Preparing Orchard Soils: Biofumigation and other strategies


Photo: K. Peter

Mid-Atlantic Fruit and Vegetable Convention

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PennState

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Preparing your orchard soils before planting?

Nope, I don't need to prepare my soils=

It takes time!

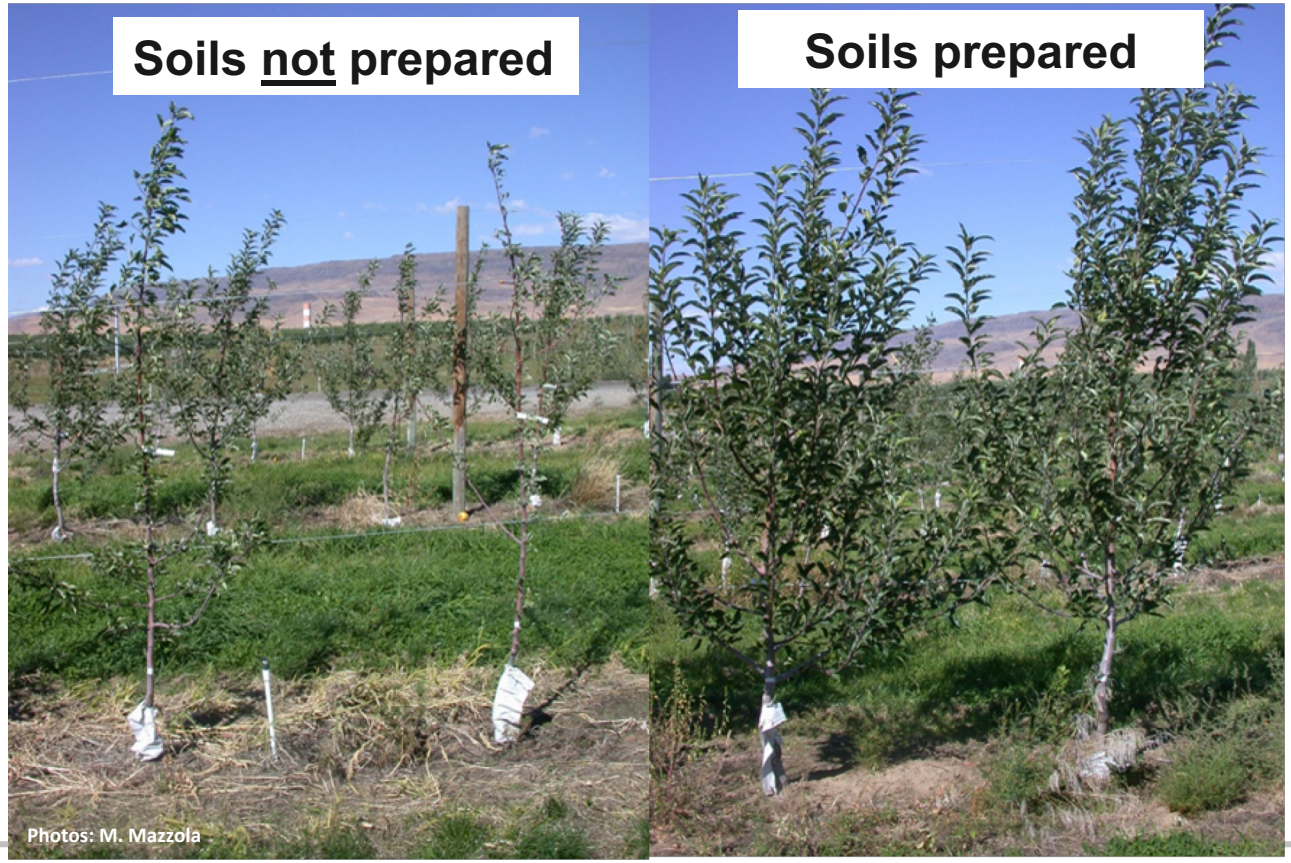
It costs money!

I don't have any problems!

Why orchard soils need to be prepared: Replant issues

Reduced productivity caused by nematodes and other pathogens

Cost: $70,000 to $ 150,000 an acre due to reduced productivity during the first four years of orchard planting*



*Sources: M. Mazzola, USDA-ARS; treefruit.wsu.edu/crop-protection/disease-management/apple-replant-disease/

Understanding the impact of nematodes and what do about it

What are nematodes and why are they so problematic?

- Not all nematodes are bad guys: we only worry about the plant parasitic nematodes
  - Feeding habits and life cycle
  - Survival and spread
  - Culprits
  - Damage
  - Symptoms of nematodes in the orchard

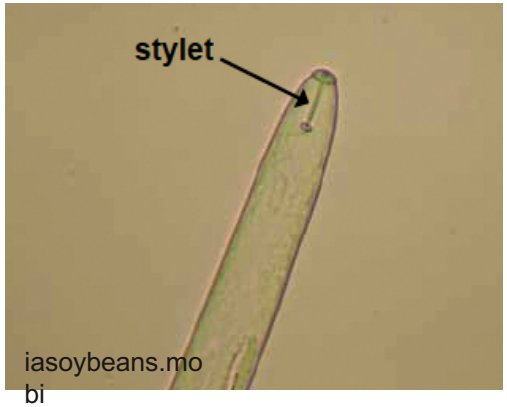
Does your orchard have nematodes?

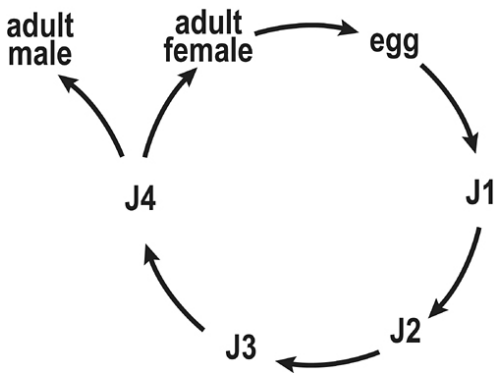
Nematodes are in you orchard –

- Now what?
- Management strategies

Plant-parasitic nematodes: Feeding habits and life cycle

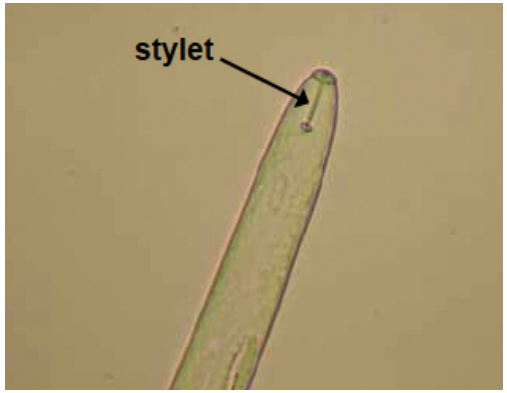
- **Feeding habits**
  - Respond to CO_2 & root exudates
  - Feed using a stylet
  - Ecto-parasites: Feed from outside the root
  - Endo-parasites: Feed from inside of the root
- **Lifecycle**
  - Develop into complete worms within eggs
    - 3 weeks (root-knot) to 2 yrs + (dagger)
- **Obligate parasites: must feed on plant tissue**

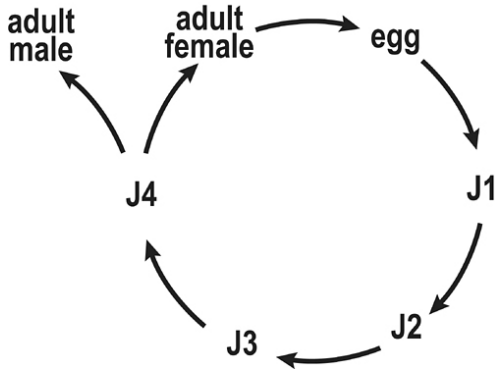




Plant-parasitic nematodes: Survival and spread

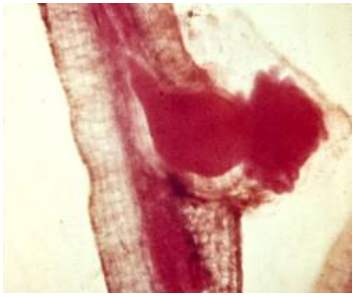
- Lack specialized survival structures
  - Decline quickly in absence of:
    - Host plant
    - Soils dried by drought or winter freezing
  - → Perennial plants (crops and weeds) can continue to support nematodes even in winter
- Survive as eggs (even during winter months)
- Move short distances in thin water layer that coats soil particles
  - Move greater distances through sandy soils
  - Human activities: Long distance movement
    - Soil on equipment
    - Propagative plant parts (example: rootstocks)
    - Irrigation water





Plant parasitic nematodes: The culprits

Most economically important plant-parasitic nematodes in the orchard…

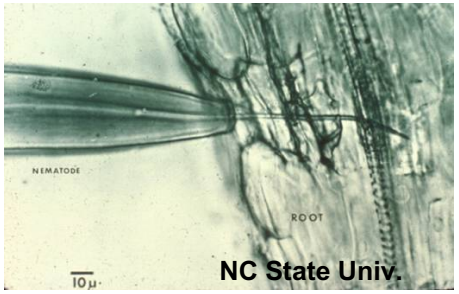


Root-Knot Nematode (RKN) (*Meloidogyne hapla*)

- Sedentary endoparasite
- Galls on roots
- Sandy soils

Root-Lesion Nematodes (*Pratylenchus* spp.)

- Migratory endoparasite
- Higher populations in sandy soils
- Replant issues



Dagger Nematode (*Xiphinema* spp.)

- Ectoparasite
- Vectors Tomato Rinspot Virus (ToRSV)
- Broad host range

Ring Nematode (*Criconemoides xenoplax*)

- Ectoparasite
- Predisposition for canker and winter injury in stone fruit
- Peach tree short life (issue in Southeast)
- Bacterial spot and Bacterial canker
- Sandy soils

Symptoms in the orchard: Nematodes present

→ Tend to be found in “hot spots”

- Poor growth of replanted fruit trees
  - Appearance of being girdled
- Above ground parts:
  - Stunted
  - Short internodes
  - Small leaves
- Root system:
  - Small (may have galls – RKN)
  - Discolored
  - Poorly developed feeder roots
- Tree death: after 1st or 2nd growing season
- Symptoms can be similar to those caused by other factors….(underground insects, nutrient or water deficiencies, RAD)

Symptoms in the orchard: Lesion nematodes present

Lesion nematode – Replant disease connection

- Roots: short, necrotic in tufts resembling witches'-broom
- Damage will depend on initial population density and soil type (worst: sandy soils)
- Apple more sensitive to damage
- Damage a greater problem on dwarfing rootstocks
- Damage is exacerbated when nutrients and soil moisture are limiting

Walter Peraza Padilla, National University of Costa Rica, Bugwood.org

http://www.omafra.gov.on.ca/IPM/english/apples/diseases-and-disorders/apple-replant-disease.html

Symptoms in a peach orchard: Daggers present = ToRSV

Dagger nematode vectors ToRSV

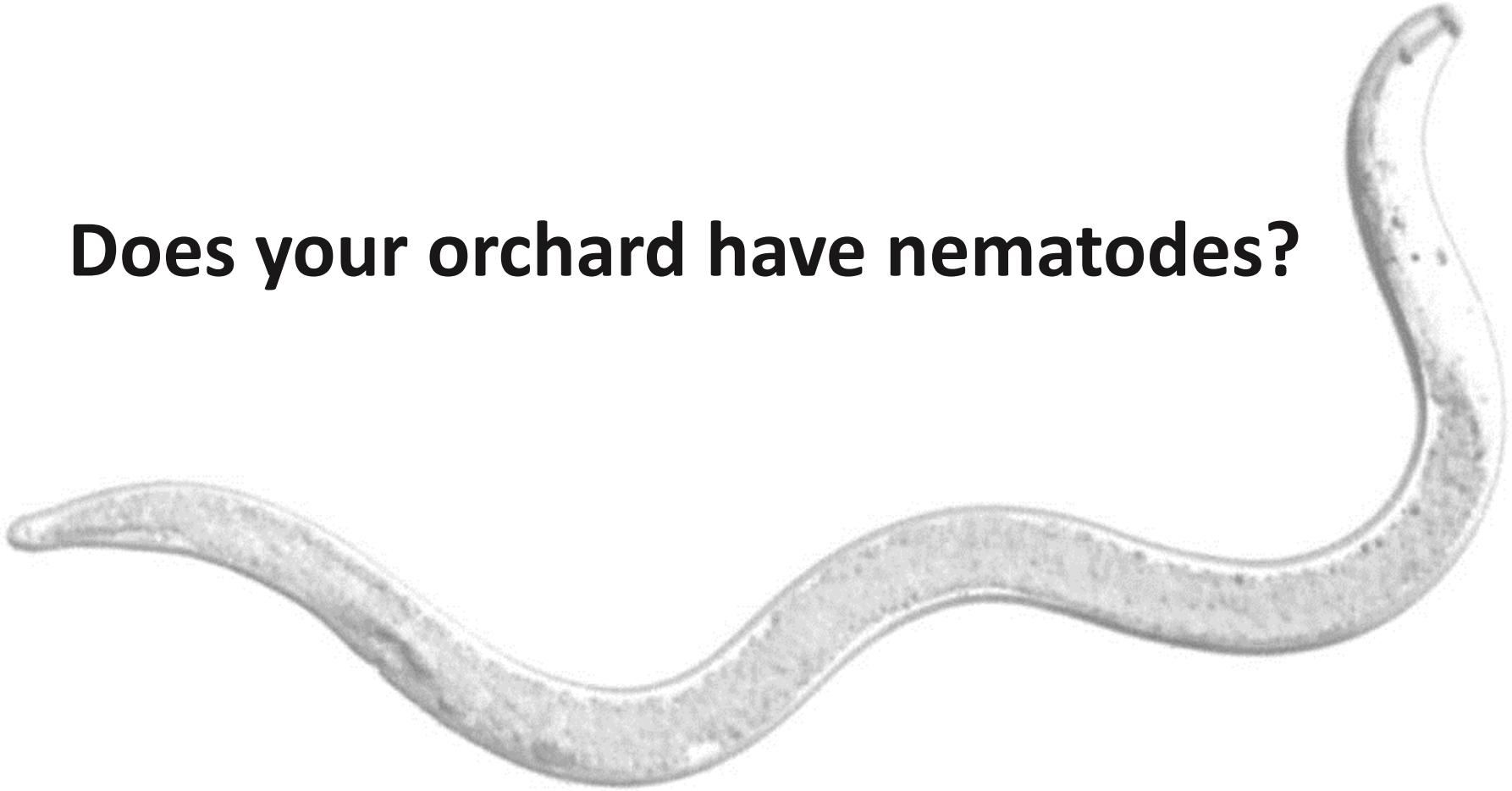
- Stone Fruit: Prunus Stem Pitting
  - Trees appear weak and show general decline
  - Leaves: upward cupping; turning yellow or reddish-purple
  - Bark thick and spongy
    - Pits or grooves may be seen in wood beneath bark of rootstock
    - Pitting may or may not extend across graft union
    - Break off easily at ground level

Symptoms in an apple orchard: Daggers present = ToRSV

- **Apple: Apple Union Necrosis**
  - **Exhibit symptoms when bearing age reached**
  - **Separation of graft union**
  - **Thick, spongy, orange-colored bark**
  - **Distinct necrotic line: Scion-rootstock union**
  - **Union weakened: scion-rootstock separation**
  - **Severity influenced by cultivar-rootstock combo**

Apple Union Necrosis: Due to an incompatibility of a resistant scion grafted onto a susceptible, but tolerant rootstock
Tolerant rootstocks: M.26, MM. 106, MAC-30, MAC-39, P-2
Partially susceptible rootstocks: M.27, MM.111, Bud9, MAC-2, MAC-9, Ottawa 3, P-18
Resistant rootstocks: C6, M.7, P-1, P-22, Robusta 5, Bud-491, MM.102, Ottawa 11, M.2, M.9, P-13, CG10, Bud-146, Kansas-14, OAR-1, CG24, M.4, M.13, P-16, Bud-490, NAC-24, Ottawa 7
Susceptible scions: Stayman, Spartan, Paulared, Winesap, Tydeman's Early, Red Delicious, Ginger Gold
Resistant scions: Rome Beauty, Empire, Golden Delicious

Does your orchard have nematodes?



Information Needed for Nematode Management

KNOW BEFORE YOU PLANT YOUR ORCHARD:

- **Accurate identification of the nematode(s) populations involved**
  - **Examine root system**
  - **Submit soil and root samples to a Nematode Diagnostic Laboratory**
- **Damage threshold densities – can vary by state**
- **Target crop plants: annual vs. perennial crops, etc.**
- **Cost-benefits of nematode damage/crop loss and cost of management options(s)**
- **Optimal sampling time: Late summer (~Labor day)**

Find out if you have nematodes: Locations for analysis

KNOW BEFORE YOU PLANT YOUR ORCHARD

Pennsylvania no longer evaluates soil samples for nematodes. Other universities have capabilities--Need to call if they will accept out-of-state samples; instructions on website:

Michigan State University
http://www.pestid.msu.edu/
Phone: (517) 355-4536
Fax: (517) 432-0899
pestid@msu.edu

Clemson University
http://clemson.edu/plantclinic
Phone: 864-646-2133
Fax: 864-646-2178
Email: nemalab@clemson.edu

Rutgers University
http://www.njaes.rutgers.edu/services
Phone: 732-9332-9140
Fax: 732-932-1270

Table 11.6. Nematode Treatment Guidelines

	No./100 cc[1]	
Nematode	**Peach**	**Apple**
Lesion	60-80	40-60
Stunt	60-80	60-80
Spiral	40	40
Stubby Root	16	16
Dagger	any – as virus vector 16+ for feeding injury	any – as virus vector 16+ for feeding injury
Ring	24	30
Cyst	not economic	not economic
Sting	8-10	8-10
Lance	40-60	40-60
Root Knot	any in new plantings	not economic

From the 2015 NJ Commercial Tree Fruit Production Guide

Nematodes are in your orchard -- Now what?

Management Strategies

Controlling nematodes: Using cover crops

Types of crops: Efficacy depends on nematode present

- Crucifer crops: mustards, rapeseed, oilseed radish, etc.
  - →Rapeseed: requires sulfur to produce nematicidal compounds

- Sudangrass and sorghum-sudangrass hybrids
  - →Nematicidal properties
  - →Non-host: does not support nematode population

- Crop rotations = ideal!*
  - Reduce and/or kill nematodes
  - Example:
    - Sorghum – sudangrass summer
    - Rapeseed (Dwarf Essex) winter

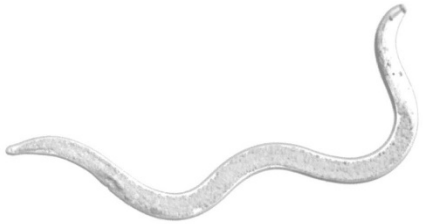
Nematode reduction:
> 10 Daggers → 0 Daggers
> 10 Lesion → 0 Lesion

*USDA – NIFA BFRDP Agreement Number: 2014-07502; Dr. Tara Baugher, Project Director

Controlling nematodes: Cover crops as biofumigants

Timely incorporation of a cover crop as a green manure

→ **Ability to release toxic products that are lethal to the nematodes upon decomposition**



- **Chop cover crop into small pieces (flail mowing)**
- **Incorporate the cover crop immediately after mowing**
- **Irrigate or cultipack to trap compounds**
- **The more cover crop = the more bio-active compounds available**

Example: Cover crop suitability as hosts for Root-Lesion Nematodes

→ Nematodes feed on non-host = numbers reduce

→ If non-host for dagger = will lose virus

Slide courtesy of Beth Gugino

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Example: Incorporation of cover crops as green manures against Root-Lesion Nematodes

→ Nematicidal properties released when incorporating cover crops = reduce nematode population

Slide courtesy of Beth Gugino

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Cover crops as biofumigants: Significant benefits

- **Economical***
  - → Investment in establishment: $386/A for apple
  - → Return: $4600
  - → Savings from not using a pre-plant nematicide: $1000-2000/A
- **Additional benefits**
  - → Reduces weed issues
  - → Increases soil organic matter
  - → Improve nutrient availability
  - → Controls erosion
  - → Can improve drainage, aeration, soil texture
  - → Environmentally friendly (chemical input reduced)
- **For full benefit: Weeds must be controlled**

*USDA – NIFA BFRDP Agreement Number: 2014-07502; Dr. Tara Baugher, Project Director

Chemical fumigation

Slide courtesy of Beth Gugino

Chemical fumigation: What and how

- General biocides: pathogens, nematodes, weeds
  - Vampam HL
  - Telone II
  - Telone C-17
  - Telone C-35
  - Basamid
- Injected – diffuse upward and laterally
- High vapor pressure necessitates tarping
- Efficacy affected by temperature, rainfall, soil texture, etc.
- Recommendation: Apply fumigants late summer/early fall; plant trees following spring

→Soil fumigants must be applied by certified applicators

→Current regulations and requirements

EPA: Soil Fumigant Toolbox: https://www.epa.gov/soil-fumigants

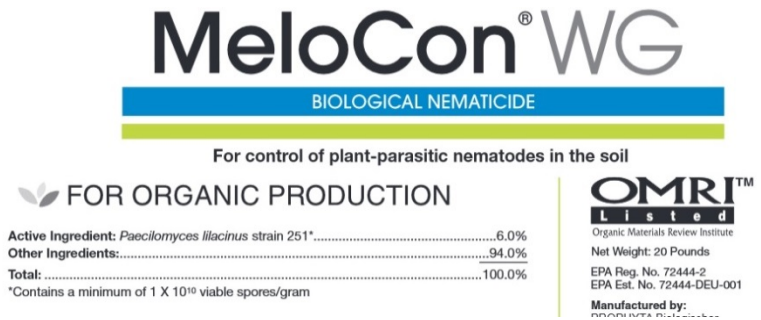
Effective fumigation requires…

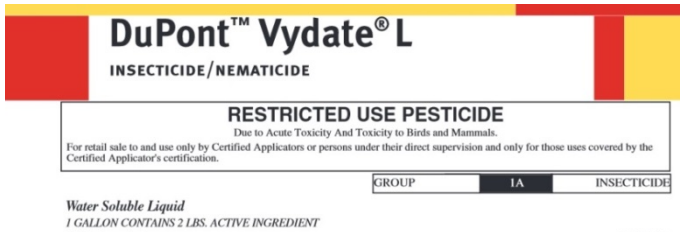
…Good site preparation!

- Soil tilled thoroughly several weeks prior
  - Break up soil clods
  - Encourage decomposition of plant debris
  - Remove large root pieces
- Soil temperature: Do not apply when soil temp at 12 inch depth is below 50°F
- Soil moisture necessary (read label)
  - Well drained
  - Do not apply when too wet or saturated
- Soil type: Higher rates of fumigants needed for heavier clay soils
- Sealing of soil surface
- Apply at least 3 weeks before planting to avoid phytotoxictiy

Non-fumigant nematicides: Via chemigation

- Narrower spectrum of activity
  - Not as effective as fumigants
- Works well when applied in the spring
  - Soil moisture and rainfall plentiful
  - Redistribution depends on water movement
- Active at lower dosages
  - Kills by modifying nematode behavior
- Non-phytotoxic – applied at planting
- Soil temp at application not critical





Nonbearing trees only (= trees that will not bear for 12 months)

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Recent biofumigants and biopesticides on the market

Only limited data is available about efficacy of these products

Dominus (Isagro USA)

- **Allyl isothiocyanate**
- **Broadcast application, flat fume application, chemigation**

Ecozin Plus 1.2 % ME (AMVAC)

- **Azadirachtin- botanical nematicide**
- **Emulsifiable concentrate**
- **Foliar spray, drench**

Insect, nematodes, soil-borne pathogens

Preventing nematode build-up and damage

- **When replanting an orchard: good tree removal**
  → Remove as much of the roots as possible
- **Exclusion/ Sanitation**
  - **Nematodes can move via:**
    → Mechanical equipment
    → Rootstocks
    → Irrigation water
  - **Before planting: biofumigation, fumigant, non-fumigant nematicides**
    - **Crop rotation with cover crops******
- **Minimize crop stress**

Preventing Tomato Ringspot Virus Infection

Knocking back Dagger Nematodes…

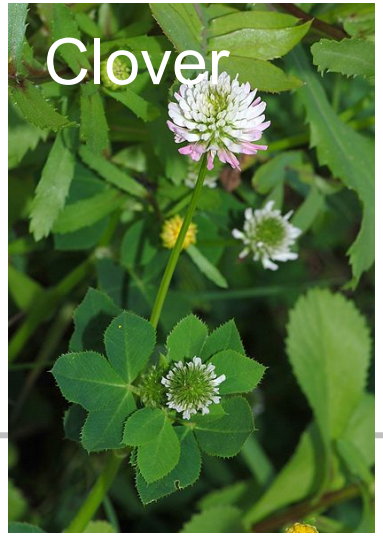
- **Biofumigation: Crop rotations**
- **Buy certified virus-free replants**
  - → Inquire which viruses are included
  - → Don't forget about pollinators!
    - ** Sometimes symptomless carriers
- **Eliminate virus reservoirs**
  - → Prevent sucker re-growth
- **Control broadleaf weeds**
  - → Prevent reintroduction of nematode transmitted viruses

Preventing Tomato Ringspot Virus Infection

Dandelions may function as a vector:

- **Seed infected: Long distance dispersal of ToRSV**
- **A reservoir host functioning as a source of virus for acquisition by nematode vectors**
  - **Short range spread=other weeds**
  - **To apple and peach trees**

23 different weeds are hosts



Reinforcing what we just learned:

Penn State Extension -- Orchard Site Preparation: Bio-renovation

https://www.youtube.com/watch?v=R4y6dw-kO18

Preparing your orchard soils before planting?

Yes, I'll prepare my soils =

I don't want to lose time!

I don't want to lose money!

I don't want any problems!

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