are very effective in laboratory and initial field studies against LPTB and PTB.

The most important considerations are (1) adequate moisture, (2) proper temperature, and (3) product viability and specificity.

Delivery and survival in the field are a challenge for practical application.
Application of “Foam Mulch”
Foam Mulch retained moisture for one - several days depending on conditions.
Fiber Mulch

Binding Agent

Materials used for hydroseeding roadside banks to prevent erosion
Nematodes survived very well in the hydroseeding mulch suspension.
Bioassays evaluating nematode efficacy against Borers and Codling Moth larvae using fiber and shredded paper mulch
100 % mortality of Borers and Codling Moth larvae.
Polyacrylamide granules absorb many times their weight in water and release it slowly under drying conditions.
Nematodes survived more than two weeks in a polyacrylamide suspension at room temperature.

Polyacrylamide produces a gel that prevents rapid drying.
Large scale application requires heavier equipment and a small hydroseeder works very well.
HYDROMULCH RECIPE

• 50 gal water

• 25,000,000 nematodes (@ 500,000 nematodes per gal.)

• @ 6 lb commercial fiber mulch

• one cup of Turbosorb (Polyacrilimide)

• 4 oz ounces Witches Brew (Binding agent)
Application of EPN / mulch
Mulch samples taken 24 and 48 hours after application all contained viable infective juveniles.
<table>
<thead>
<tr>
<th>Treatment</th>
<th>Mortality (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EPN + water</td>
<td>0 %</td>
</tr>
<tr>
<td>EPN + fiber</td>
<td>33%</td>
</tr>
<tr>
<td>EPN + fiber + gel</td>
<td>66%</td>
</tr>
</tbody>
</table>
2012 - Commercial Orchard Experiments

4 Apple Orchards infested with Dogwood Borers
3 Peach Orchards infested with Peach Tree Borers

Treatments applied 2\textsuperscript{nd} + 3\textsuperscript{rd} week of May:
- Turbomulch with nematodes
- Turbomulch without nematodes – control

Random samples collected 2\textsuperscript{nd} and 3\textsuperscript{rd} week of August and checked for presence of EPN

<table>
<thead>
<tr>
<th>No. Samples:</th>
<th>Treatment:</th>
</tr>
</thead>
<tbody>
<tr>
<td>76 Apple</td>
<td>Mulch with nematodes</td>
</tr>
<tr>
<td>57 Apple</td>
<td>Mulch without nematodes</td>
</tr>
<tr>
<td>131 Peach</td>
<td>Mulch with nematodes</td>
</tr>
<tr>
<td>29 Peach</td>
<td>Mulch without nematodes</td>
</tr>
</tbody>
</table>
Average Number of Nematodes recovered from Treated and Untreated Apple and Peach

<table>
<thead>
<tr>
<th>No. Trees</th>
<th>A+EPN</th>
<th>A-Control</th>
<th>P+EPN</th>
<th>P-Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. Trees</td>
<td>76</td>
<td>57</td>
<td>131</td>
<td>29</td>
</tr>
</tbody>
</table>

- A+EPN: 76 trees with 131 nematodes
- A-Control: 57 trees with 57 nematodes
- P+EPN: 131 trees with 330 nematodes
- P-Control: 29 trees with 200 nematodes

Legend:
- EPN
- Free
Dr. David Shapiro-Ilan evaluating a fire-gel (Barricade®) and entomopathogenic nematodes for control of Lesser Peach Tree Borer.
**Estimated Cost of Materials**

*Cost based on calculating amount of material needed to cover an acre and prorating to a per tree basis.*

<table>
<thead>
<tr>
<th>Material</th>
<th>Quantity</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mulch</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50 bales mulch</td>
<td>$500</td>
<td></td>
</tr>
<tr>
<td>Turbosorb</td>
<td>45</td>
<td></td>
</tr>
<tr>
<td>Witches Brew</td>
<td>70</td>
<td></td>
</tr>
<tr>
<td>Nematodes</td>
<td>7,500</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>$8,115</td>
<td></td>
</tr>
</tbody>
</table>

| Fire-gel          |           |            |
| 65 gal barricade  | $4,160    |            |
| Total             | $11,660   |            |

Approximately 12,500 gal of material
Using ½ gal of material / tree = 25,000 treated trees

@ $0.33 / tree @ $0.47 / tree

<table>
<thead>
<tr>
<th>Number of Trees</th>
<th>Cost</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>300</td>
<td>$99</td>
<td>$141</td>
</tr>
<tr>
<td>600</td>
<td>$198</td>
<td>$282</td>
</tr>
</tbody>
</table>
Summary:
We have developed a novel technique to apply EPN to tree trunks that provides protection from desiccation and UV light.

The nematodes remain viable and active for days allowing them to find and enter borer galleries.

Optimum application conditions such as fog, mist or cloudy days should prolong viability and improve efficacy.
We would like to thank:

• The State Horticultural Association of Pennsylvania (SHAP) for supporting the early stages of this project.

• Northeast SARE for subsequent funding allowing us to scale up to a commercial level.