Nematodes and Citrus IPM

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Nematodes and Citrus IPM

Entomopathogenic nematodes (EPNs) to manage citrus root weevils

Plant parasitic nematodes that attack citrus

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Weevil IPM

- EPNs
- Insecticides (monitoring)
- Fumigation
- Rootstocks
- Cultural practices
  - Soil drainage
  - pH
  - Physical barriers
  - Regional considerations (EPN conservation)

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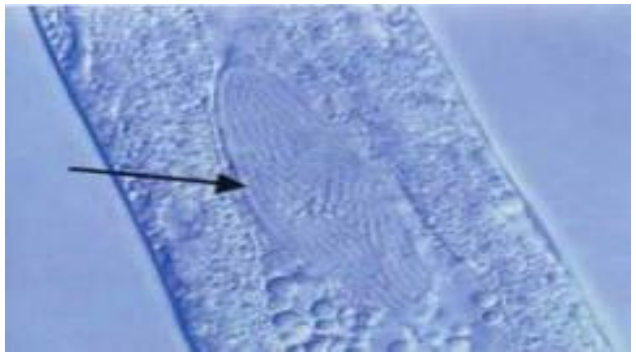
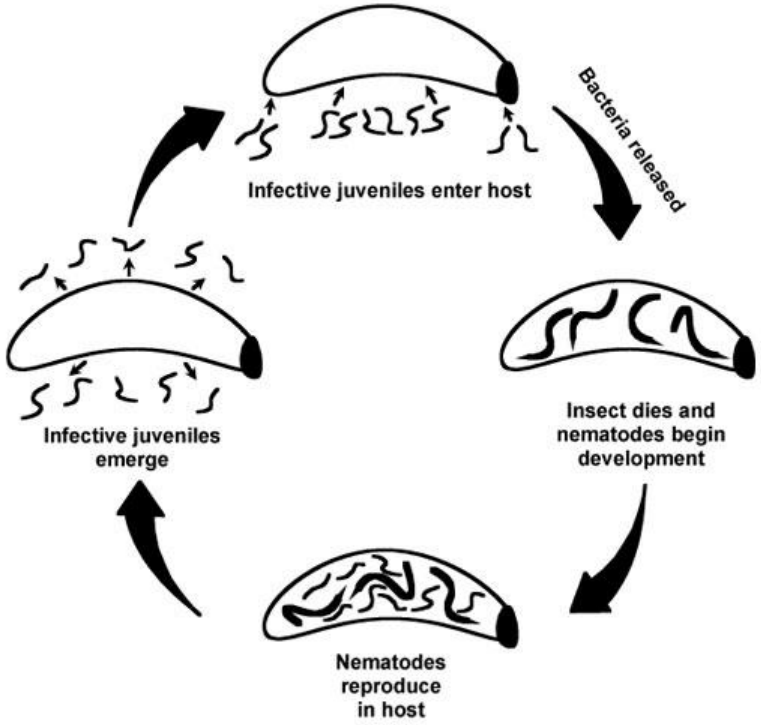
Diaprepes root weevil is difficult to control because:

- ✓ Adults lay eggs that hatch and fall to soil all year long
- ✓ The larvae in soil emerge as adults all year long
- ✓ But the chemical- and bio-pesticides are non-persistent.



EPNs function in association with entomopathogenic bacterial symbionts that provide nutrients and protection from competitors.



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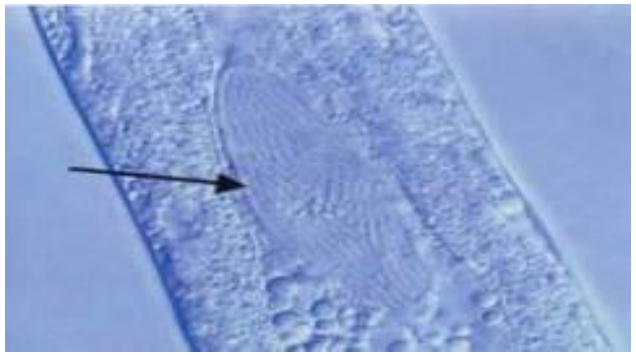
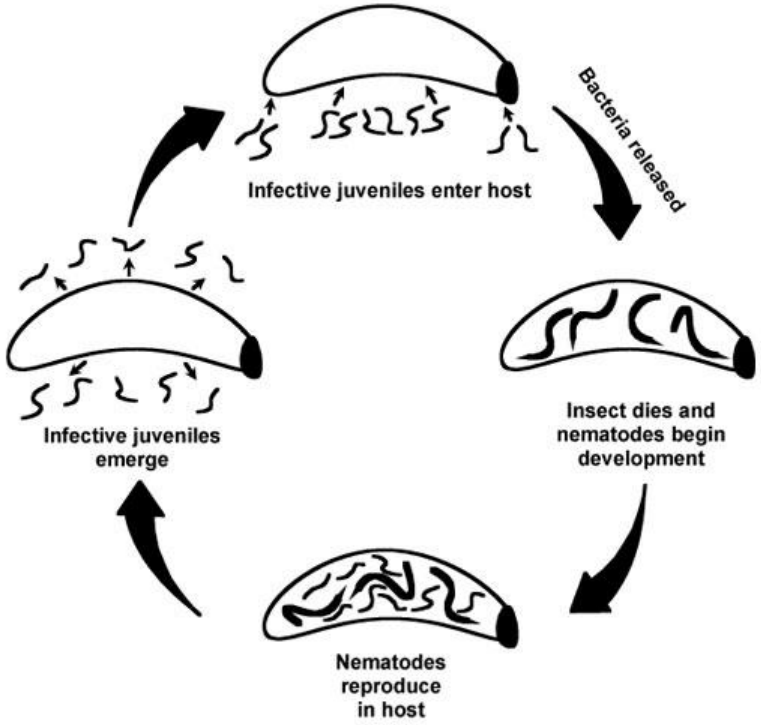


EPNs also function as nonpersistent pesticides. Kill insects in first 1-2 weeks following application, but natural enemies of nematodes soon reduce their numbers.



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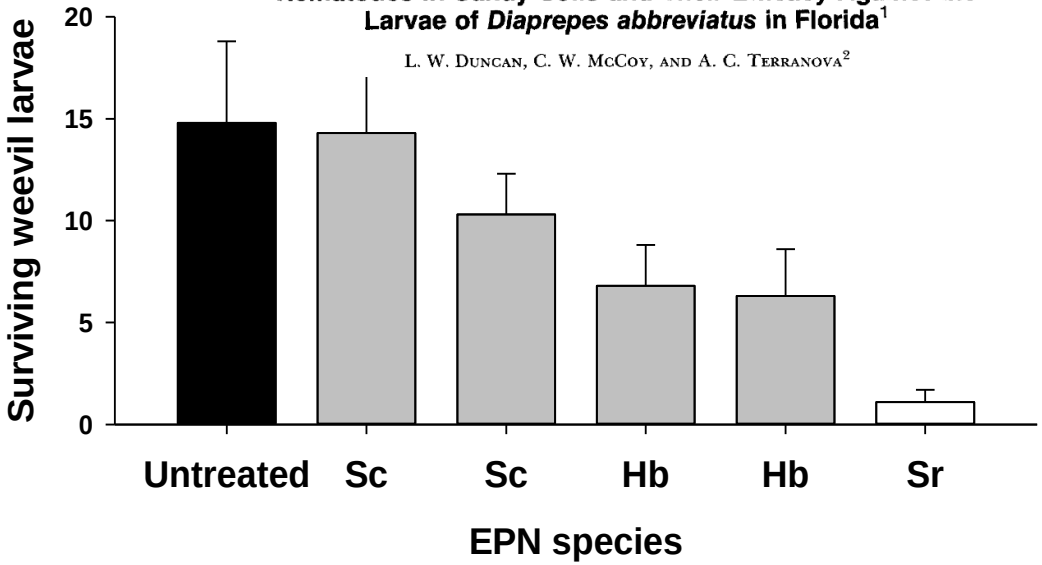
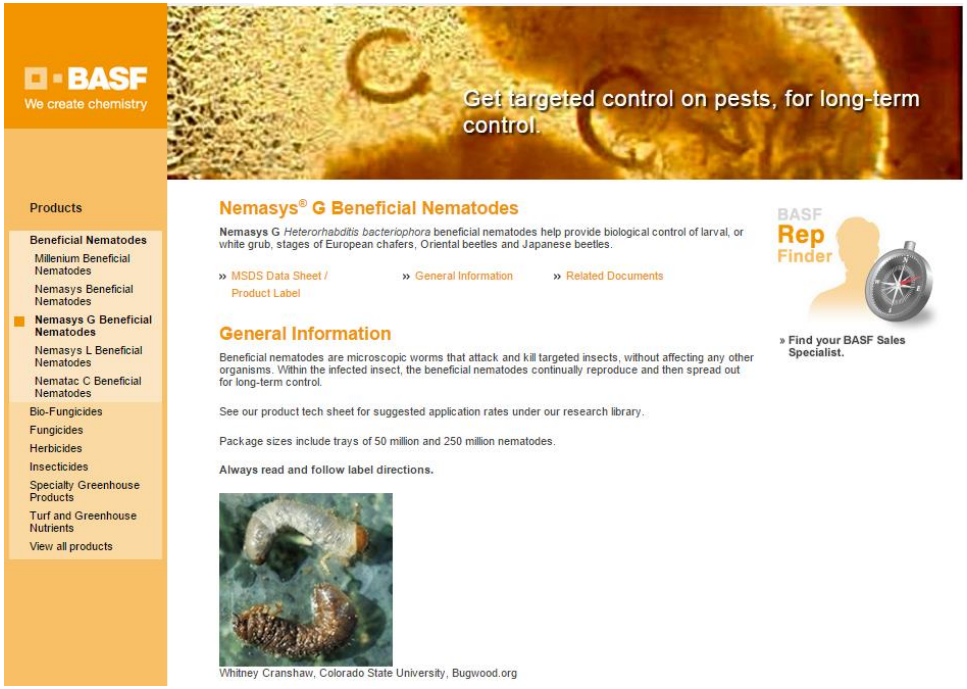
Journal of Nematology 28(1):56–67. 1996.

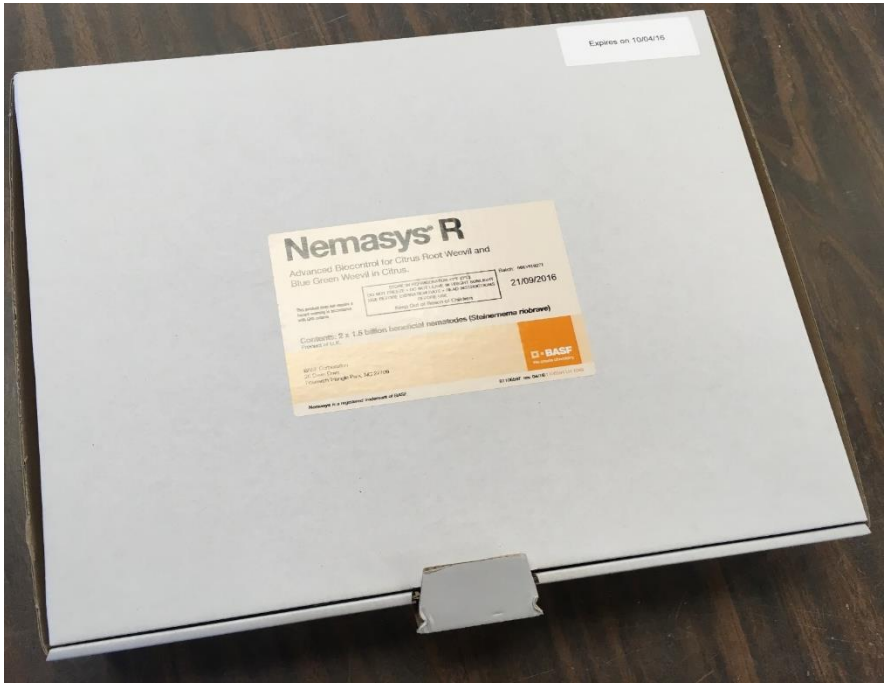
Estimating Sample Size and Persistence of Entomogenous Nematodes in Sandy Soils and Their Efficacy Against the Larvae of *Diaprepes abbreviatus* in Florida[1]

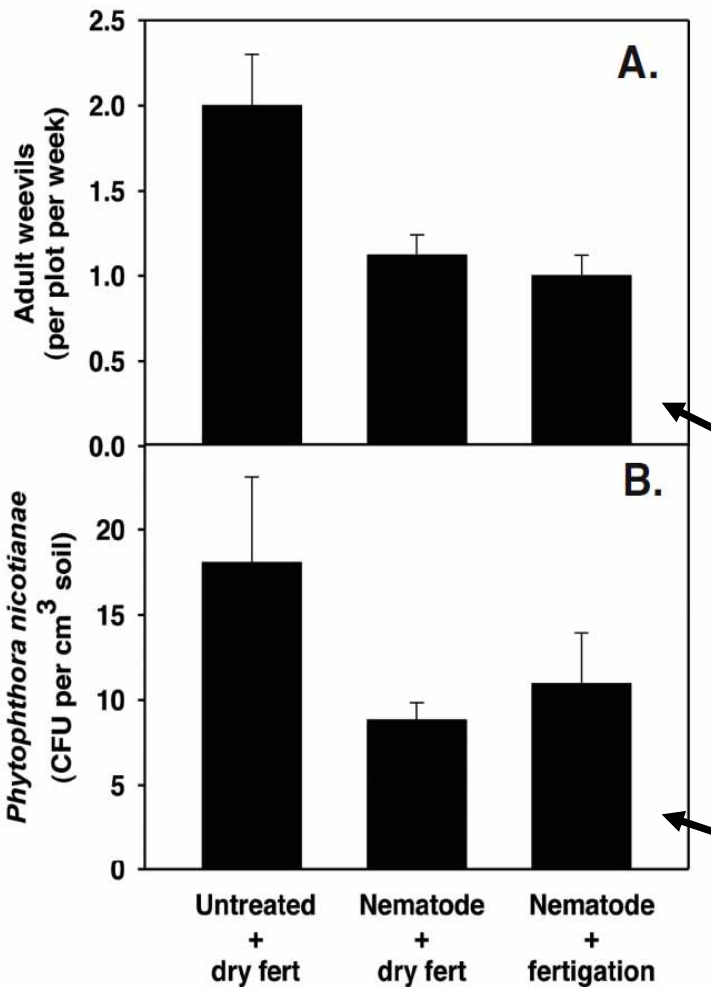
L. W. Duncan, C. W. McCoy, and A. C. Terranova[2]



Twenty years of research has demonstrated that *Steinernema riobrave* is the best known EPN for managing citrus root weevils.







BioVector 355

Steinernema riobrave

Treat 2 x per year
(spring and fall)
25 EPNs per cm^2 soil surface

70-90% mortality of sentinel weevil larvae.

Non-persistent one to two weeks

EPNs control Phytophthora in the pest-disease complex

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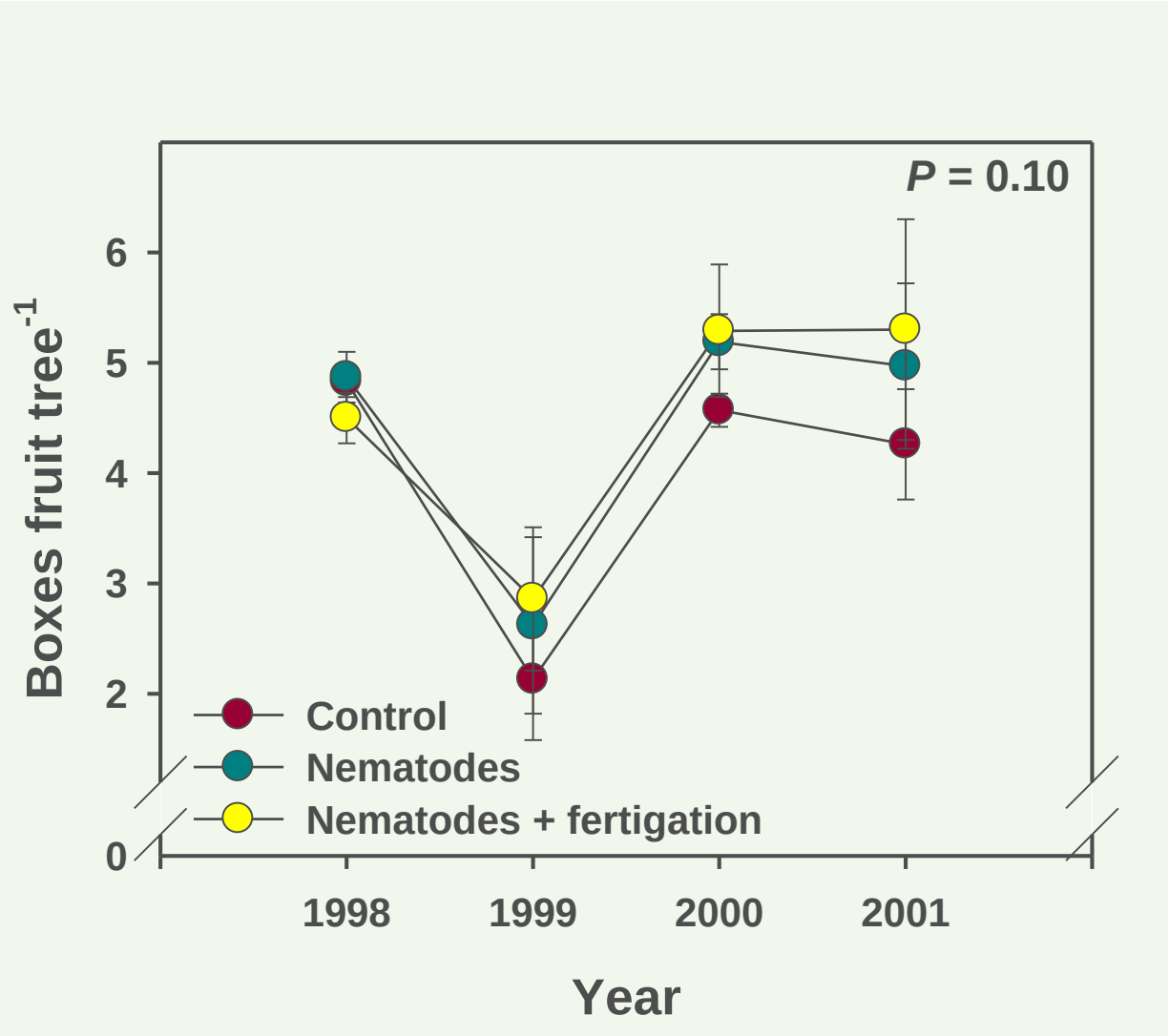

4-fold to 11-fold return on treatment cost depending on whether marketed fresh or processed

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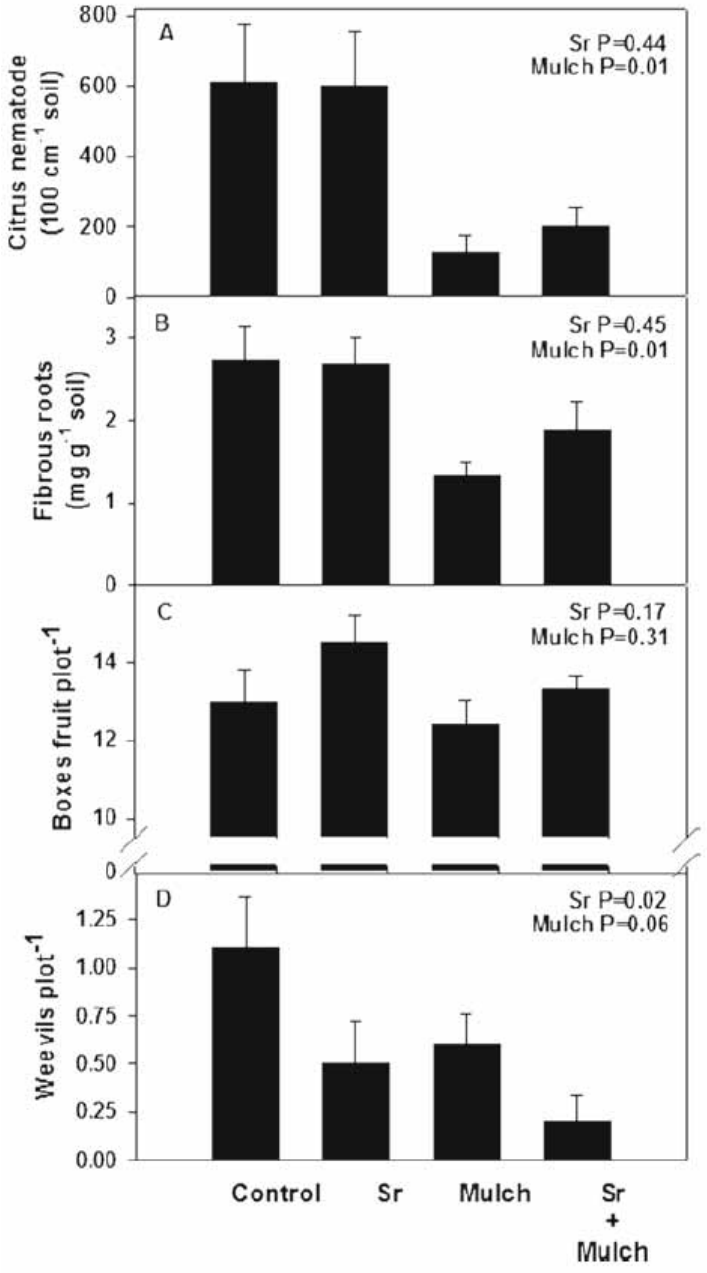

Second trial, similar results

Note the increased yield

Note the reduction of adult weevils by half

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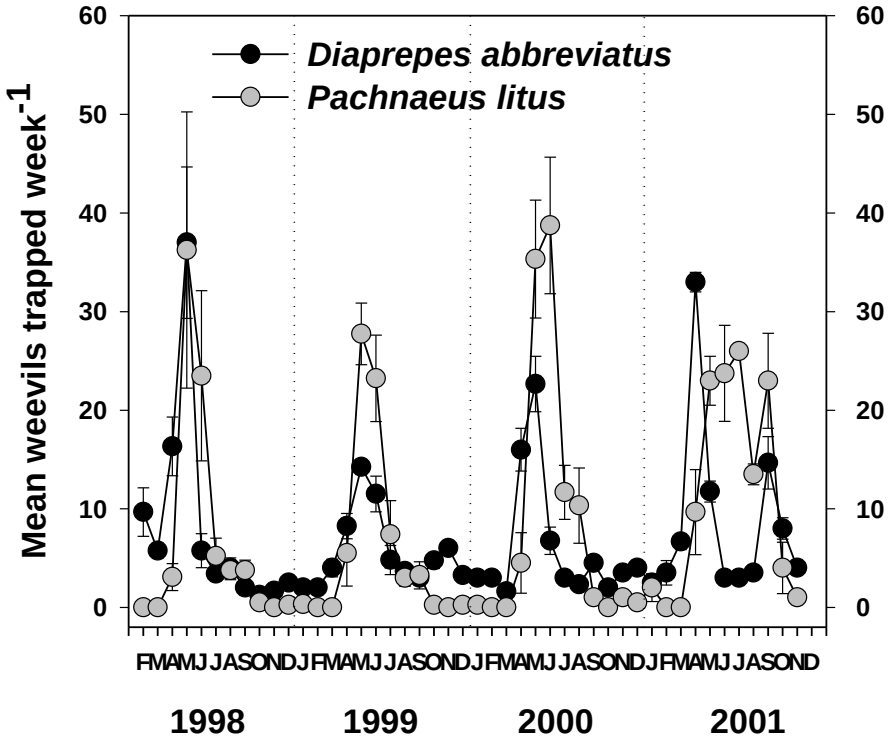
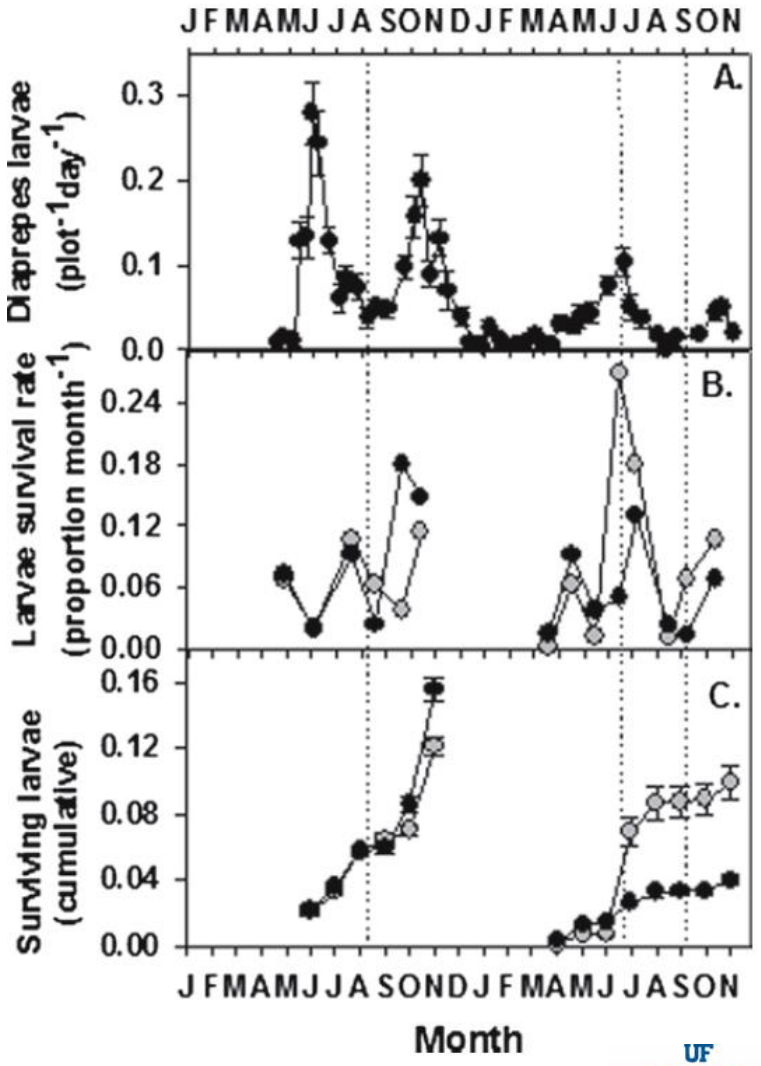
Timing chemical insecticide applications requires monitoring



Timing EPNs less obvious



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Cost

One package of 3 billion infective juvenile nematodes (IJ) will treat 15 acres assuming 25% coverage by irrigation emitters.

@18,365 IJ/ft^2 soil surface
Or 0.26 cents per ft^2

For grove of 150 trees/A, 25% coverage requires 9.6 ft diameter spray pattern.

Cost to achieve same dose for some other spray pattern diameters shown here.

Cost

The effectiveness of EPNs is a function of the nematode species, the application rate, the soil conditions and the frequency of application.

Growers should consider increasing the frequency of application as much as can be afforded. E.g., at 12 ft. dia. irrigation pattern x 2 applications = $87/yr. A 6 foot pattern could apply 8 applications per year for the same cost.

Weevil management

- EPNs
- Insecticides (monitoring)
- Fumigation
- Rootstocks
- Cultural practices
  - Soil drainage
  - pH
  - Physical barriers
  - Regional considerations (EPN conservation)

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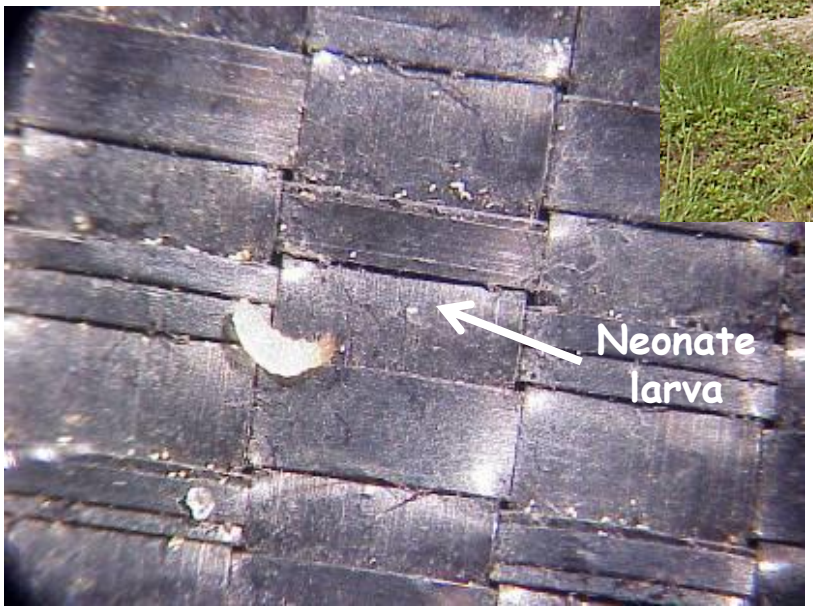
Cultural Practices

Landscape fabric can be installed as a barrier to prevent larvae from entering soil and adults from exiting soil

McKenzie et al. 2001
Duncan et al 2008

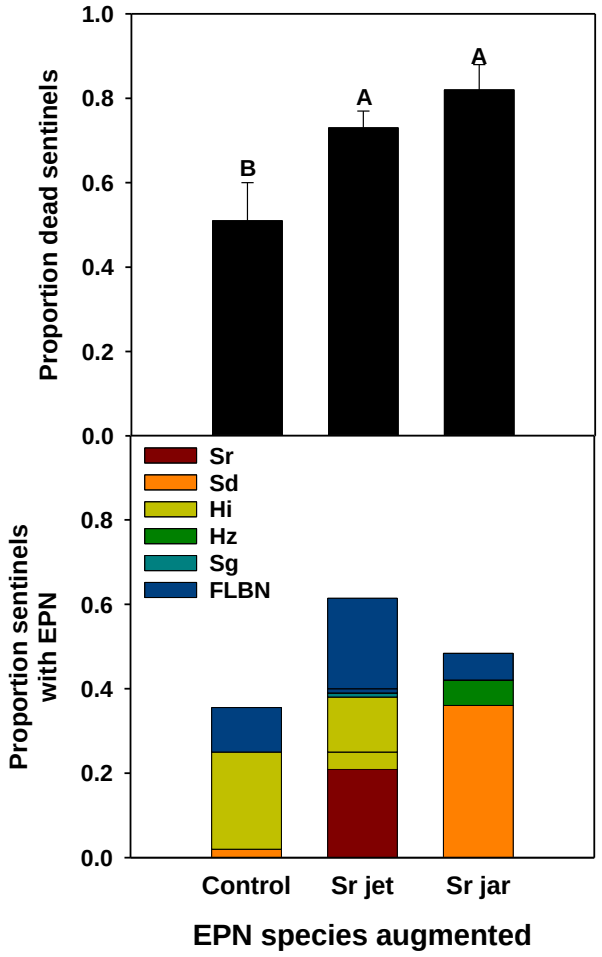


The integrity of these barriers was maintained for 5-6 years. Herbicide savings equaled the fabric cost.

This barrier is made from a single piece of 15-foot wide fabric. Holes cut with branding iron.

Reflective mulch for psyllid control

Hamlin on Swingle June 2016
Heavily infested by DRW in 2006



Hamlin on Swingle June 2016
Root system typical of scattered declining trees

Conserving EPNs

In addition to augmenting soils with the exotic *Steinernema riobrave* to manage *Diaprepes* root weevil, there are options to enhance and exploit naturally occurring native EPN communities:

- ✓ Reduce soil pH to inhibit bacterial ectoparasites of EPNs
- ✓ Coarsen soil texture in tree planting holes to increase EPN efficacy
- ✓ Employ composted animal manure mulch to increase biological control by EPNs
- ✓ Introduce Sx into depauperate flatwoods orchards
- ✓ Plant germplasm that respond to herbivory with semiochemical attractants for EPNs

Nematode-induced tree declines in Florida

Citrus nematode, T*ylenchulus semipenetrans (*Slow decline)

Burrowing nematode, *Radopholus similis* (Spreading decline)

Coffee lesion nematode, *Pratylenchus coffeae* (Citrus slump)

Sting nematode, *Belonolaimus longicaudatus*

Dagger nematode*, Xiphinema vulgare*

Integrated Management of Plant Parasitic Nematodes on Citrus

- ✓ Sanitation
- ✓ Host plant resistance/tolerance
- ✓ Cultural practices
  - pH
  - Salinity
  - Supplemental irrigation-fertigation
  - Avoid cultivation for weed control
- ✓ Chemical and biological pesticides

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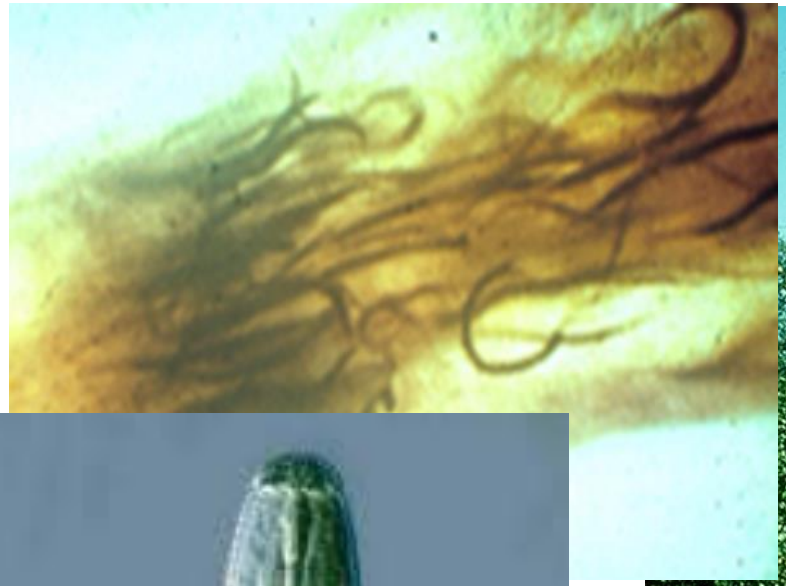

Spreading decline caused by the citrus race of *Radopholus similis* the burrowing nematode

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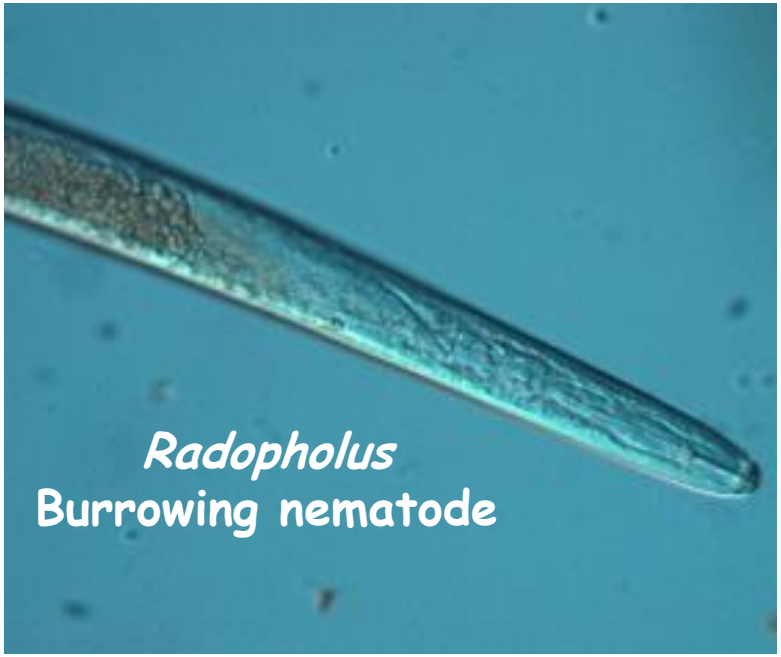
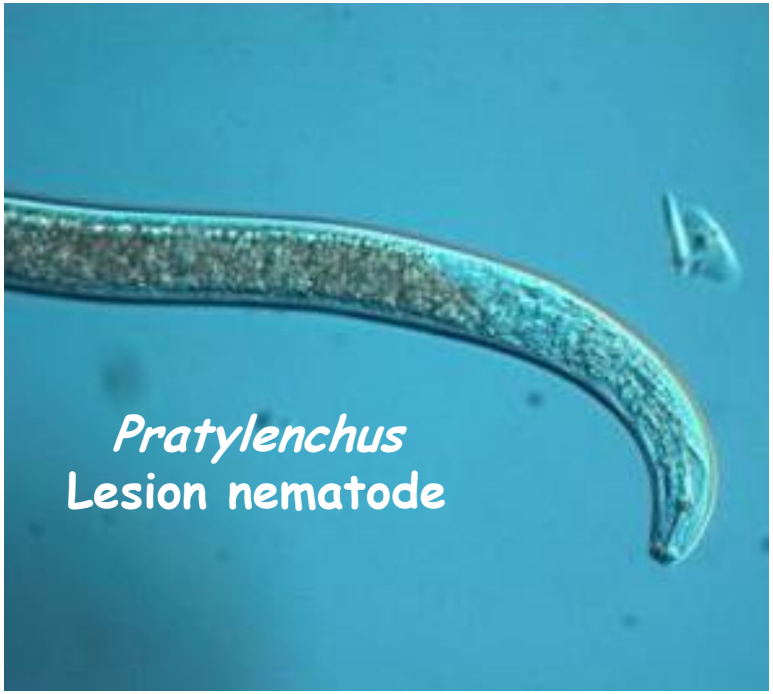
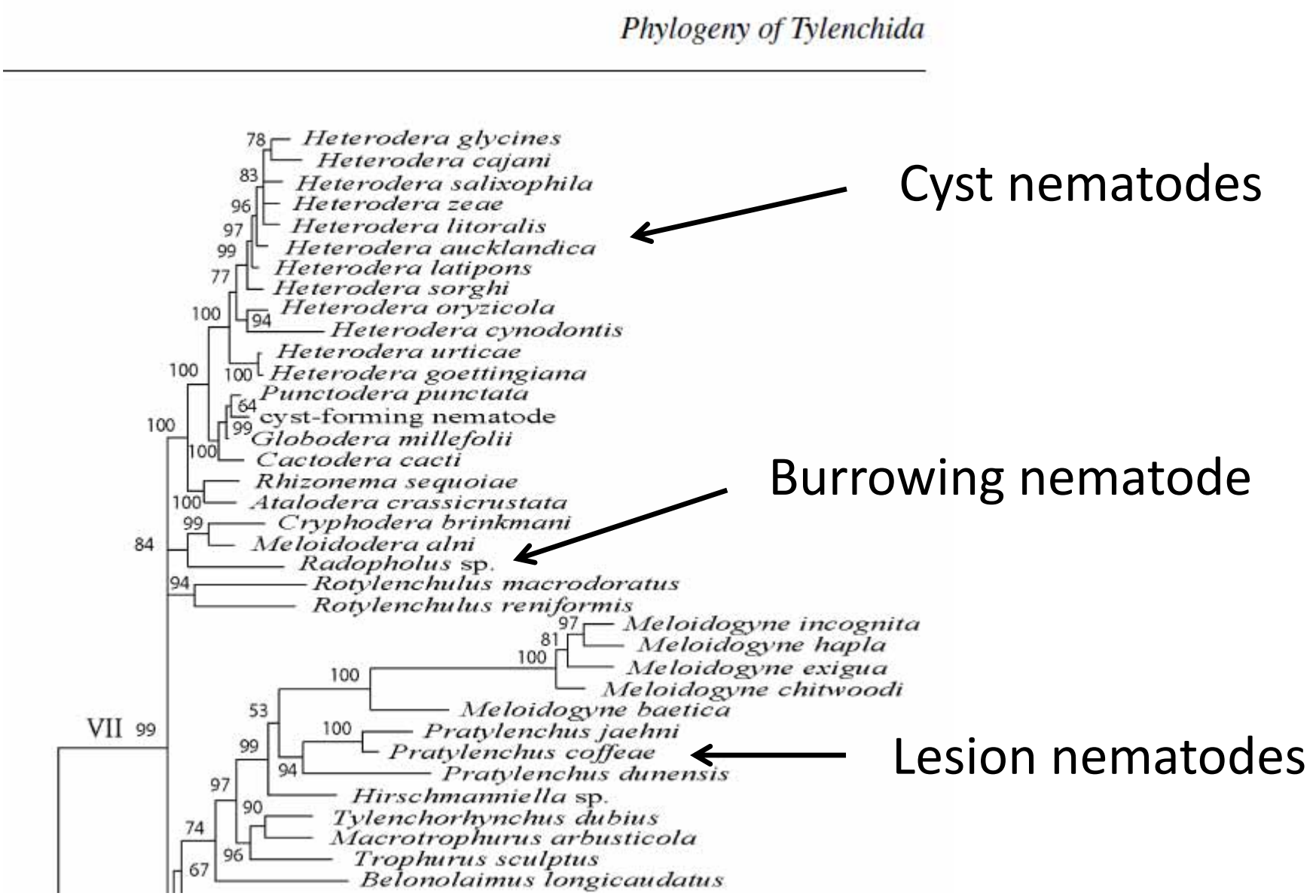




Which 2 are cousins?



Subbotin et al., 2006, Nematology 8: 455-474

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Journal of Applied Ecology 2002
39, 915–923

The effect of transgenic nematode resistance on non-target organisms in the potato rhizosphere

SUE E. COWGILL, RICHARD D. BARDGETT*, DAAN T. KIEZEBRINK and HOWARD J. ATKINSON

Transformed potato in 2002 to express a cystatin that disrupts digestion of certain proteins and also a peptide that interferes with sensory function of cyst nematodes.

Molecular Plant Pathology

MOLECULAR PLANT PATHOLOGY (2012) 13(8), 842–851 DOI: 10.1111/J.1364-3703.2012.00792.X

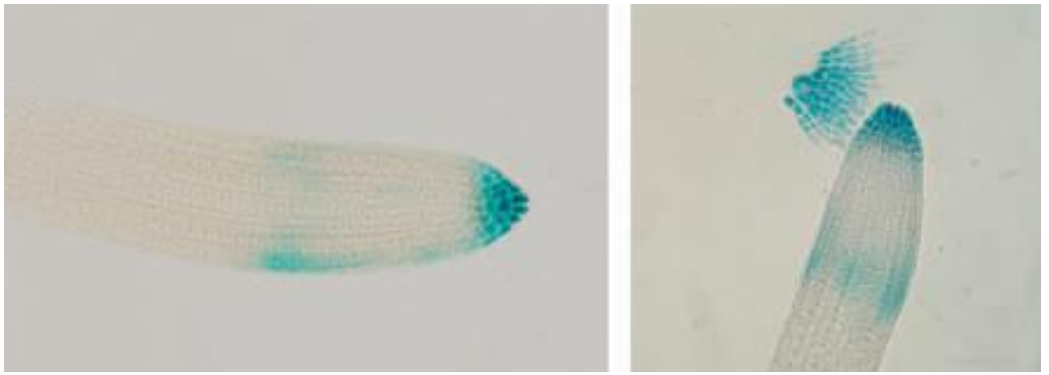
Generation of transgenic plantain (*Musa* spp.) with resistance to plant pathogenic nematodes

HUGH RODERICK[1], LEENA TRIPATHI[2], ANNET BABIRYE[2], DONG WANG[1,†], JAINDRA TRIPATHI[2], PETER E. URWIN[1,*] AND HOWARD J. ATKINSON[1]

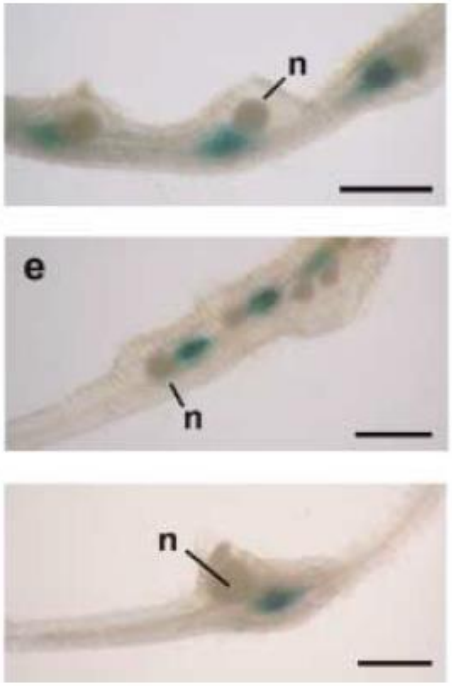
In 2012 transformed banana with these genes to confer resistance not only to burrowing nematode, but to lesion, and root-knot nematodes as well.

Lilley et al. 2004 & 2011.
Plant Biotechnology Journal 2: 3-12
Plant Biotechnology Journal 9:151–161

AtMDK-20 (root cap promoter)



Tub-1 promoter



RB-7 promoter

Gene constructs - Manjul Dutt and Jude Grosser

Gene	Construct	Function	No pf plant produced
Cowpea thionin II	2300-1867-CII	Inhibition of trypsin	12
OC-IΔD86	2300-1867-OCI	Modified rice cystatin	20
Maize Oryzacystatin	2300-1867-ZM	cysteine proteinase inhibitor	5

Cloned into pC2300-1867, a plant transformation vector containing a root specific promoter.

Used to transform Carrizo citrange rootstock.

Evaluate regenerated transgenic plants.

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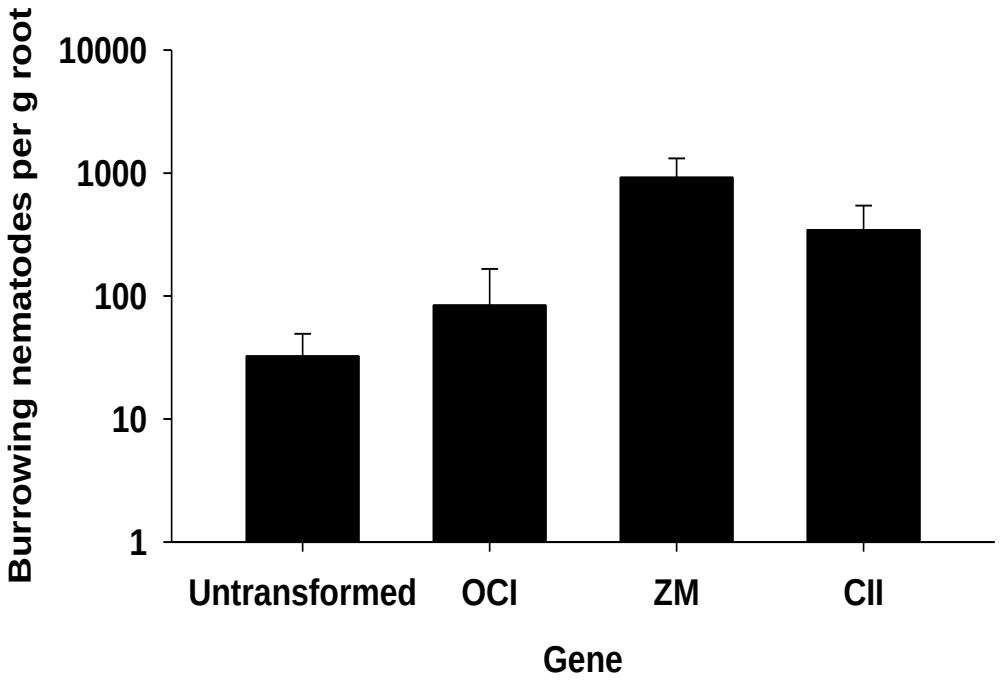

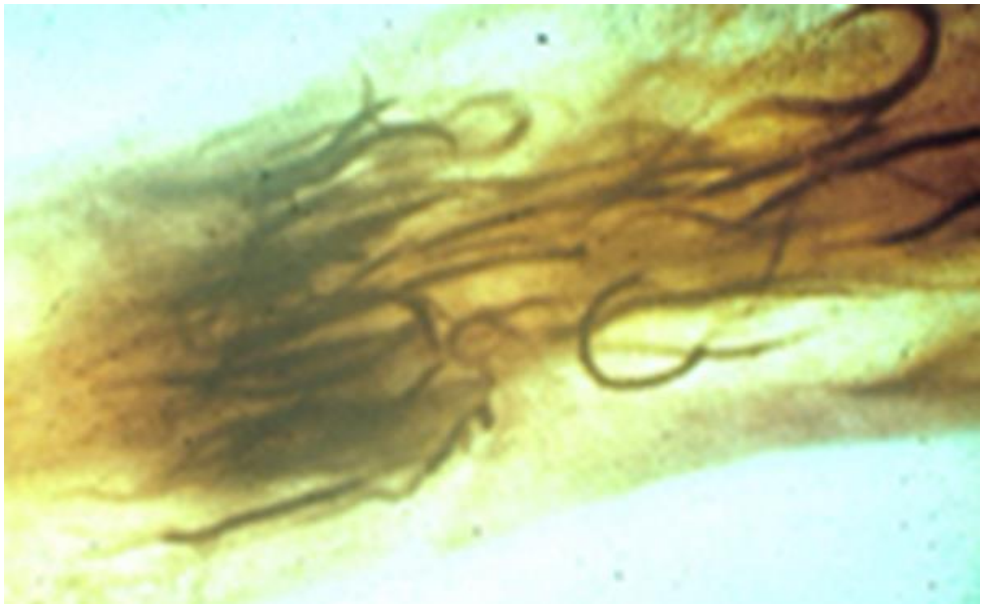

Evaluation of lines is ongoing.

14 lines with no detectable protein expression support burrowing nematode reproduction.

Two lines (ZM and CII) exhibited expression and neither supported burrowing nematodes.

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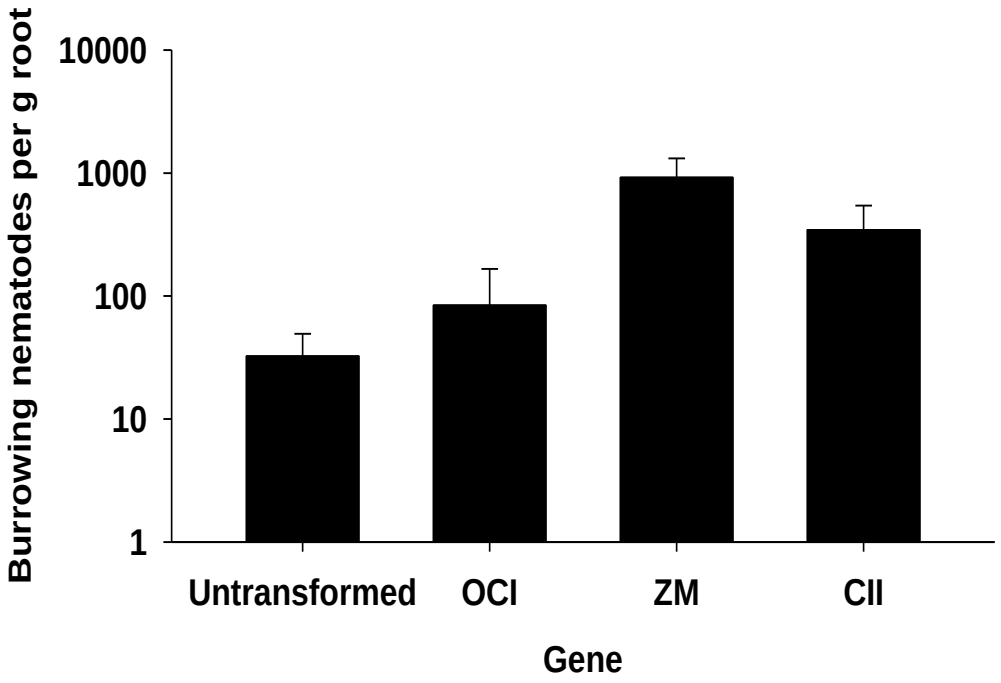

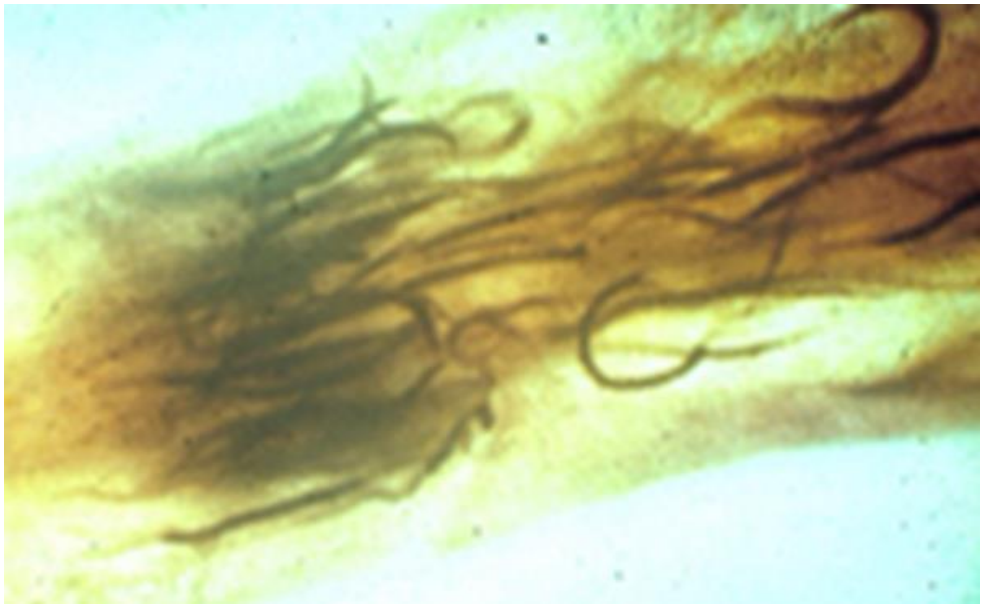

Future work

Increase lines with high gene expression and nematode suppression.

Stack genes.

Transform Kuharski Carrizo to express these genes.

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Next generation rootstocks transformed for nematode resistance

- Inexpensive
- Durable resistance (multigenic targets)
- May confer protection against multiple nematode species
- No known environmental or safety risk

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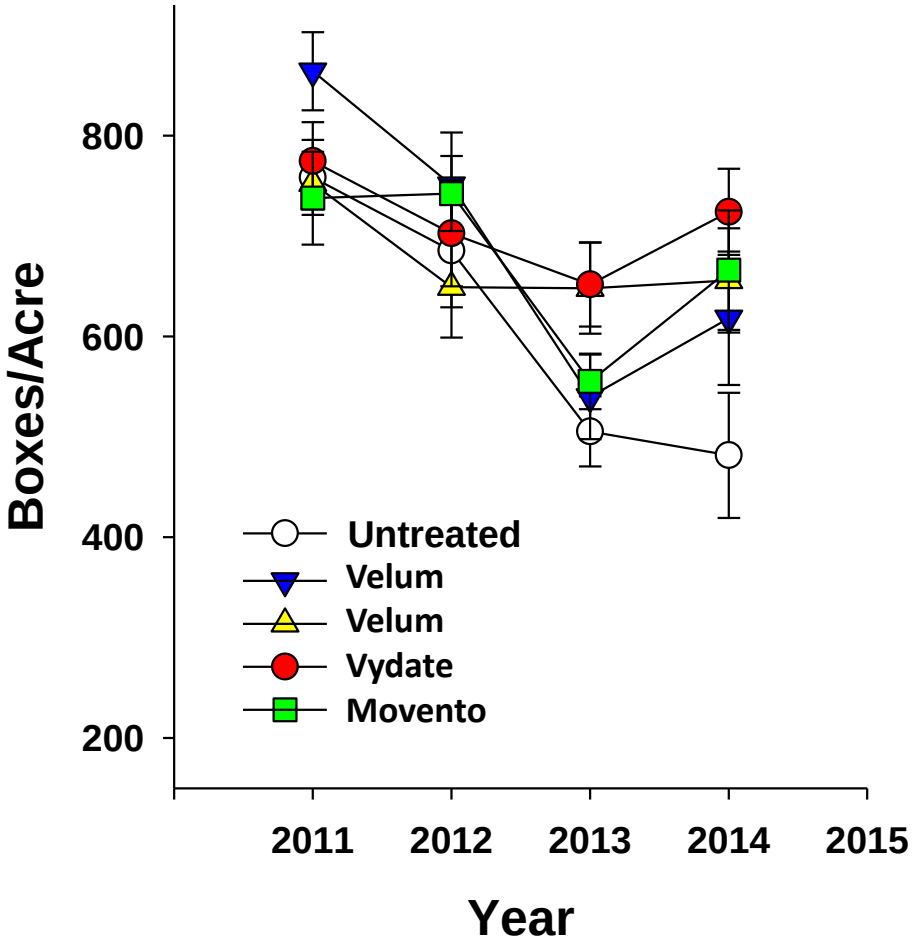
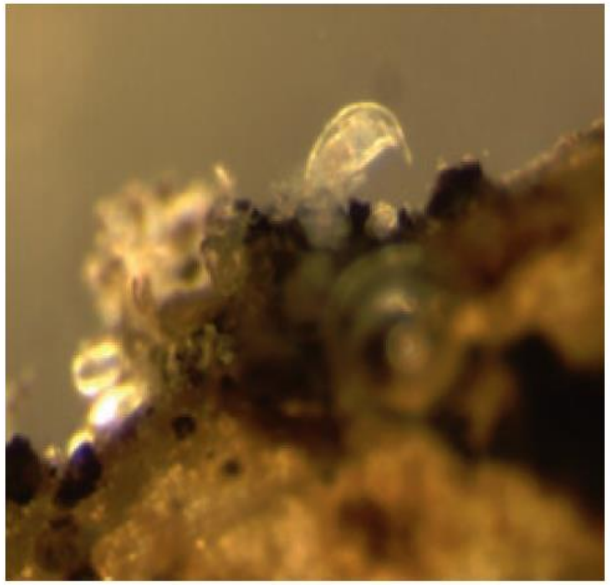
Effects of nematicides to control citrus nematode in a productive HLB affected grove





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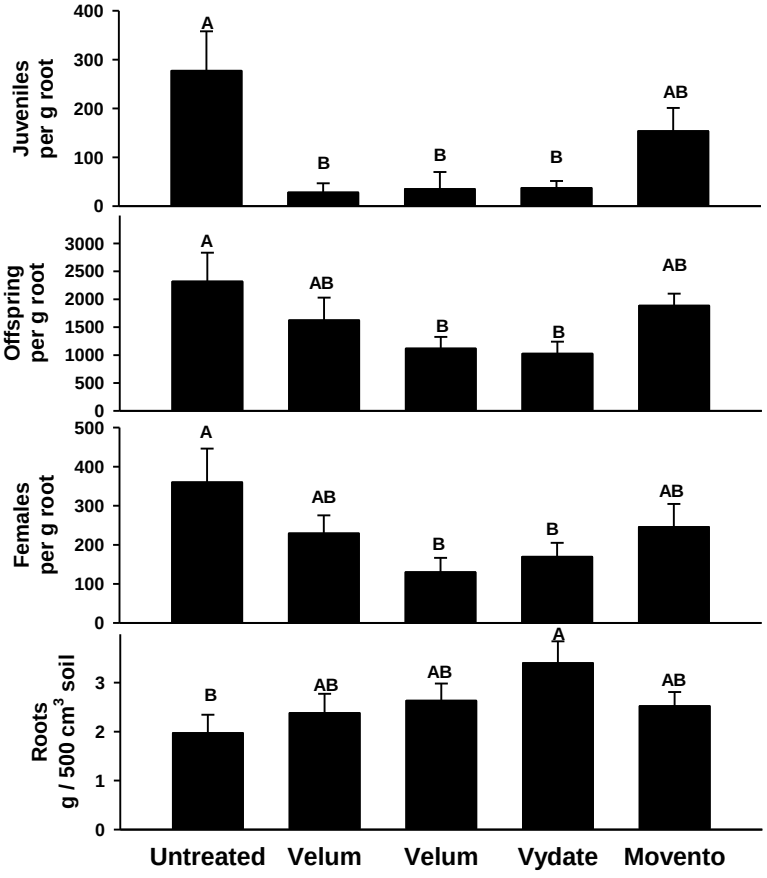
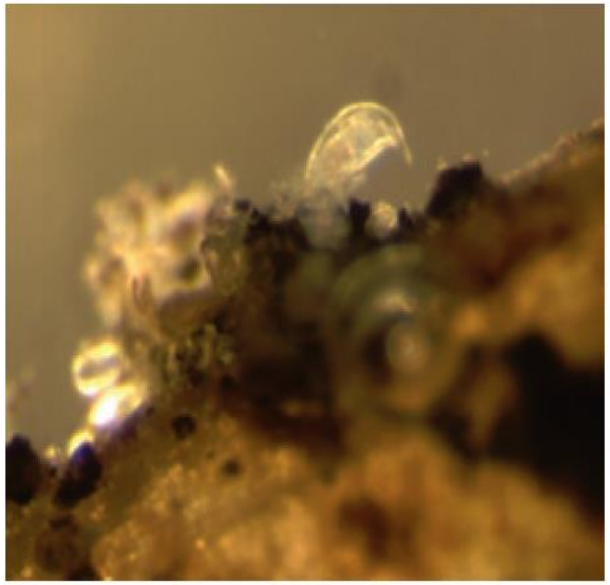
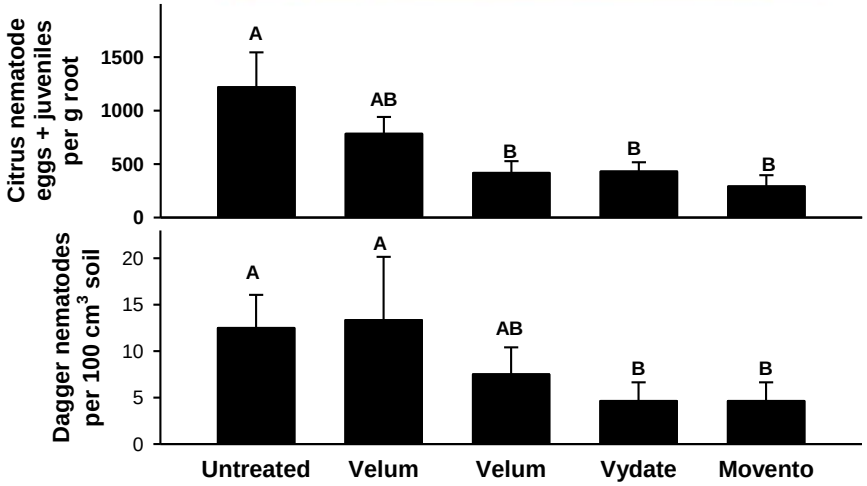
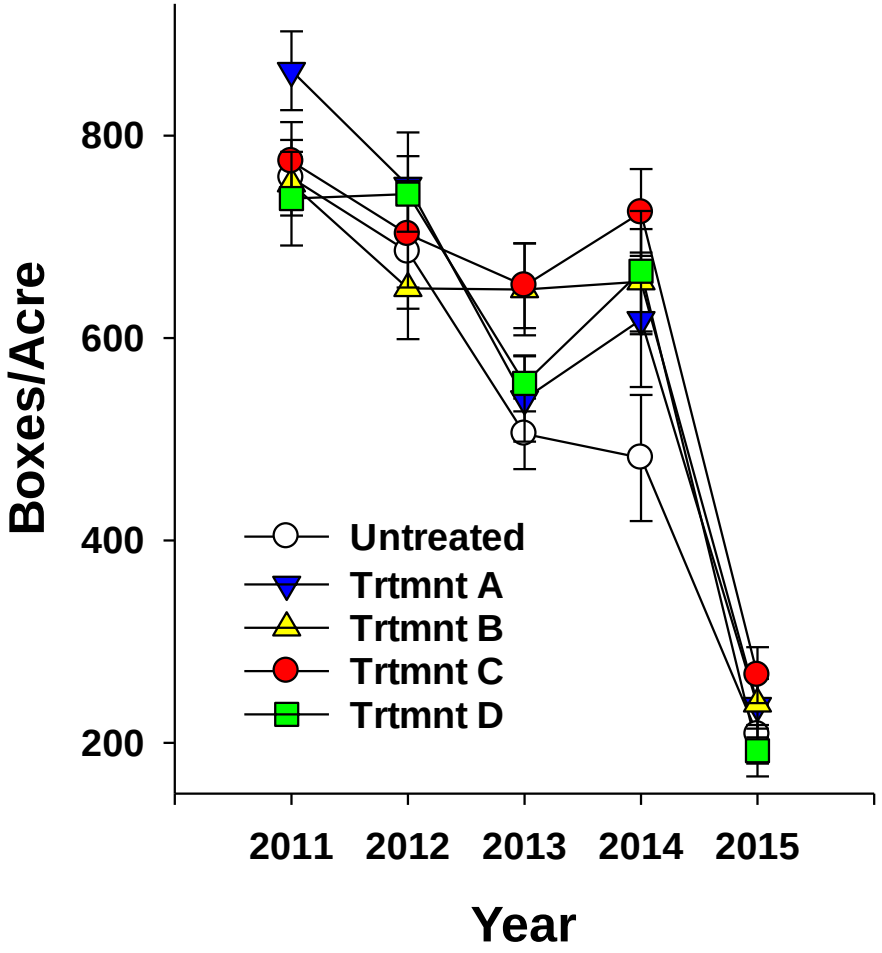
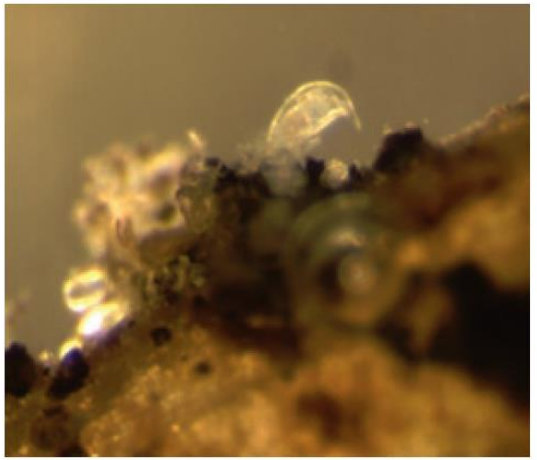






Sudden collapse symtoms during 2015 season





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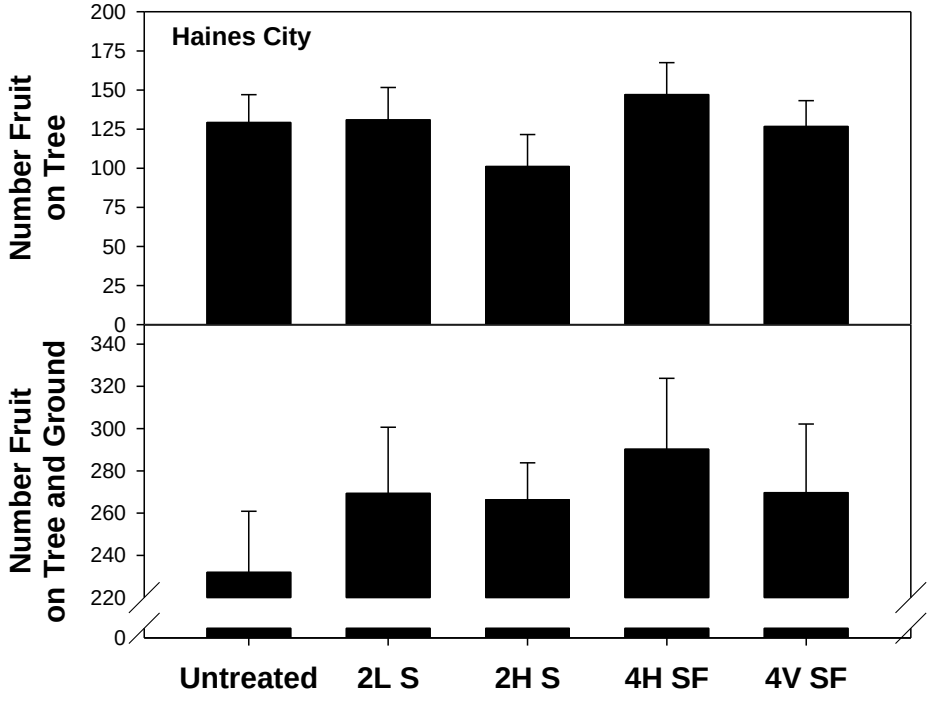
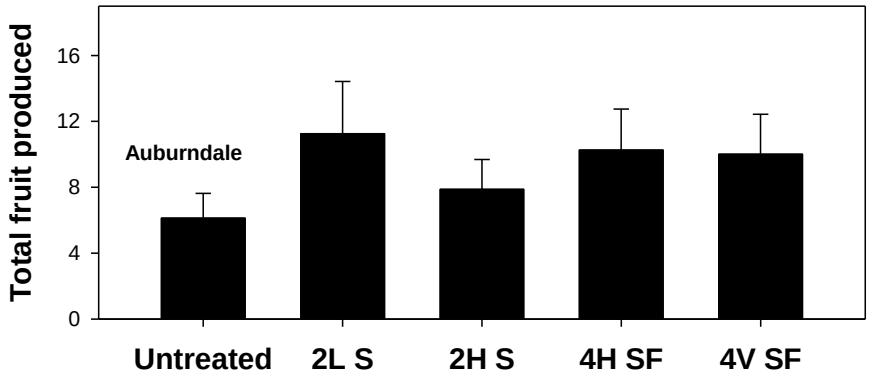
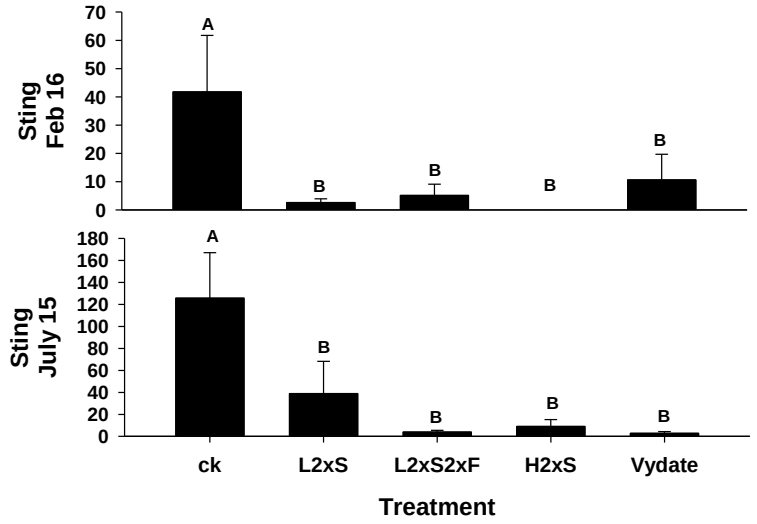
Adult weevil discovered during harvest in February 2016 and structural root damage typical of the declining trees


Haines City
Number Fruit on Tree
Number Fruit on Tree and Ground
200
175
150
125
100
75
50
25
0
340
320
300
280
260
240
220
0
Untreated
2L S
2H S
4H SF
4V SF


Auburndale
Total fruit produced
16
12
8
4
0
Untreated
2L S
2H S
4H SF
4V SF


Sting Feb 16
70
60
50
40
30
20
10
0
A
B
B
B
B
Sting July 15
180
160
140
120
100
80
60
40
20
0
A
B
B
B
B
ck
L2xS
L2xS2xF
H2xS
Vydate
Treatment

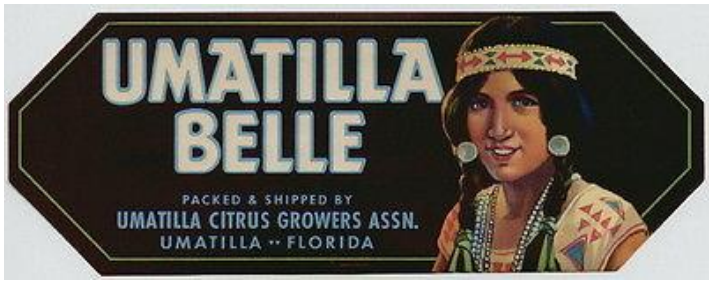
Acknowledgements

John Strang
Allison Drown
Garvey Hall
Steve Farr
Fleetwood Chestnut
John Curtis

Fahiem El-Borai
Joshua Fluty
Robin Stuart
Raquel Campos-Herrera
Ekta Pathak
Sheng-Yen Wu

Bayer
DuPont
BASF


BELLE of WINTER HAVEN
WINTER HAVEN GROWERS INC.
GROWERS AND SHIPPERS
WINTER HAVEN, FLORIDA


UMATILLA BELLE
PACKED & SHIPPED BY
UMATILLA CITRUS GROWERS ASSN.
UMATILLA •• FLORIDA


BLUE HERON
BRAND
Tangerines
Grapefruit
Oranges
BROOKSVILLE CITRUS GROWERS ASSN.


Florida
CITRUS FRUIT
Clipper
KEEN FRUIT CORPORATION
GROWERS & SHIPPERS
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