Management Ideas for Plant-parasitic Nematodes in Juice and Wine Grapes

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Nematodes and grapes worldwide

- Plant-parasitic nematodes are production limiting in most grape producing regions
- Species present will depend upon location
- Most commonly found genera:
  - *Meloidogyne* (root-knot)
  - *Xiphinema* (dagger)
  - *Mesocriciconema* (ring)
Meloidogyne spp. (Root-knot)

Many hosts:
Potato, alfalfa, mint, onion, dandelion, chickweed, nightshade, clover, mustards

Species:
- *M. hapla*
- *M. incognita*
- *M. javanica*
- *M. arenaria*

Sedentary endoparasite

Pictures from ipcnet.org
**Xiphinema spp. (Dagger)**

**Hosts and Distribution:**
Worldwide, mostly woody perennials and broadleaf weeds

**Important species in grape:**
- X. americanum
- X. revesi
- X. pachticum
- X. index

**Migratory ectoparasite**

**Nematode transmitted viruses:**
- Tomato ringspot virus
- Grape fanleaf virus
- Tobacco ringspot virus

All stages feed and survive
Fact or Fiction? Dagger nematodes

Many types of nematodes can transmit viruses.  
**FICTION**

Dagger nematodes are commonly found in WA.  
**FACT**

NEPO viruses are widespread in WA vineyards.  
**FICTION**
Fact or Fiction? Dagger nematodes

Dagger nematodes are difficult to control. **FICTION** and **FACT**

- Planting vines free of viruses is the best way to manage nematode transmitted viruses. **FACT**
- There are rootstocks resistant to dagger nematode. **FICTION (for now)**

Predatory nematodes can be used to control dagger nematodes. **FICTION (for now)**
**Mesocriciconema xenoplax** (Ring)

**Hosts and Distribution:** Worldwide, mostly woody perennials

Migratory ectoparasite

All stages feed and survive

Picture from Jack Pinkerton
Research on Concord grape in WA

Effects of *Macroposthonia xenoplax* on the Growth of Concord Grape

G. S. SANTO and W. J. BOLANDER

Abstract: Concord grape (*Vitis labrusca*) plants were inoculated with *Macroposthonia xenoplax* at levels of 100, 1,000, and 10,000 nematodes. After 4 months, plants inoculated with 10,000 *M. xenoplax* were stunted, and root systems were darker and had fewer feeder roots than those in other treatments. The lower nematode inoculation levels suppressed top growth but did not affect root growth. *M. xenoplax* reproduced well on Concord grapes. Key Words: *Vitis labrusca*, ring nematode, reproduction.

- Research conducted in 1976
- No other information available
Current status of nematode management

• Limited number of products available
• Restrictions on the use of soil fumigants
• Alternative management practices exist (rotation, cover crops, biological control)
• Plant resistance cornerstone to any nematode management program
• Future methods and targets?
Decision-making for nematode management

- Decide to Replant a Vineyard
- Sample for Plant-Parasitic Nematodes
- Pre-plant Nematode Management
- Planting Material Selection
- Plant Establishment and Health
- Post-plant Nematode Management

**How can knowledge of nematode biology drive these decisions?**
Decision-making for nematode management

Decide to Replant a Vineyard

Sample for Plant-Parasitic Nematodes

Pre-plant Nematode Management

Planting Material Selection

Plant Establishment and Health

Post-plant Nematode Management

How

Interpretation

Vineyard Renovation

Fumigation

Rootstock

Own-rooted

How can knowledge of nematode biology drive these decisions?
Cropping history

Scenarios that may cause you to pause and think:

• Old orchard with history of nematode transmitted viruses
• Vineyard replant site
• Field with a history of potato, alfalfa, or mint production
Decision-making for nematode management

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How can knowledge of nematode biology drive these decisions?
Biology-driven sampling

**Horizontal**

Vine spacing 6 ft, emitter spacing 4 ft (35 samples)

- x = sampling location
- = vine
- = emitter
- = potential wetting zone

**Vertical**
Biology-driven sampling

Some nematodes have very defined habitats while others don’t...
## Interpretation of results

<table>
<thead>
<tr>
<th>Common name</th>
<th>Scientific name</th>
<th>Occurrence (%)</th>
<th>WA threshold (#/250 g soil)</th>
<th>Reported damage potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>Root-knot</td>
<td><em>Meloidogyne hapla</em></td>
<td>60</td>
<td>100</td>
<td>25-40%</td>
</tr>
<tr>
<td>Ring</td>
<td><em>Mesocriconema xenoplax</em></td>
<td>14</td>
<td>300</td>
<td>12%</td>
</tr>
<tr>
<td>Dagger</td>
<td><em>Xiphinema americanum</em></td>
<td>59</td>
<td>25</td>
<td>?</td>
</tr>
<tr>
<td>Lesion</td>
<td><em>Pratylenchus sp.</em></td>
<td>45</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>Pin</td>
<td><em>Paratylenchus sp.</em></td>
<td>50</td>
<td>None</td>
<td>?</td>
</tr>
</tbody>
</table>
Sampling summary

• Sample directly under emitters to a depth of ~12 inches
• What about overhead irrigated Concord grapes?
• If densities exceed “theoretical” thresholds consider treatment
• Data indicates that *Pratylenchus* is not a parasite of grape in this system
• When considering the presence of *Xiphinema* also consider if viruses are present
• Unfortunately, interpretation of sample reports is not straight-forward
Decision-making for nematode management

- Decide to Replant a Vineyard
- Sample for Plant-Parasitic Nematodes
- Pre-plant Nematode Management
- Planting Material Selection
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- Post-plant Nematode Management

How can knowledge of nematode biology drive these decisions?
Soil fumigants

- 1,3-Dichloropropene plus chloropicrin (Telone products)
  - 1,3-D is the 6th most abundantly used pesticide in the U.S.
- Vapam (metam sodium)
- K-pam (metam potassium)
- Dominus (allyl isothiocyante)

**Goal of fumigation:** Reduce nematode population densities in an area to allow for successful plant establishment
Vapam drip fumigation trial

- Trial established fall 2014
- Vines treated with glyphosate/Vapam or not
- Replanted spring 2015

Pre-fumigation densities:
- 73 *M. hapla*/250 g soil
- 213 *Xiphinema*/250 g soil
Non-fumigant strategies

• Cover crops
• Fallow
• Anaerobic soil disinfestation
• Solarization
• Brassica seed meals
• Others?
Pre-plant management summary

- Fumigation does not eliminate nematodes from a vineyard
- Nematodes vary in response to fumigants
- Make every effort to maximize fumigant efficacy
- How do other pre-plant management strategies fit into WA vineyards?
Decision-making for nematode management

- Decide to Replant a Vineyard
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- Post-plant Nematode Management

- How
- Interpretation
- Vineyard Renovation
- Fumigation
- Rootstock
- Own-rooted

How can knowledge of nematode biology drive these decisions?
Own-rooted vines in WA

- Own-rooted vines are predominately grown
- Concerns over frost damage
- Limited information on use of rootstocks for nematode management in this region
Northern root-knot nematode prefers Chardonnay.
Greenhouse evaluation of rootstocks

Added 9000 *M. hapla* eggs to pots

Number of *M. hapla*/pot
Rootstock field trial

- Trial established fall 2014
- Vines treated with glyphosate/Vapam or not
- Subplots vine type
- Replanted spring 2015

<table>
<thead>
<tr>
<th>Rootstock</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>101-14 MTG</td>
<td>Moderate to high nematode resistance. Phylloxera and crown gall resistance. Low vigor low drought tolerance.</td>
</tr>
<tr>
<td>Harmony</td>
<td>Nematode and crown gall resistant. Not phylloxera resistant.</td>
</tr>
<tr>
<td>Teleki 5C</td>
<td>Moderate nematode resistance. Moderate vigor. Early ripening.</td>
</tr>
</tbody>
</table>

Own-rooted Chardonnay Industry standard
Rootstock field trial

Data collected
- Nematode population densities spring/fall
  - *M. hapla* egg densities fall
  - Pruning weights
  - Fruit yield and quality

Added *M. hapla* to some vines (NF+)
Rootstock field trial

Pre-fumigation densities:
73 M. hapla/250 g soil

6-months after planting

Fum (F) $P = 0.0396$
Root (R) $P = 0.0016$
F*R $P = 0.0561$
Rootstock field trial

Pre-fumigation densities:
73 M. hapla/250 g soil

1.5-years after planting

Fum (F) $P = 0.2724$
Root (R) $P = 0.0002$
F*R $P = 0.3422$
Rootstock field trial

2.5-years after planting

Meloidogyne hapla juveniles/250 g soil

Fum (F) $P = 0.3968$
Root (R) $P = 0.0002$
F*R $P = 0.7642$

Fumigated
Non-fumigated
Non-fumigated + M. hapla
Rootstock field trial

Own NG  Harmony  Own G  101-14  1103P  5C
Plant selection summary

- Only plant vines certified free of viruses and nematodes
- Consider the use of red varieties on sites with *M. hapla* to slow population growth
- Teleki 5C appears to support low root-knot nematode populations at a range of densities
- Ability of rootstocks to keep nematode populations low may be density dependent
Decision-making for nematode management

1. Decide to Replant a Vineyard
2. Sample for Plant-Parasitic Nematodes
3. Pre-plant Nematode Management
4. Planting Material Selection
5. Plant Establishment and Health
6. Post-plant Nematode Management

How can knowledge of nematode biology drive these decisions?
Registered post-plant nematicides

- Movento (spirotetramat)
- DiTera (*Myrothecium verrucaria*)
- Nema Q (*Quillaja* saponins)
- Promax (thyme oil)
- Melocon (*Paecilomyces lilacinus* strain 251)
- Cordon (1,3-dichloropropene)
- Luna Privilege (fluopyram)
- 7 neem products (azadirachtin)
- Employ (harpin)
- Enzone (sodium tetrathiocarbonate)
- Admire/Nuprid/Alias (imidacloprid)

From WSU PICOL – Accessed Nov 1, 2017
## Post-plant nematicide trials

Trials established in spring 2014 and 2015

<table>
<thead>
<tr>
<th>Trade name</th>
<th>Chemical Name</th>
<th>Mode-of-Action</th>
<th>Application method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Movento</td>
<td>Spirotetramat</td>
<td>Acetyl CoA carboxylase inhibitor</td>
<td>Foliar</td>
</tr>
<tr>
<td>Nimitz</td>
<td>Fluensulfone</td>
<td>Affect nematode locomotion, pharyngeal pumping, egg laying</td>
<td>Drip</td>
</tr>
<tr>
<td>Velum</td>
<td>Fluopyram</td>
<td>Succinate dehydrogenase inhibitor</td>
<td>Drip</td>
</tr>
<tr>
<td>Salibro</td>
<td>Fluazaindolizine</td>
<td>Unknown</td>
<td>Drip</td>
</tr>
</tbody>
</table>
Post-plant nematicide trials

- Products applied per manufacturer protocols
- Pre- and post-plant nematode sampling
- Pruning weights and fruit yield
Post-plant nematicide trials

Post-Plant Nematicide Performance

Average J2 (#/250g soil)

- Nontreated
- Velum Prime
- Nimitz
- Salibro

Legend:
- Pretreatment
- May-16
- October-16
Biology-driven nematicide application

A developmental model for *M. chitwoodi* on potato

![Graph showing nematode populations and degree-days over time.](image)

*Fig. 3.* Penetration and population development of *Meloidogyne chitwoodi* in field-grown Russet Burbank potato tubers during 1985.

Pinkerton et al. (1999)
Biology-driven nematicide application

Can something similar be done for *M. hapla* on grape?

- Soil samples are taken using a soil probe
- Samples are run through an elutriator to separate roots and J2s.
- Roots are further treated to collect eggs from the root surface
- J2s are counted directly from elutriator.

- Samples collect monthly (Oct – April) and weekly (May – Sept) from WA vineyards
- Juveniles in soil, eggs/g root, and root development monitored
Biology-driven nematicide application

Eggs

Juveniles
• Optimal timing of post-plant nematicicides still to be determined
• A degree-day model of nematode development may help
• Can a vineyard be “rescued” from nematodes?
Conclusions

Decide to Replant a Vineyard
Sample for Plant-Parasitic Nematodes
Pre-plant Nematode Management
Planting Material Selection
Plant Establishment and Health
Post-plant Nematode Management

How
Interpretation

Vineyard Renovation
Fumigation

Rootstock
Own-rooted

Yes
No

How can knowledge of nematode biology drive these decisions?
Future directions

- Continue monitoring existing field trials
- Demonstrate impact of nematodes on vine productivity
- Expand research to include Concord grape?
Thank you
<table>
<thead>
<tr>
<th>Nematode species</th>
<th>Common name</th>
<th>Mean (max) no./250 g soil</th>
<th>% Occurrence relative to total samples collected</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Meloidogyne hapla</em></td>
<td>Northern root-knot</td>
<td>85 (1,088)</td>
<td>60</td>
</tr>
<tr>
<td><em>Xiphinema</em> sp.</td>
<td>Dagger</td>
<td>25 (284)</td>
<td>59</td>
</tr>
<tr>
<td><em>Pratylenchus</em> sp.</td>
<td>Root lesion</td>
<td>9 (155)</td>
<td>45</td>
</tr>
<tr>
<td><em>Mescocriciconema xenoplax</em></td>
<td>Ring</td>
<td>5 (170)</td>
<td>14</td>
</tr>
<tr>
<td><em>Paratylenchus</em> sp.</td>
<td>Pin</td>
<td>54 (981)</td>
<td>50</td>
</tr>
<tr>
<td><em>Tylenchorynchus</em> sp.</td>
<td>Stunt</td>
<td>0 (12)</td>
<td>8</td>
</tr>
<tr>
<td><em>Trichodorus</em> sp.</td>
<td>Stubby</td>
<td>2 (2)</td>
<td>2</td>
</tr>
</tbody>
</table>
Biology-driven sampling

Further support of the relationship between nematodes and vines
Fact or Fiction? Dagger nematodes

- First report of nematode transmitting viruses made in 1958
- Only a few types of nematodes can transmit viruses:
  - 3 genera
  - 30 species
  - 15 viruses
Risk to grape in Washington?

• Limited reports of nematode-transmitted viruses in WA grapes (4-5)
  – Grape fanleaf virus
  – Tobacco ringspot virus

• *Xiphinema* reported in WA
  • *X. revesi* (2014)*
  • *X. pachticum* (2007)
  • *X. americanum* (1993)*
  • ?
Early observations

Root-knot Nematode Population Dynamics Over Time

- Cab Control
- Cab Low
- Cab Med
- Cab High
- Char Control
- Char Low
- Char Med
- Char High

Root-knot nematode juveniles/250 g soil

October-07, April-08, October-08, April-09, October-09, April-10, October-10