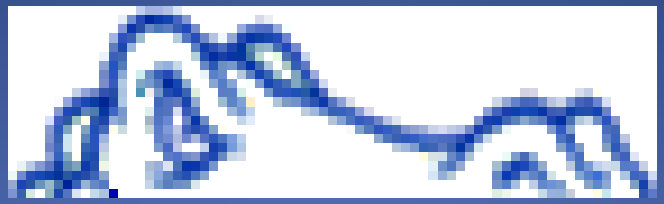

UNIVERSITY OF FLORIDA
IFAS

Status of Plant Pathogenic Nematode Management in Southeastern USA

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Nematology Management 2014

- How different is nematode management programs today compared with 50 years ago?

- Negatives --

- We have loss many of the best chemical nematicides.
- There has not been much new chemistry added.

Nematology Management 2014

- How different is nematode management programs today compared with 50 years ago?

- Positives --
- Precision ag has fine-tuned chemical application, applicable for a few agric. sites.
- There are probably more nematode resistance genes employed overall.
- We have a better handle on nematode species and their id.
- Beyond that, how different are the approaches?

Management of Nematodes

Physical

- Heat
- Electrical
- Microwave
- Irradiation
- Flooding
- Osmotic
- Solarization

Biological

- Organisms – fungi, bacteria
  (currently man has little control)

Resistance – breeding, grafting, tolerance

Legislative (quarantine)

Prevention of spread

Avoidance

Cultural

- Rotation & cover crop
- Manures
- Fallow-flooding
- Allelopathic plants
- Sanitation & clean planting stock
- Time of planting
- Trap and antagonistic crop
- Nutrition and general care of crop
- Destruction of crop residue

Chemical

- Chemicals
  - Fumigant
  - Non-fumigant
  - New chemistry

Application methods, equipment, and dosages

We are now entering the post-methyl bromide era.

Cancellations/withdrawals of nematicides began mid-1970's

Fumigants

- D-D
- DBCP
- EDB

Nematicides

- DD Mencs
- Methyl bromide
- Idomethane

Multi purpose

Nonfumigants

- Fensulfothion
- Fenamiphos
- Demeton
- Diazinon

Organo phosphates

- Carbofuran
- Aldicarb (underway)

Car-bam-ates

DBCP & EDB were superb nematicides, and Methyl bromide was a quality broad spectrum fumigant.

Nonfumigants

Organo-phosphates
- Fensulfothion
- Fenamiphos
- Demeton
- Diazinon

Carbamates
- Carbofuran
- Aldicarb

Nematicide Fumigants

- D-D
- DBCP
- EDB

Multi-purpose Fumigants

- Methyl bromide
- Idomethane
- Vorlex

Characteristics desired in nematicides– 2014

- Efficacy
- Economical
- Effective at low dosage
- Low mammalian toxicity
- Environmentally friendly
- Nonpersistant
- No microbial degradation
- No phytotoxicity
- Easy to apply – preplant, at plant, post plant
- Active against different types of nematodes
- Low or no leaching
- No odor issues
- No off-site issues

Nematodes are among the most abundant animals on earth.

Three basic types:

!. Nonparasitic nematodes often referred to as free-living

2. Plant-parasitic nematodes

3. Animal-parasitic nematodes

Don’t ever think that nematodes can not harm you!

Dog heartworm *Dirofilaria immitis*

Mosquito borne

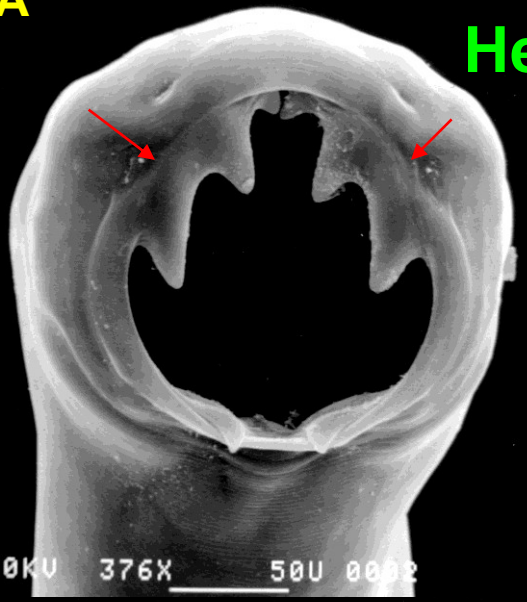
Characteristics of Nematoda

Nema = Thread Tode = Like

1. Multicellular, non-segmented invertebrate animals
2. Bilaterally symmetrical (some radial symmetry)
3. Body cavity a pseudocoelom
4. Body wall a cuticle and hypodermis
5. Lumen of esophagus tri-radiate in cross section.
6. Excretory system lacks flame cells
7. Anus and male gonopore joined (cloaca)
8. No respiratory or circulatory systems.

Animal-parasitic nematode

A



External

Head or lip region view

A. *Felicitus hookeri*

B. *Heterodera schachtii*

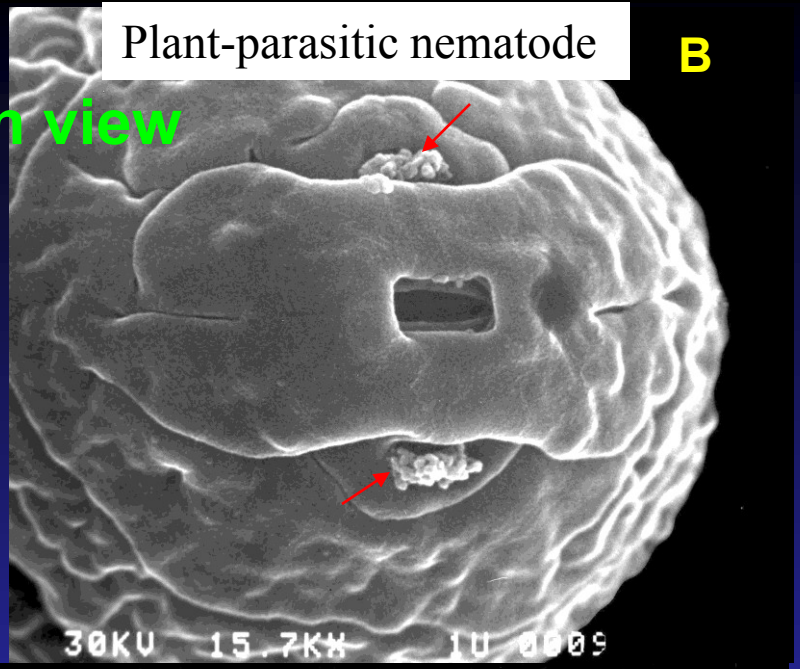
C. Dorylaim

D. *Epsilonema*

E. Chromadorid

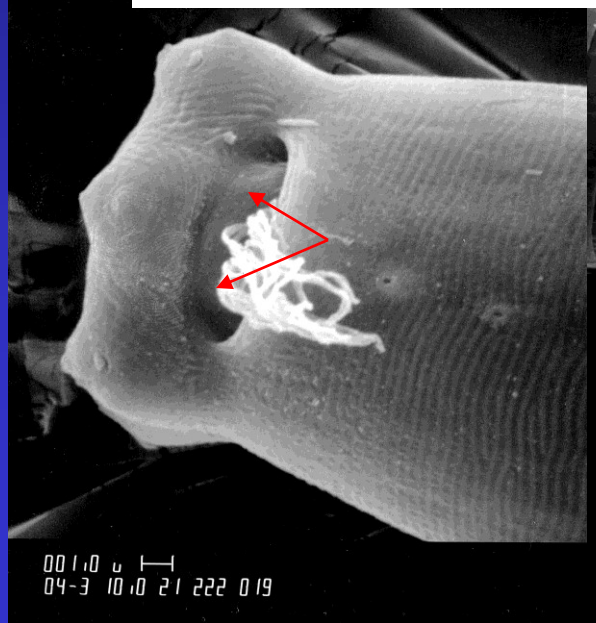
Plant-parasitic nematode

B



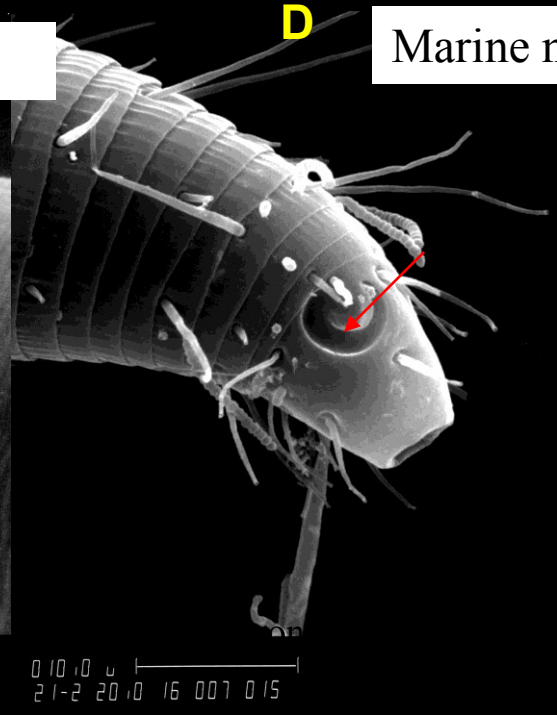
C

Free-living nematode



D

Marine nematodes



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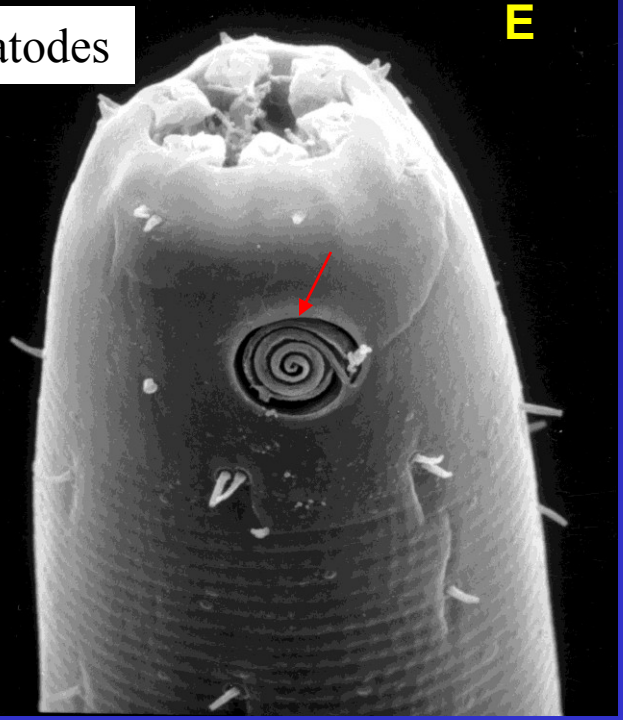
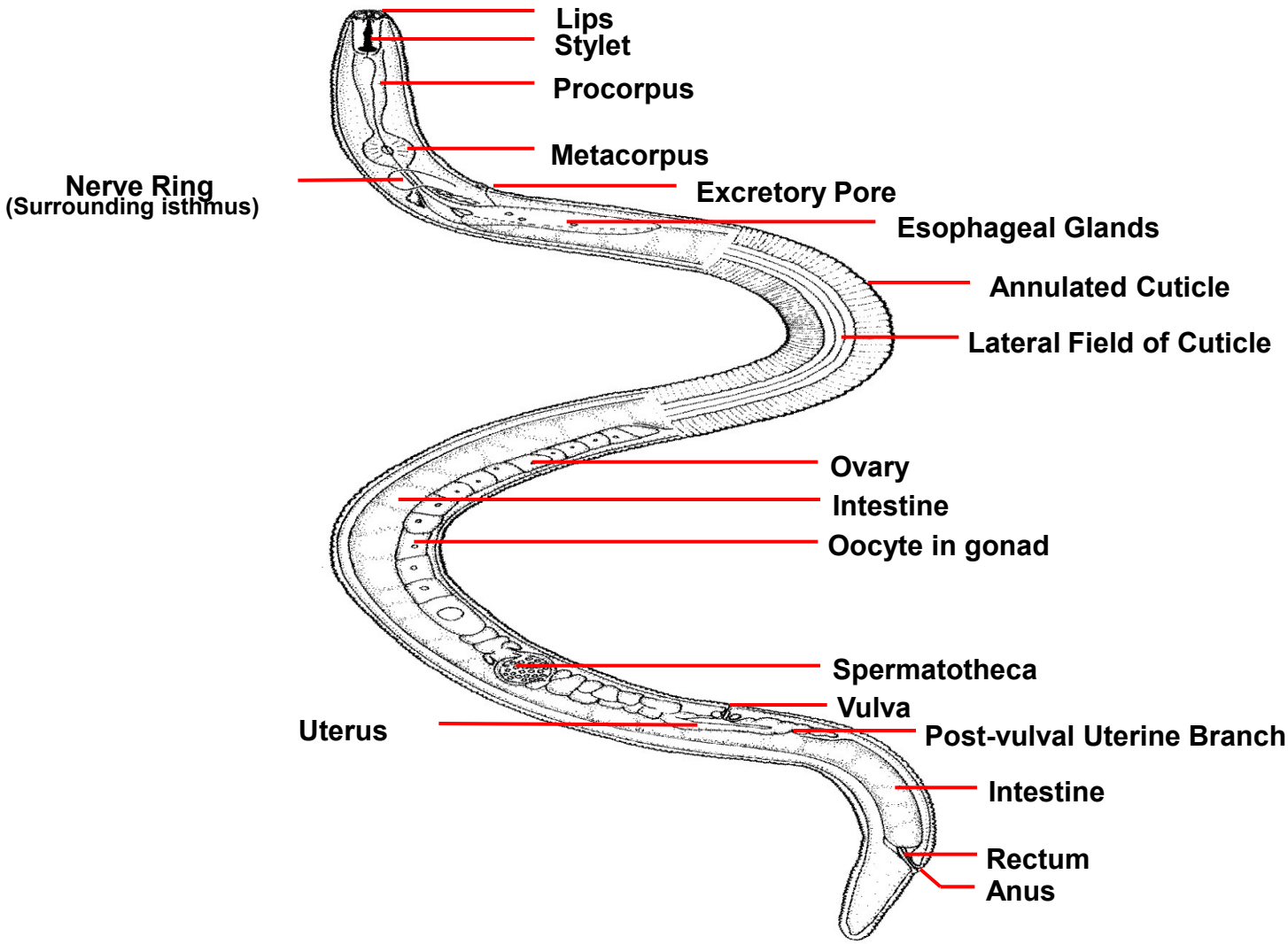
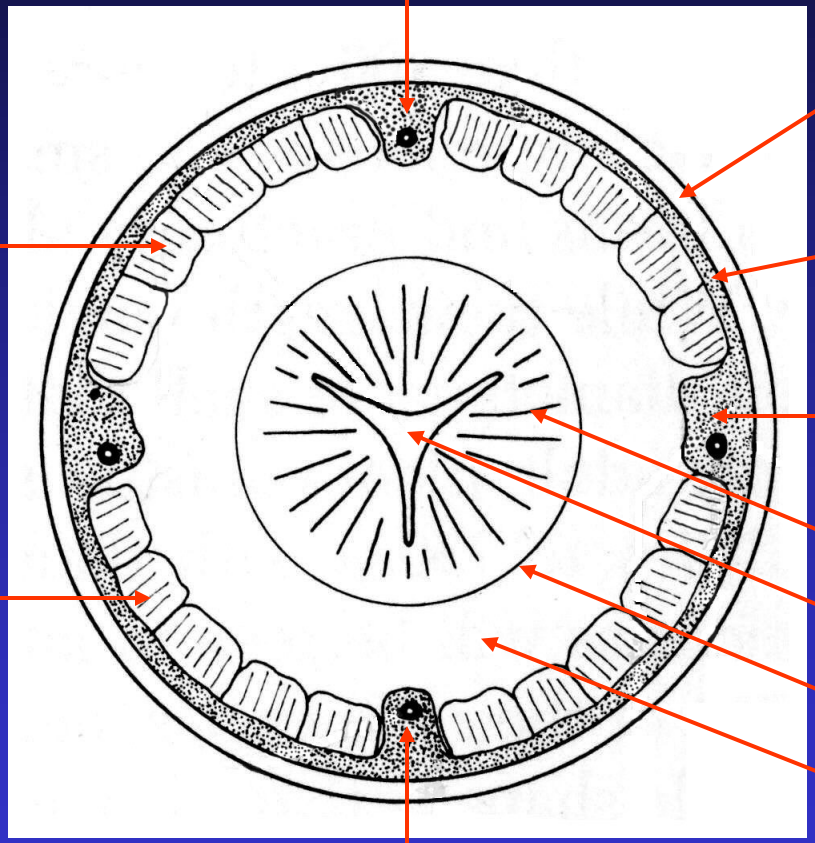


Pratylenchus penetrans lesion nematode – General morphology



After D.C.M. Corbett, CIH Descriptions.

Transverse Section of Nematode
through esophagus



From Jenkins and Taylor, 1967

How do we identify plant-parasitic nematodes (ppn) –

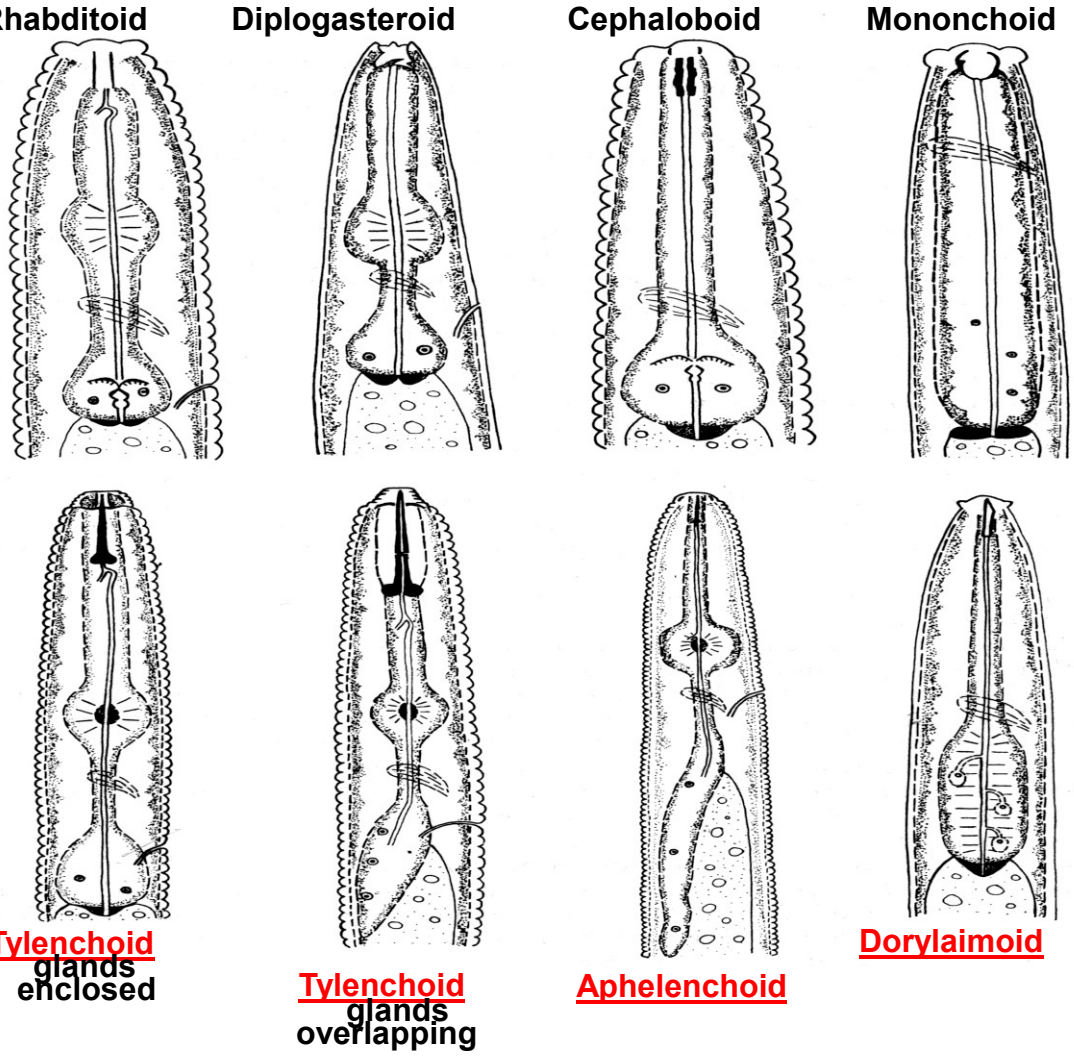
1. Overview of size and shape of nematode
2. Esophagus region – shape and size
3. Stylet shape and size – all plant parasites have a stylet

Plant-parasitic nematodes are relative small requiring magnification to see them.

First, they generally have to be extracted from soil, where most times they are found.

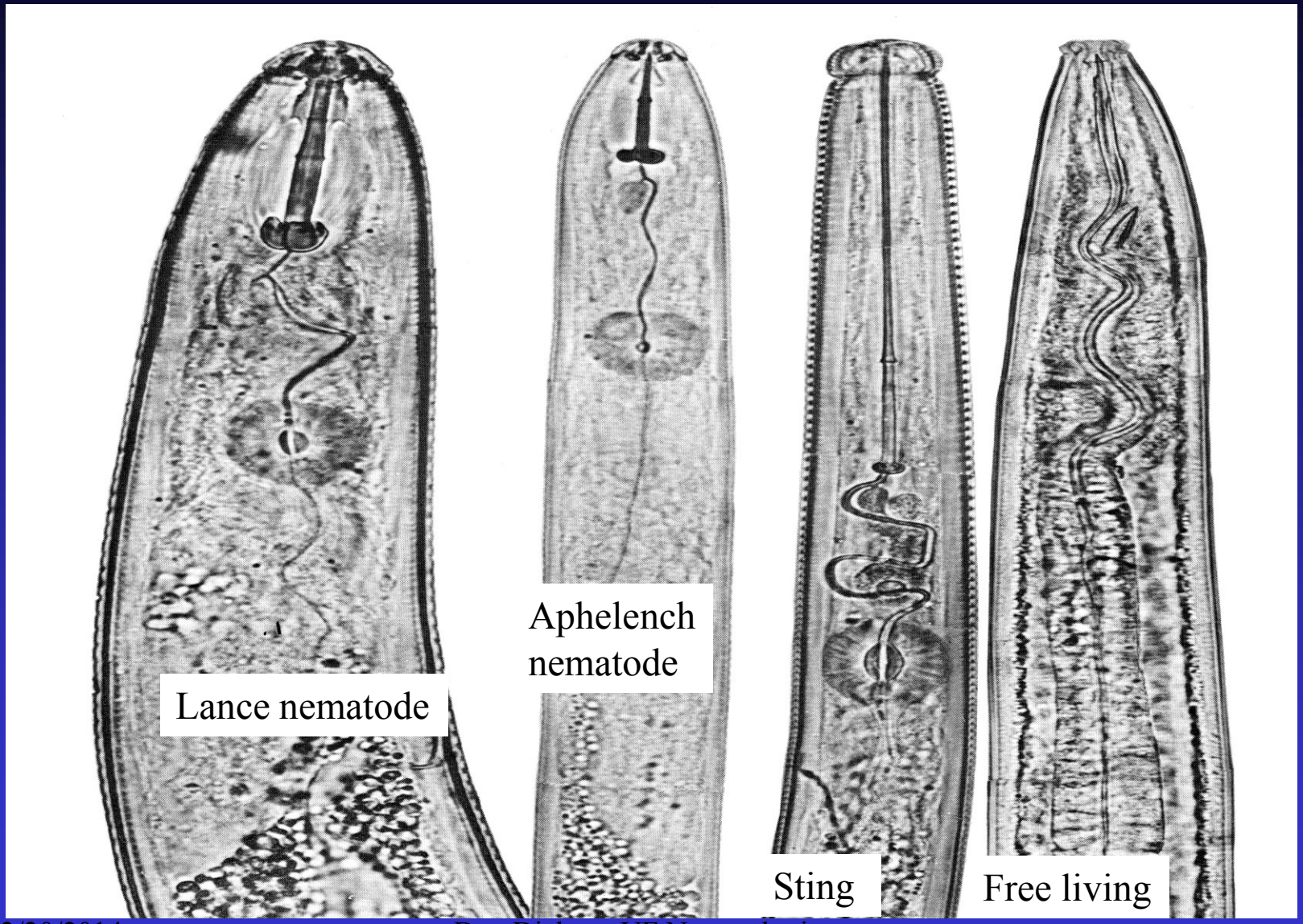
Extraction from soil generally requires special equipment and know-how, and procedures are laborious.

Esophageal types (red & underlined indicate ppn)



From Jenkins & Taylor, 1967

Photo of Nematode Stylets



From Mai and Lyon, 1960

Cuticular Annulation

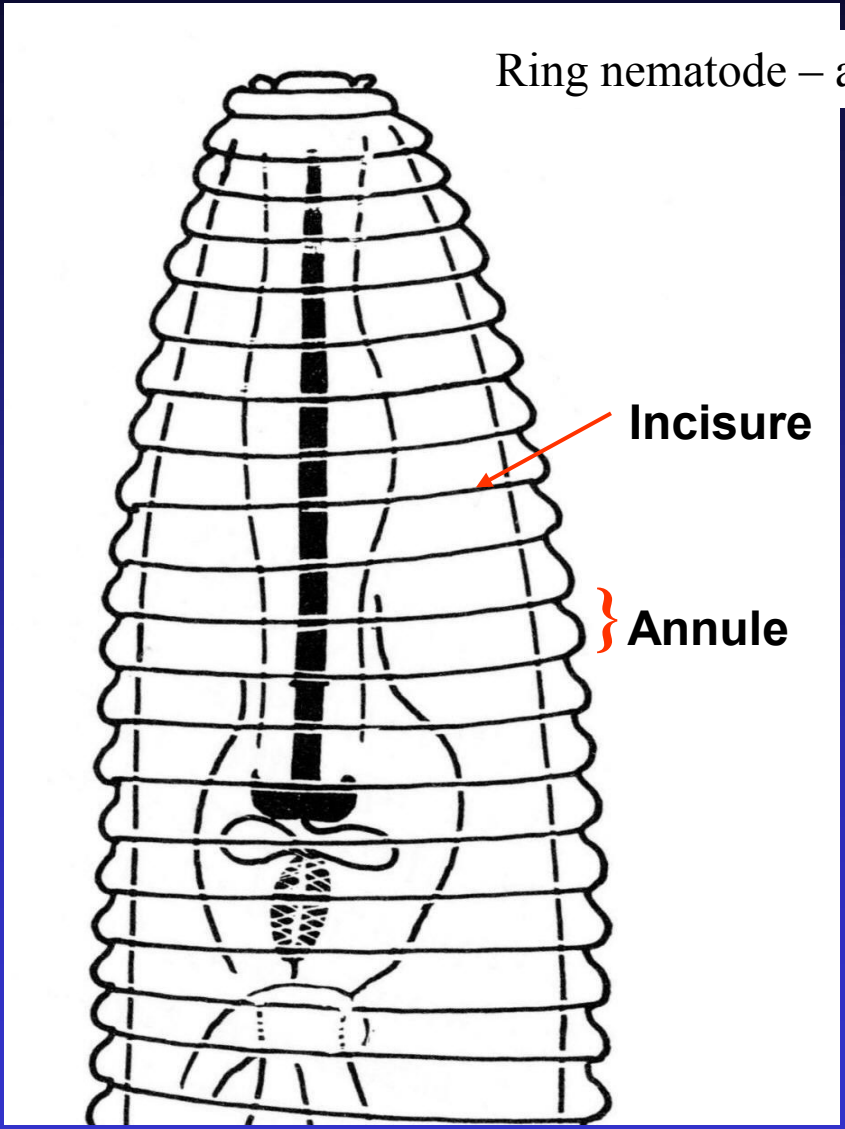
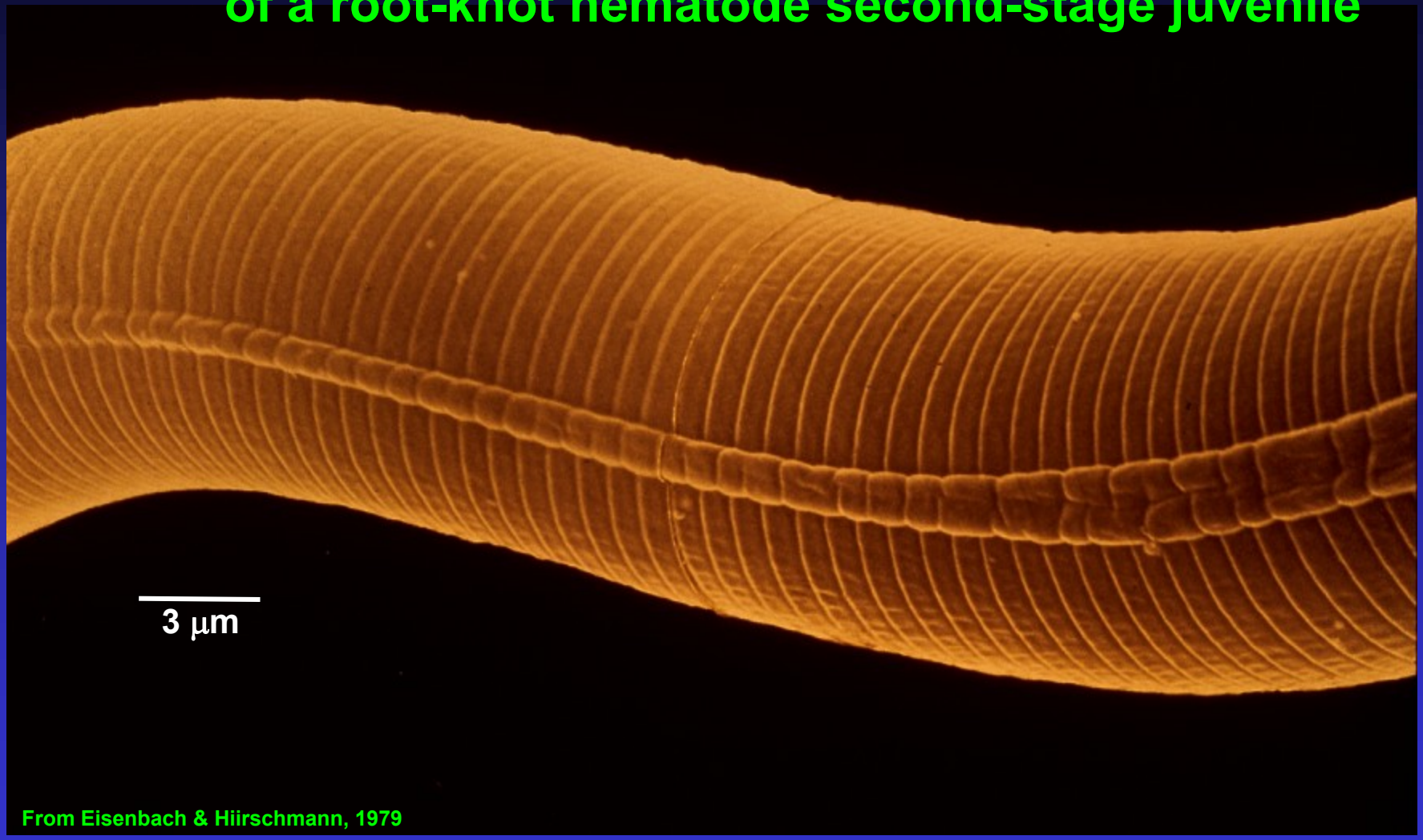


Photo of the cuticular annulation and lateral field of a root-knot nematode second-stage juvenile



From Eisenbach & Hiirschmann, 1979

Mode of reproduction

- Four sexual forms:
- Male
- Female
- Hermaphrodite
- Intersex

Nematode Reproduction — Three methods among PPN

- Cross fertilizing: ♂ and ♀ mate. Gametes produced in separate individuals. Copulation required. Most common mode of reproduction & common among ppn.

- Parthogenesis: Only ♀ gametes produced (reproduction in absence of ♂ gametes), also common among ppn.

Nematode reproduction con't

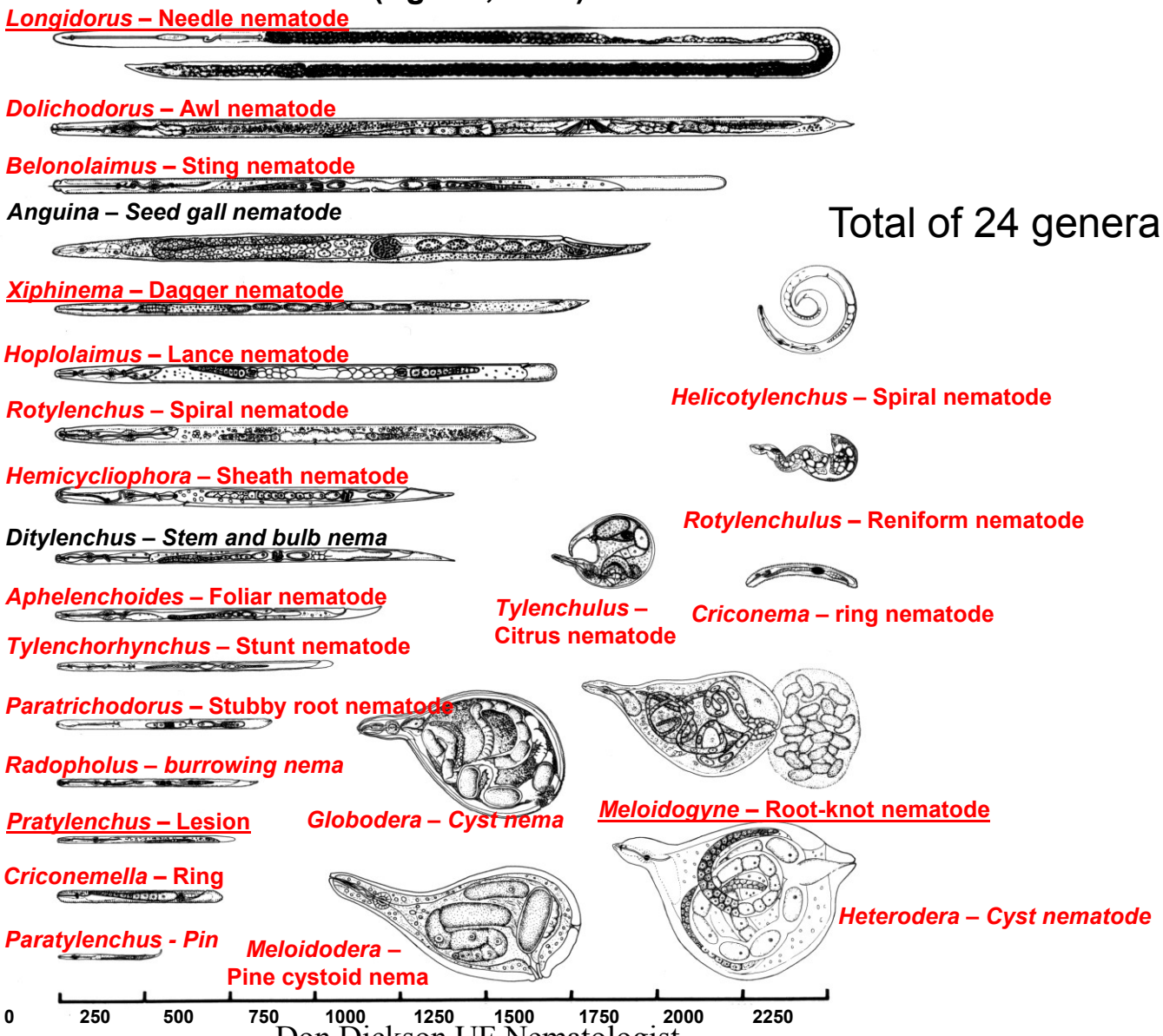
Hermaphoroditism – ♂ and ♂ gametes produced within same individual.

Copulation not required, but may occur.

Most common among free-living nematodes, but rare among ppn.

Important Disease Causing Plant-Parasitic Nematodes

(Agrios, 1997)

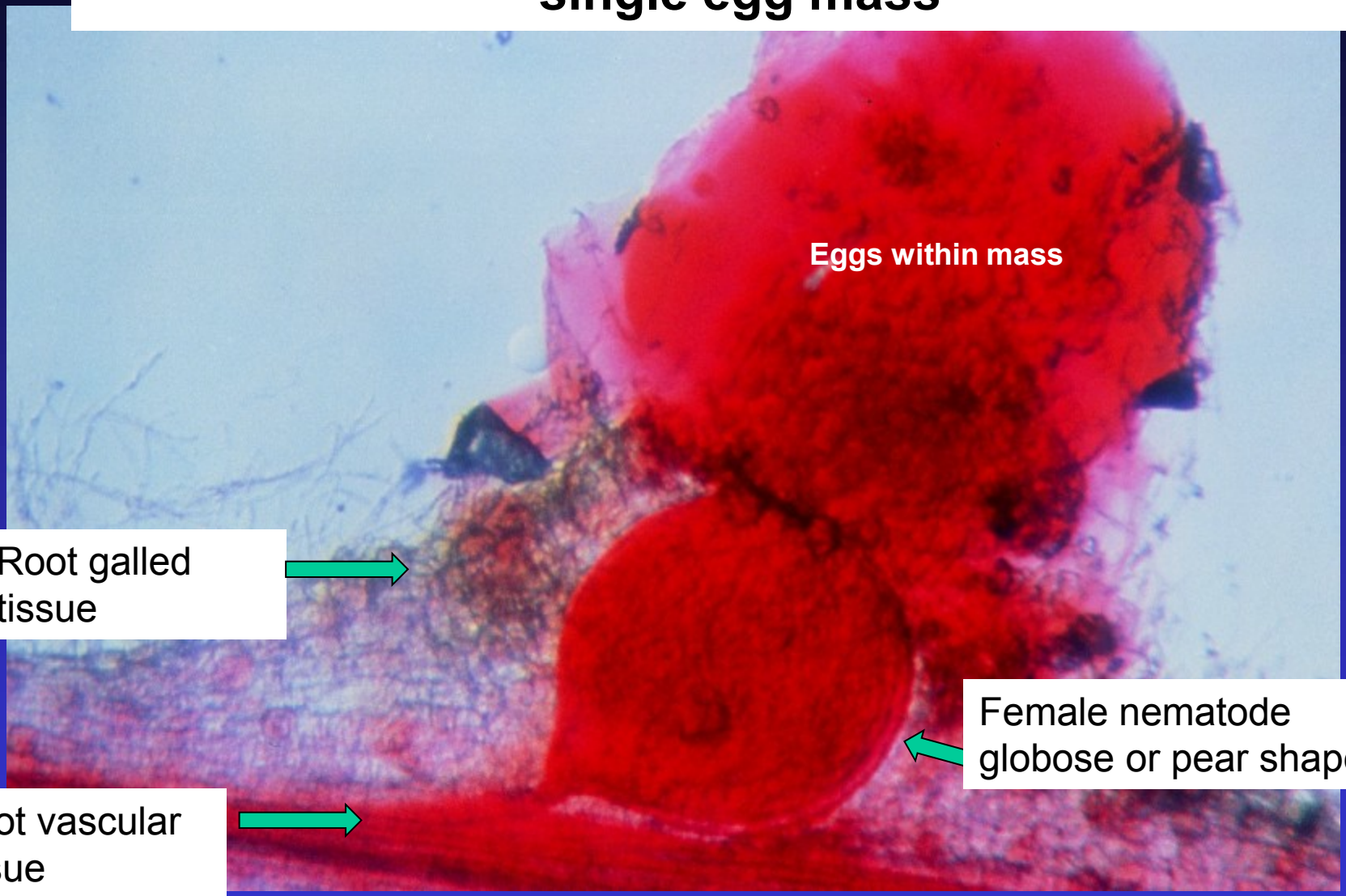


Total of 24 genera

Javanese root-knot nematode, causes severe galling on tomato roots.

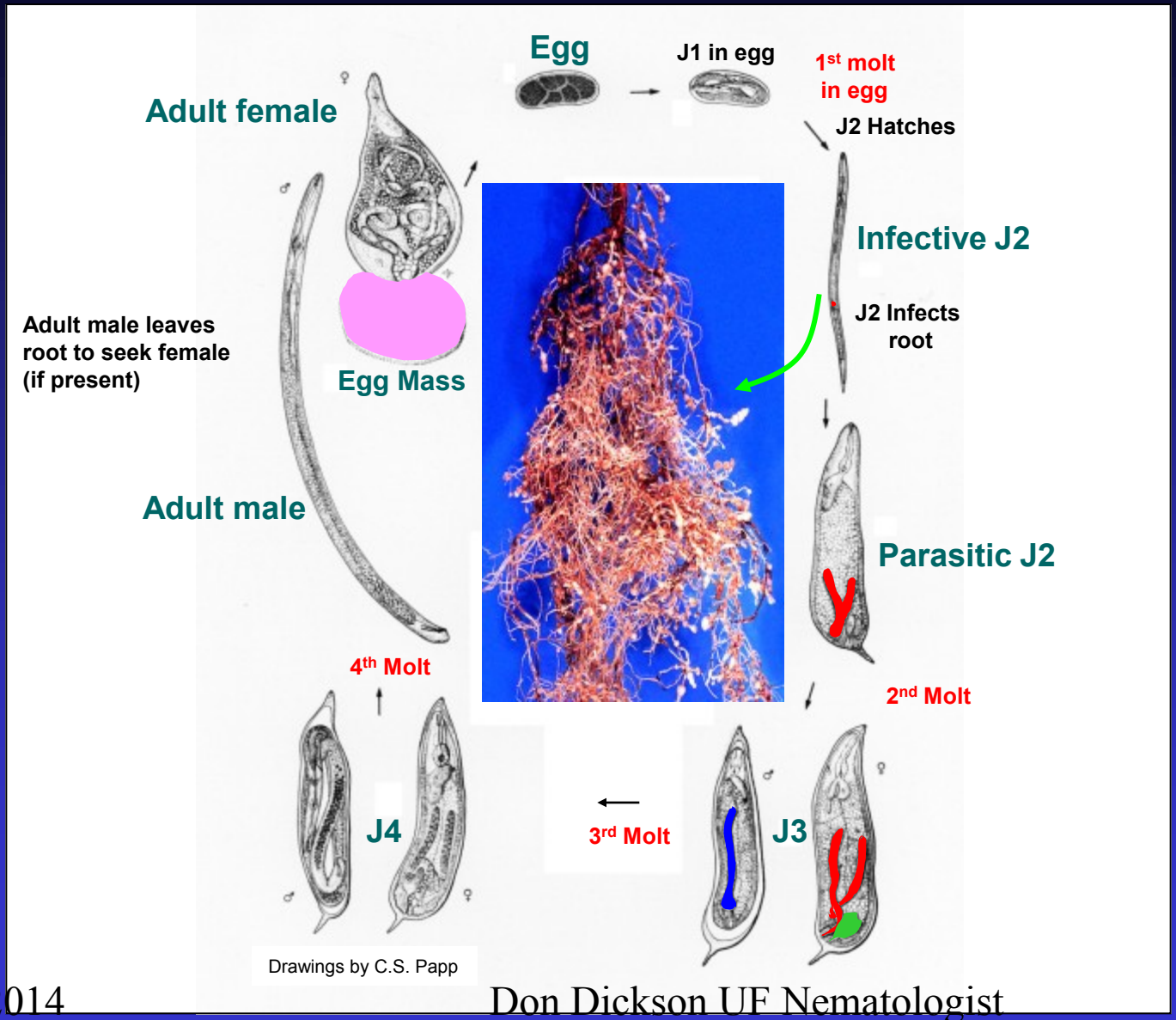
Root-knot nematode below ground damage on tomato roots.

Single mature Root-knot nematode female with single egg mass

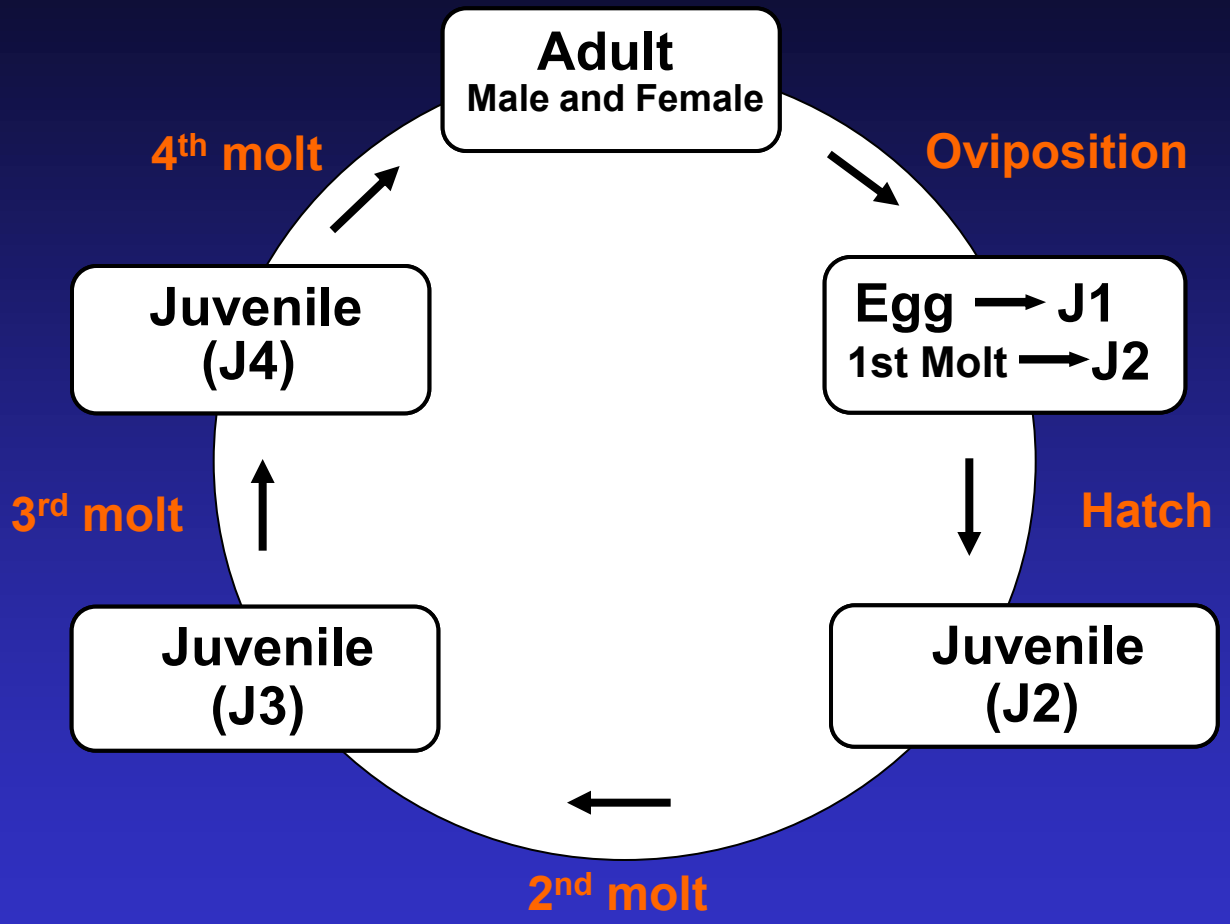


Root-knot Nematode Life Cycle

Meloidogyne spp.

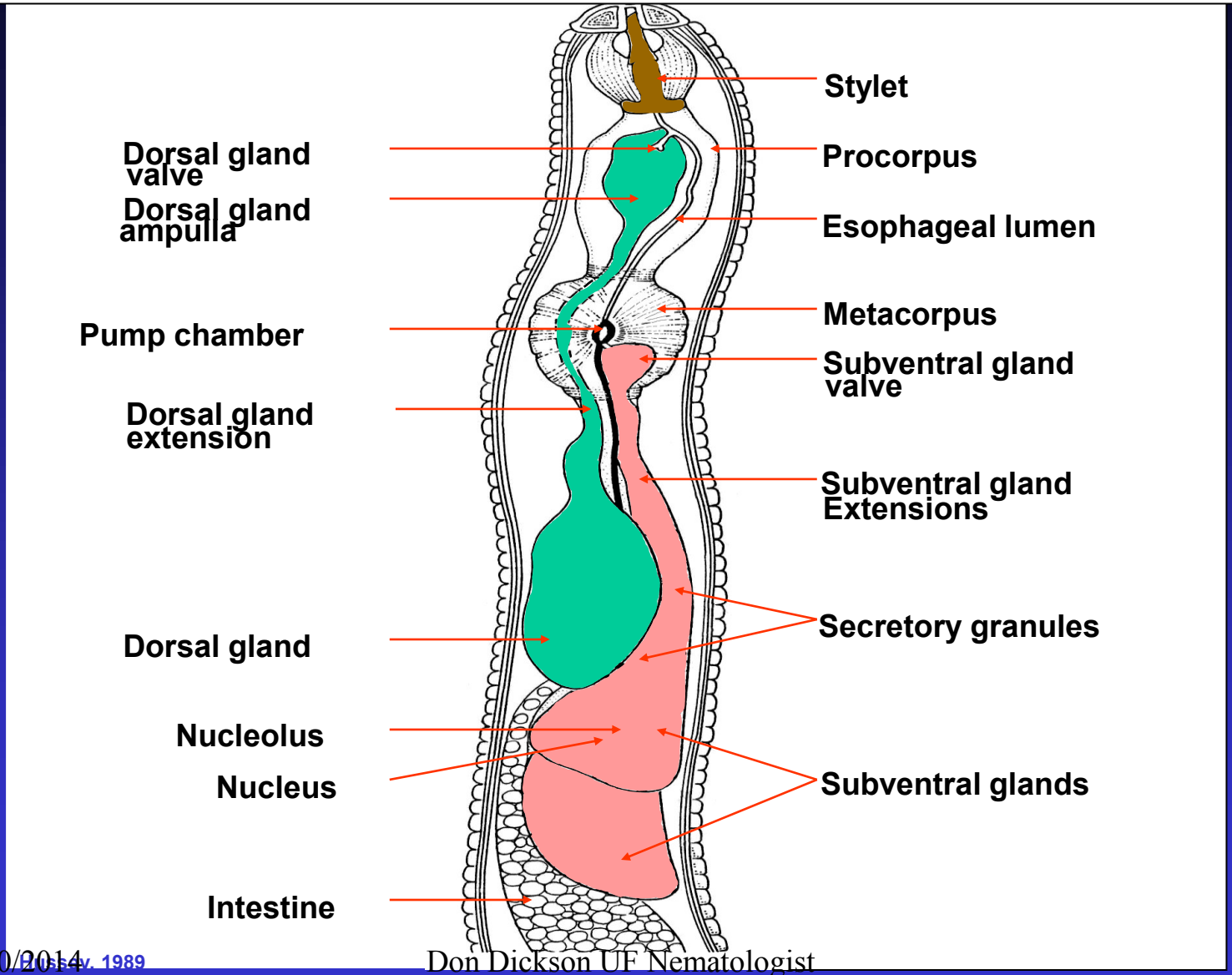


Life Cycle of a Plant-Parasitic Nematode



Typical of most plant-parasitic nematodes

Root-knot nematode Infective Juvenile showing esophagus glands



Root-Knot Nematodes in Florida

- *Meloidogyne incognita* *
- *M. arenaria* *
- *M. javanica* *
- ***M. enterolobii*** *!
- ***M. floridensis*** *!
- *M. hapla* *
- *M. partityla*
- *M. christiei*
- *M. cruciani*
- *M. graminis*
- *M. spartinae*
- *M. graminicola*
- *M. marylandi*

- * Most important species in vegetable production.
- ! Currently only reported to occur in Florida.
- There are over 90 species of root-knot nematodes reported worldwide.

Most Important Root-Knot Nematode species for Crop Production in Florida

- *Meloidogyne incognita* – Southern rkn - 4 host races
- *M. arenaria* – Peanut rkn - 2 host races
- *M. javanica* – Javanese rkn - 4 host races
- ***M. enterolobii*** – Guava rkn
- ***M. floridensis*** – Peach rkn

Meloidogyne enterolobii
guava root-knot nematode

- Tested on root-knot nematode resistant varieties
  - Tomato +
  - Pepper +
  - Soybean +
  - Sweet potato +
  - Peach -

Meloidogyne floridensis
peach root-knot nematode

- Breaks resistance in peach rkn resistant rootstocks
  - Nemaguard
  - Guardian
  - Floraguard
  - Nemared
  - Okinawa

Variability among root-knot nematodes

- Within a species of root-knot nematodes there exist differences in pathogenic virulence.

- In other words all populations of root-knot nematodes do not act the same in the amount of disease they cause.

Root-knot nematode above ground damage on tomato – early season

Root-knot nematode above ground damage on tomato – late season

Some major crops with nematode resistance

- Vegetables – carrot, tomato, pepper, potato, sweet potato
- Agronomic – tobacco, soybean, sugarbeet, cowpea, vetch, corn, peanut
- Fruit trees – peach, citrus
- Resistance is to endoparasitic nematode (primarily cyst and rkn), not ectoparasitic nematodes
- Important – nematode races come into play

Grafting

- Grafting may play an important role.
- Two examples includes tomato and gardenia.
- Research is ongoing with melons and other crops.

Bioengineering resistance

- Identified parasitism genes in root-knot and cyst nematodes.
- Parasitism genes make a nematode unique in that it has ability to be a plant parasite. It can infect and feed on crops.
- Technique = use RNA interference to silence parasitism genes.
- Idea is to genetically modify plants to produce double-stranded RNA, which knocks out nematode parasitism genes.

Root-knot Nematode Resistance in Tomato

Will M*i*-gene hold with high soil temperatures in Florida?

Cvs.	M*i1*-gene	Field design
Crista	Yes	Split plot design – treated and nontreated with Telone II @ 12 GPA
Amelia	Yes	
BHN 586	Yes	
Red Bounty	Yes	

Tomato marketable yield Spring 2011

Cvs.	TRT lbs	NT lbs	Growth rating Trt	Nt	Galling index Trt	Nt
Bella Rosa	76 Aa	66 Aa	7.6	4.8	21 Aa	25 Aa
Amelia	68 Aa	57 Ab	6.6	5.6	0.2 Ab	0.2 Ab
Red Bounty	80 Aa	65 Aa	7.3	6.4	18 Aa	15 Aab

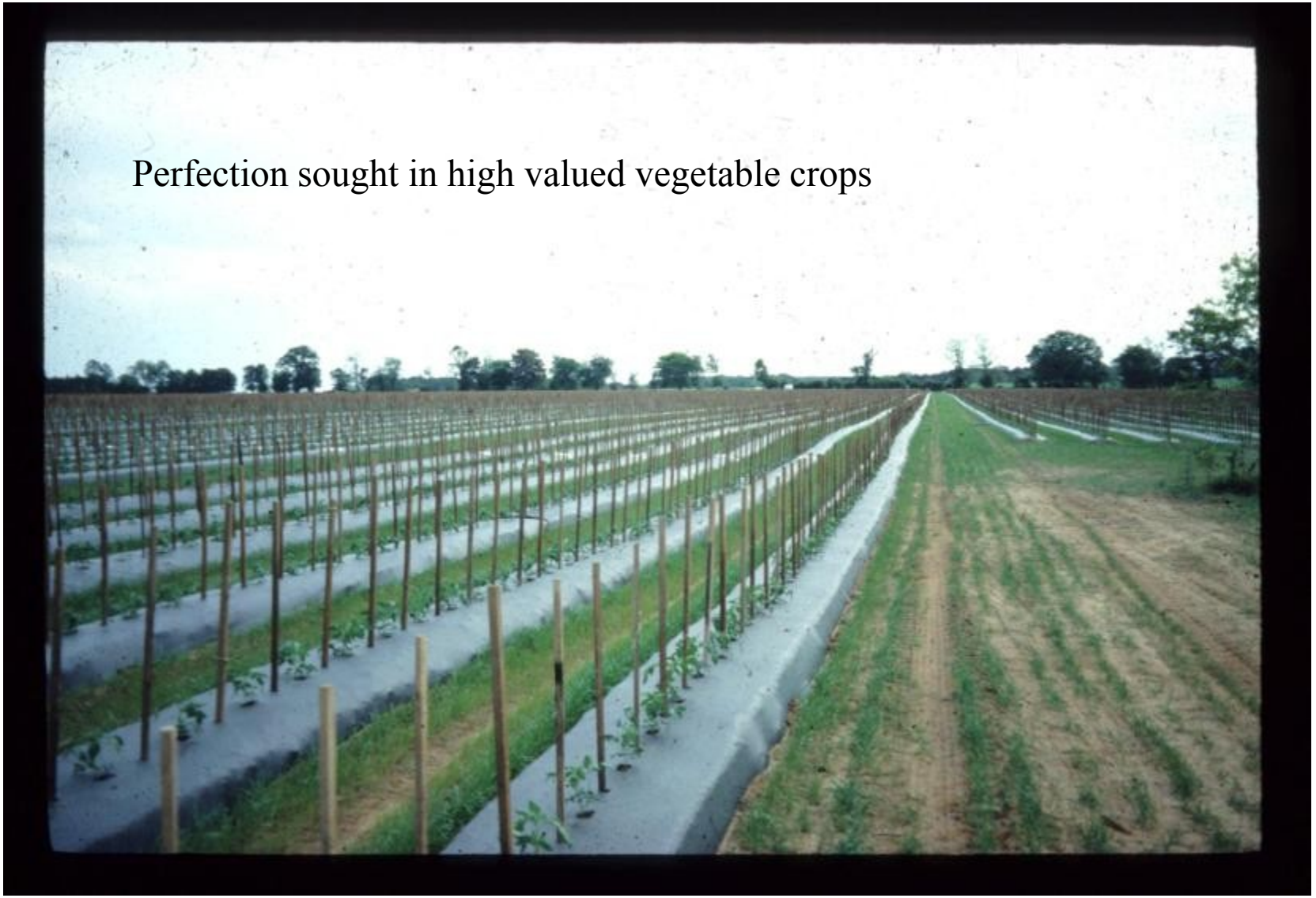

Nontreated 2012 Treated
Red Bounty = RKN resistant


Nontreated 2012 Treated
Amelia = RKN resistant


Nontreated 2012 Treated
Bella Rosa = RKN susceptible

Chemicals used to manage nematodes on vegetables & other crops for the past 60+ years

Application of Nematicide with Hand-Injectors (Fumigun)


Perfection sought in high valued vegetable crops

2/20/2014 Don Dickson UF Nematologist


No suitable fumigant or herbicide applied to manage purple and yellow nutsedges

Nontreated control, no broad spectrum fumigant used. Crabgrass can be overwhelming


Southern stem blight -- Sclerotium rolfsii
No broad spectrum fumigant applied

Fumigants available 2014

1. Telone II (1,3-D)
2. Telone C17 and C35 (1,3-D + chloropicrin)
3. Pic-Clor 60 (chloropicrin + 1,3-D)
4. Metam sodium and metam potasium
5. Chloropicrin
6. Dazomet
7. Paladin (DMDS)

Registered Fumigants -- 2010

Methyl bromide formulations – (no CUE's requested for 2014)

1,3-D – Mostly nematodes
1,3-D + chloropicrin (broad spectrum, little herbicide activity)
Chloropicrin formulations – (little or no control of PPN)
Pic Clor 60
Metam sodium and metam potassium – (poor control of RKN)
Dazomet – (single label on turfgrass)

Which are most useful for nematodes Mgt in vegetables

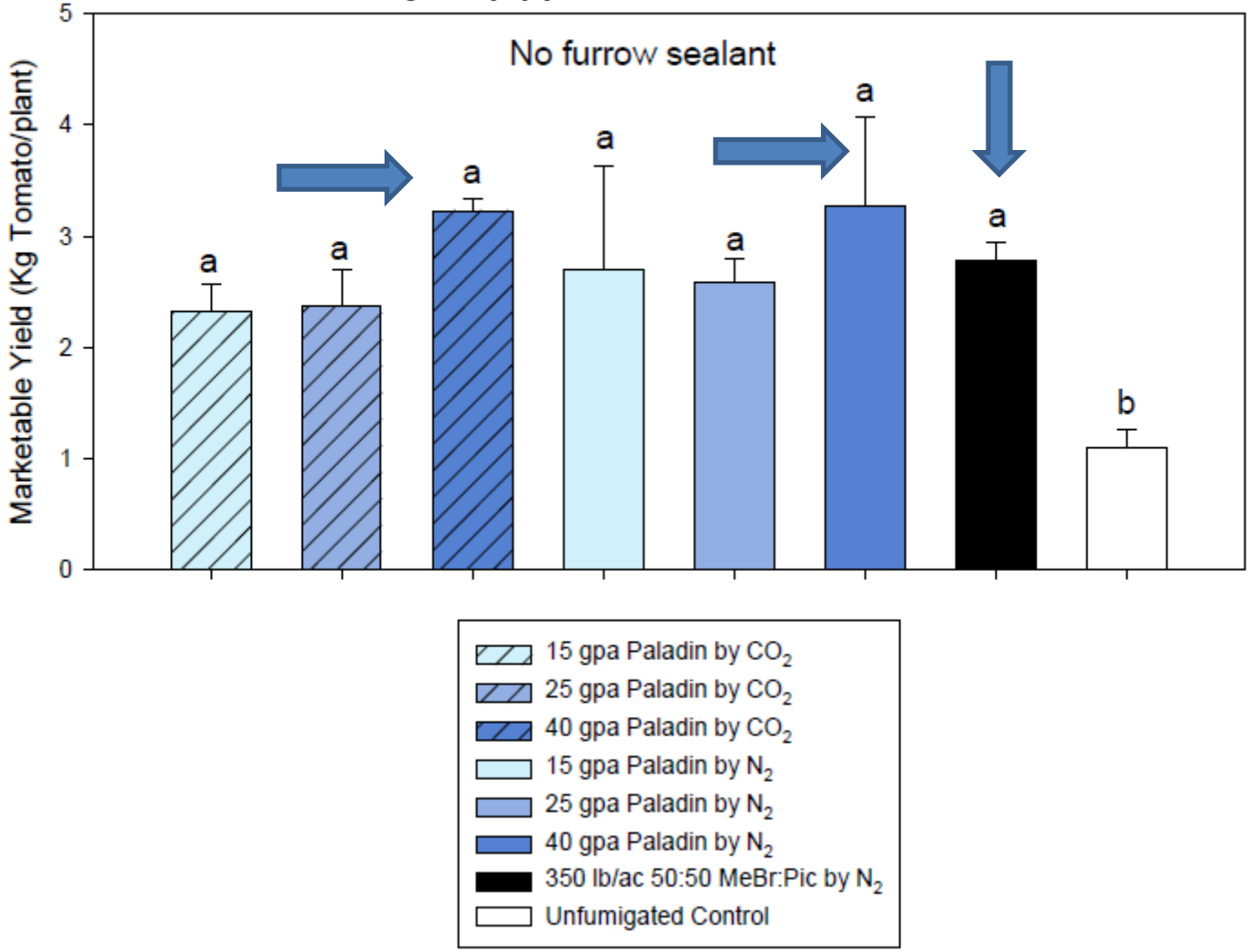
1,3-D, 1,3-D + chloropicrin formulations, Pic Clor 60

New product, labeled (broad spectrum or multi-purpose)

Dimethyl disulfide -- Paladin

Marketable Crop Yield

DMDS = Paladin



Companies with new chemistry for nematode management in vegetables

Bayer
DuPont
Makhteshim-Agan (MANA) Now ADAMA
Syngenta

DevGen (purchased by Syngenta, product discontinued effective February 2014)
Divergence (purchased by Monsanto)

Carrot cv. Indiana Hybrid. 2010. A look at future!

Treatment	Number of taproots 04/13	Total yield (lb) 04/13	Marketable yield (lb) 04/13	Marketable yield loss (%)
1 kg/ha	485 a	53.35 a	36.63 a	31.34
2 kg/ha	470 ab	60.17 a	41.36 a	31.26
3 kg/ha	406 cd	58.65 a	39.04 a	33.44
4 kg/ha	459 abc	57.02 a	38.41 a	32.64
Vydate 6.0 lb/ac	437 abc	59.89 a	42.66 a	28.77
Temik 6.0 lb/ac	418 bcd	62.20 a	45.17 a	27.38
Nontreated	367 d	33.07 b	17.82 b	46.05

New nematicides

Different formulations (wettable powder, spray concentrate, seed treatments, etc., all requiring varying methods of application

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Spray over surface, incorp. -- preplant, at-plant, post-plant

Drip application – preplant, at-plant, and post-plant & multi-applications

Seed treatment or seedling media treatment

Plant-hole drenches

Chemigation

Yetter coulter fumigant applicator


Mini-combo bedder

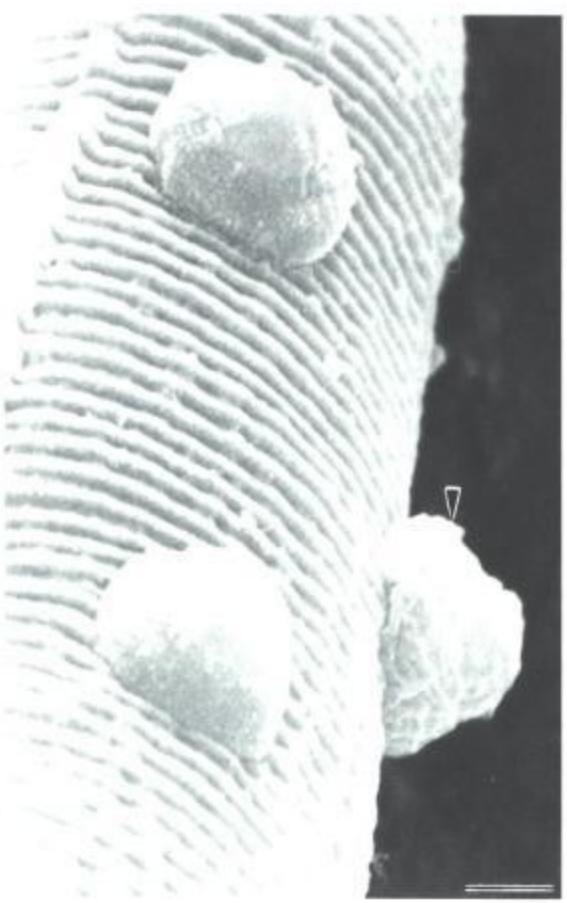

Raven GPS system

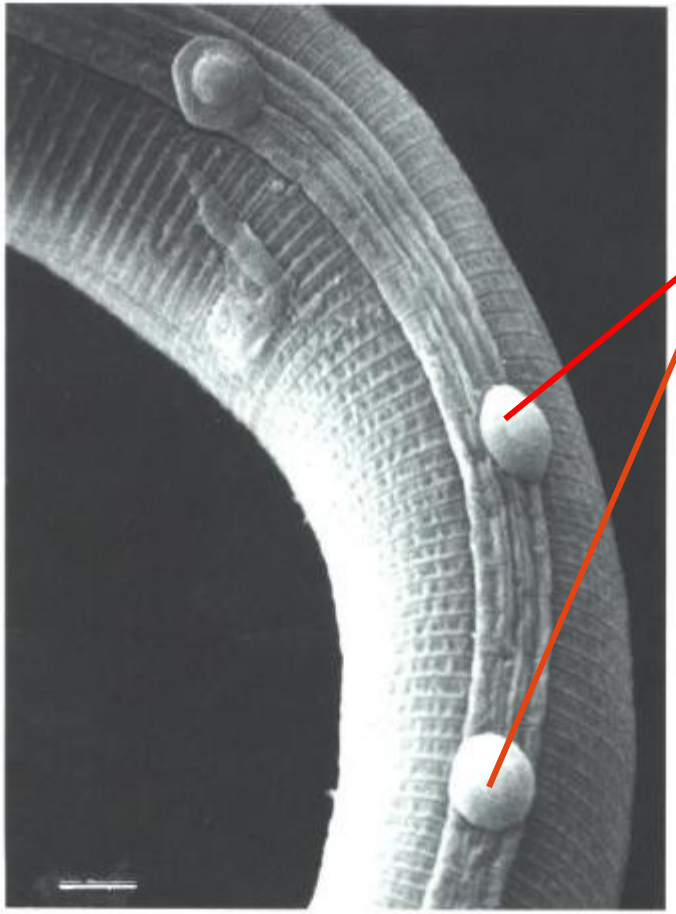

4203

Nematode suppressive organisms

- Fungal agents
  - *Pochonia chlamosporium* (dev. as product)
  - *Nematophthora gynophilia*
  - *Paecilomyces lilacinus* (product available)
  - *Hirsutella rhossiliensis* and other spp.
  - Arkansas fungus 18
  - *Catenaria* spp.
  - Many nematode trapping fungi

Pasteuria penetrans – Bacterial parasite



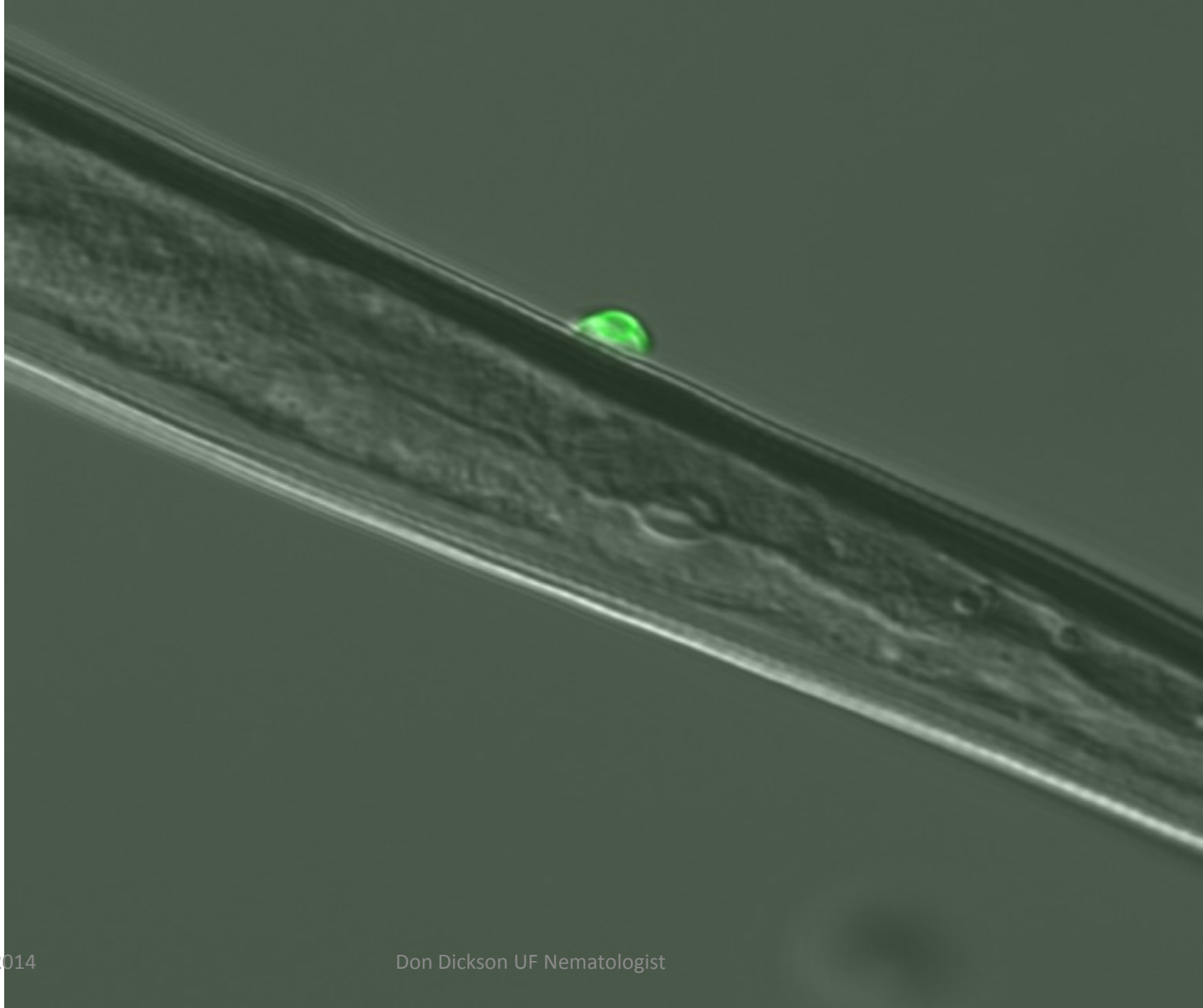


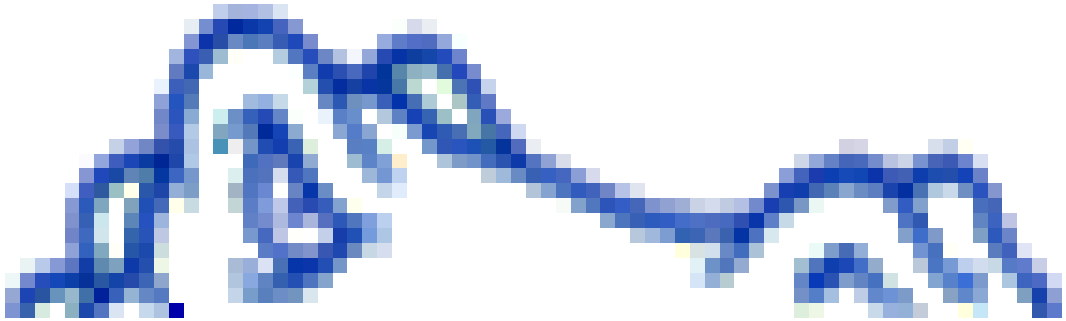
Endospores of
P. penetrans
attached to
J2 of *Meloidogyne*

Anterior region

Lateral field

Z. Chen et al., Phytopathol., 87: 273-283.





In Summary

1. *MI-1* gene not broken by soil temperatures, resistant tomato cvs. with low galling percentages, but yields vary from season to season.

2. Multi-purpose fumigants remain useful, with dimethyl disulfide offering promise.

3. New chemistry promising but must be coupled with other materials to ensure weed and soilborne fungal management.

Thank you