MANAGING PLANT-PARASITIC NEMATODES USING ORGANIC FARMING APPROACHES

Philip Waisen and K.-H. Wang
Root-knot and Reniform Nematodes

- Worldwide there are > 4,100 species of plant-parasitic nematodes.
- $100 billion/yr loss worldwide.
- $10 billion/yr loss in USA.
- Root-knot nematodes can cause 20-38% crop loss.
Root-knot Nematodes

Okra

Beet

tomato

Split roots of carrot

Blemishes on cross section of a potato tuber

Cucurbit crops are most susceptible

Picture: Koon-Hui Wang

Picture: Society of Nematologists

Kona root-knot nematodes on coffee
Reniform Nematodes

Crops in Hawaii most damaged by Reniform nematode

Pineapple

Papaya

Cowpea

Sweet potato

Broad host range
Cover Crops Suppressive to Plant-parasitic Nematodes

- Sunn hemp: Crotalaria juncea -- monocrotaline
- French Marigold: Tagetes patula -- α-terthiyln
- Sorghum-sudangrass: -- Dhurrin
- Radish and mustard: -- glucosinolate
The Secret of Sunn Hemp in Suppressing Plant-parasitic Nematodes

Mechanisms:
1. Serves as a poor host
2. Allelopathic
3. Enhance nematode-trapping fungi
4. Enhance beneficial nematodes and soil arthropods, increase plant tolerance

Sunn hemp superhero video:
http://www.youtube.com/watch?v=AG_CYsVmqN4

HānaiʻAi Newsletter June-July-August 2012.
### Effect of crop age, tissues, and biomass amount on SH allelopathic effects

<table>
<thead>
<tr>
<th>1 month</th>
<th>2 month</th>
<th>3 month</th>
<th>4 month</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="1 month" /></td>
<td><img src="image2.png" alt="2 month" /></td>
<td><img src="image3.png" alt="3 month" /></td>
<td><img src="image4.png" alt="4 month" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>4 ages × 4 tissues × 5 Concentration</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaf</td>
<td>2.5%</td>
</tr>
<tr>
<td>Stem</td>
<td>1.0%</td>
</tr>
<tr>
<td>Flower</td>
<td>0.5%</td>
</tr>
<tr>
<td>Roots</td>
<td>0.1%</td>
</tr>
<tr>
<td>Whole plant</td>
<td>0</td>
</tr>
</tbody>
</table>

4 dishes, 2 trials
Effect of crop age, tissues, and biomass amount on SH allelopathic effects

- SH Leaf tissue was most suppressive, and the result resembled those in the whole plant tissues.
- Suppressive effect of SH is most significant at 2- and 3-month old.

<table>
<thead>
<tr>
<th>Conc (%)</th>
<th>Dry Biomass (tons/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>0.5</td>
</tr>
<tr>
<td><strong>0.5</strong></td>
<td><strong>2.5</strong></td>
</tr>
<tr>
<td><strong>1</strong></td>
<td><strong>5</strong></td>
</tr>
<tr>
<td>2.5</td>
<td>12.5</td>
</tr>
</tbody>
</table>
Can we achieve 2.5 to 5 tons dry biomass in Hawaii?

**Graph:**

- **Y-axis:** Dry biomass (tons/acre)
- **X-axis:** Months (Apr-Jun, May-Jul, Jun-Aug, Jul-Sep, Aug-Oct, Sep-Nov, Oct-Dec)
- **Legend:**
  - Blue: pH > 6
  - Red: pH < 5

**Locations and Biomass:**

- **Poamoho:** 8 tons/acre (pH > 6)
- **Hawaii Kai:** 5 tons/acre (pH > 6)
- **Kunia:** 4 tons/acre (pH < 5)
- **Lanai:** 3 tons/acre (pH < 5)
- **Waimanalo:** 2 tons/acre (pH > 6)
- **Whitmore:** 1 ton/acre (pH < 5)

**Seeding Rates:**

- **30 lb seeds/acre**
- **60 lb seeds/acre**

**Preliminary pH Classifications:**

- **A:** pH > 6
- **B:** pH < 5

**Notes:**

- **Holehua:**
- **Waimanalo:**
Managing Reniform Nematodes with Sunn Hemp

- Vermiform stage of reniform nematodes are easier to kill than the anhydrobiotic stage.

SH+ = Soil amended with sunn hemp
Irr = land irrigated
SH = planted with sunn hemp
CP = planted with cowpea

Thus, farmers should plant sunn hemp soon after termination of a sweet potato crop.
Cover Crops
Suppressive to Plant-parasitic Nematodes

Sunn hemp
*Crotalaria juncea*
-- monocrotaline

French Marigold
*Tagetes patula*
-- $\alpha$-terthinyl

Sorghum-sudangrass
-- Dhurrin

Radish and mustard
-- glucosinolate
MANAGING PLANT-PARASITIC NEMATODES USING TRAP CROPPING AND BIOFUMIGATION

Philip Waisen* and K.-H. Wang
Plant-parasitic Nematodes

- > 4,100 species of plant-parasitic nematodes are known
- $100 billion/yr loss worldwide
- $10 billion/yr loss in USA
- Root-knot nematodes can cause 20-38% crop loss
- Especially damaging to cucurbit crop (no resistant cultivars)
- Cover crops provide great potential to suppress plant-parasitic nematodes.

Sunn hemp
*Crotalaria juncea* -- monocrotaline

French Marigold
*Tagetes patula* -- \(\alpha\)-terthinyl

Sorghum-sudangrass
-- Dhurrin

Radish and mustard
-- glucosinolate
Oil Radish and Mustard as Biofumigants

Glucosinolates + Myrosinase = Isothiocyanates

Cover with black plastic

Weed whacked

Soil incorporated

Glucosinolates

Isothiocyanates

More isothiocyanates

Trap isothiocyanates
**Oil radish and Mustard as Trap Crops**

<table>
<thead>
<tr>
<th>Trap crop</th>
<th>Root-knot nematode</th>
<th>Reniform nematode</th>
<th>Trap cropping effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil radish</td>
<td>Poor host</td>
<td>Poor host</td>
<td>Slightly</td>
</tr>
<tr>
<td>Mustard</td>
<td>Excellent host</td>
<td>Non-host</td>
<td>Good for root-knot</td>
</tr>
</tbody>
</table>

*Anhydrobiotic*
Objectives

- To screen oil radish and mustard cultivars for trap cropping and biofumigation effects against root-knot and reniform nematodes.

- To determine best termination time of oil radish in a field trial.

- To determine best cultural practices for biofumigation effects.
1.1 Susceptibility of radish cultivars to *M. javanica*

<table>
<thead>
<tr>
<th>Radish cvs</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpine</td>
<td>$98.22/lb</td>
</tr>
<tr>
<td>April Cross</td>
<td>$112/ 10 million seeds</td>
</tr>
<tr>
<td>Discovery</td>
<td>N/A</td>
</tr>
<tr>
<td>Miyashige</td>
<td>$76.50/lb</td>
</tr>
<tr>
<td>Oshine</td>
<td>$169.95/lb</td>
</tr>
<tr>
<td>Sodbuster</td>
<td>$2.25/lb</td>
</tr>
<tr>
<td>Summer Cross</td>
<td>$147.90/lb</td>
</tr>
<tr>
<td>Tillage Radish</td>
<td>$3.72/lb</td>
</tr>
</tbody>
</table>

8 oil radish cvs + ‘Orange Pixie’ tomato inoculated with root-knot nematodes, examine for 1 month.

A) Radish gall index; B) Nematodes/250 cm³ soil; C) Nematodes/4-L pot

In the soil
‘Caliente 199’ mustard is an excellent host for root-knot nematode (*M. javanica*) whereas it is a poor host for reniform nematode (*Pi*=1000 IJ2s)
Nematode infested soil was amended with 1% (w/w) residues of 8 oil radish cvs. and compared to unamended control, ‘Orange Pixie’ tomato was used as bioassay crop.

Starting nematode populations
Root-knot = 2130
Reniform = 2270

Plant growth difference on tomato ‘Orange Pixie’
Biofumigation Effect of Oil Radish to root-knot and reniform nematodes

NA = no amendment; AC = April Cross; AL = Alpine; MI = Miyashige; OS = Oshin; SB = Sodbuster; SC = Summer Cross; TR = Tillage Radish
Objectives

- To screen oil radish and mustard cultivars for trap cropping and biofumigation effects against root-knot and reniform nematodes.

- To determine best termination time of oil radish in a field trial.

- To determine best cultural practices for biofumigation effects.
Growing period of Oil Radish as a Cover Crop

<table>
<thead>
<tr>
<th>Growing period</th>
<th>Termination of oil radish</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 weeks</td>
<td>2 weeks</td>
</tr>
<tr>
<td>6 weeks</td>
<td>6 weeks</td>
</tr>
<tr>
<td>4 weeks</td>
<td>4 weeks</td>
</tr>
<tr>
<td>2 weeks</td>
<td>8 weeks</td>
</tr>
<tr>
<td>0 week</td>
<td></td>
</tr>
</tbody>
</table>

Oil radish was planted for different length of time (0, 2, 4, 6 and 8 weeks). Experiment was arranged in RCBD with 4 replications. Pumpkin was planted after oil radish (OR) termination and incorporation, nematodes were sampled at OR termination and at 4 weeks after pumpkin planting.
Severity of pumpkin root galls by root-knot nematodes

Root Gall Index based on 0 – 12 scale
Oil radish did not suppress PPN in the soil but reduce root galls on pumpkin

Repeated measure over 3 sampling dates at monthly interval

<table>
<thead>
<tr>
<th>Herbivores</th>
<th>Nematodes/250 cm³ soil</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Root-knot nematode</td>
<td>178 A</td>
</tr>
<tr>
<td>Reniform nematode</td>
<td>371 A</td>
</tr>
<tr>
<td>Stubby root nematode</td>
<td>36 A</td>
</tr>
</tbody>
</table>

Graphs showing gall index and fruit weight over time.
Objectives

- To screen oil radish and mustard cultivars for trap cropping and biofumigation effects against root-knot and reniform nematodes.
- To determine best termination time of oil radish in a field trial.
- To determine best cultural practices for biofumigation effects.
Materials and methods
Cover crop termination and biofumigation

7 Treatments
1) ORT=oil radish + weed whack + till
2) ORBP=oil radish + weed whack + till + black plastic
3) ORNT=oil radish + sickle + weed mat (=NT)
4) MST=mustard + weed whack + till
5) MSBP=mustard + weed whack + till + black plastic
6) MSNT=mustard+sickle + weed mat (NT)
7) BG=Bare ground
Materials and methods

Biomass production

1) ORT=oil radish + weed whack + till; 2) ORBP=oil radish + weed whack + till + black plastic; 3) ORNT=oil radish + sickle + weed mat; 4) MST=mustard + weed whack + till; 5) MSBP= mustard + weed whack + till + black plastic; 6) MSNT=mustard + sickle + weed mat; 7) Bare ground control
Materials and methods

Cover crop termination and biofumigation

1 week after covering weed mat

1 week after covering black plastic

‘Felix’ zucchini transplanted at 3 ft spacing
Biofumigation effects of oil radish and mustard on nematodes

1) ORT=oil radish + weed whack + till; 2) ORBP=oil radish + weed whack + till + black plastic; 3) ORNT=oil radish + sickle + weed mat; 4) MST=mustard + weed whack + till; 5) MSBP= mustard + weed whack + till + black plastic; 6) MSNT=mustard + sickle + weed mat; 7) Bare ground control
Plant growth after incorporation of radish and mustard green green manures

2 weeks after planting

- Chlorophyll (SPAD units)
  - BG
  - MST
  - ORT
  - MSNT
  - ORNT
  - ORBP
  - MSBP

- Canopy width (cm)
  - BG
  - MST
  - MSNT
  - ORT
  - ORBP
  - ORNT
  - MSBP
Conclusions

- ‘Sodbuster' oil radish is a potential conventional trap crop and a good biofumigant cultivar against root-knot and reniform nematodes.

- Terminating oil radish at 4 weeks reduced galling on pumpkin and increased the total fruit weight (74%).

- Weed whacking oil radish or mustard + till + covering black plastic for 1 week reduced plant-parasitic nematodes by 39%. 
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