NEMATODE MANAGEMENT WITH AND WITHOUT FUMIGANTS

Johan Desaeger, Nematology, UF/IFAS GCREC

Vegetable Growers Meeting, June 18, 2020

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TOMATO, MAY 2020, WIMAUMA, FL

Too much water?

WATERMELON, WIMAUMA,FL, MAY 2020

Disease?

Fusarium-resistant plants (grafted on squash root stock)

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Root-knot nematodes are everywhere in Florida

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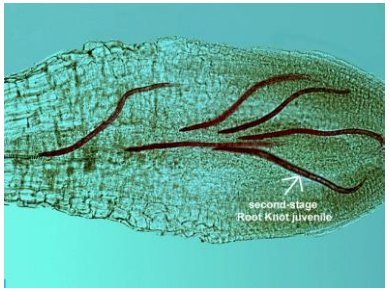
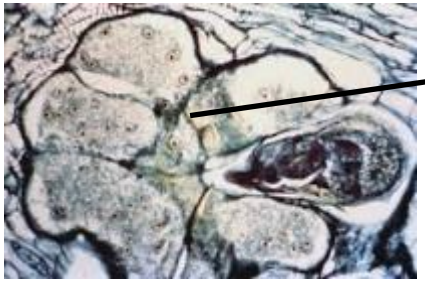
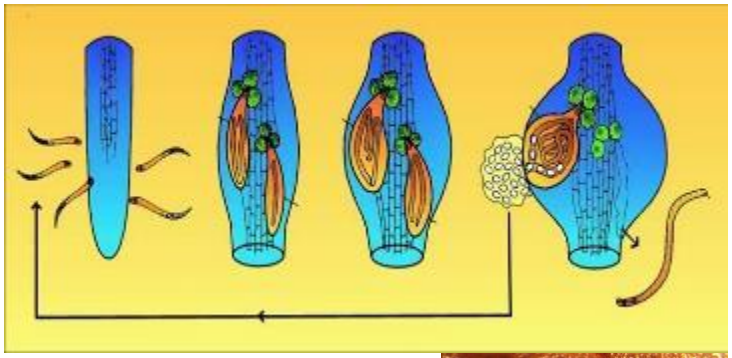
Root-knot nematodes – Nematodo agallador (*Meloidogyne* spp.)

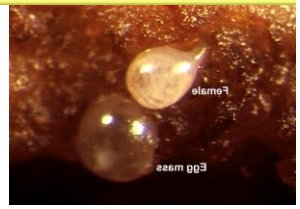
Endoparasite – infective juvenile enters the root, and spends rest of life inside the root – protected from environment





Giant cell





STRAWBERRY FIELD, WIMAUMA 2020

Sting nematodes - *Belonolaimus longicaudatus,* # 1 FL strawberries

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Sting Nematode Impacts to Double Cropping Florida Strawberry

Eggplant

Tomato

Cantaloupe

Pepper

Onion

Yellow Squash or Zuchinni

Sweet Corn

NEMATODE MANAGEMENT IDEALLY IS:

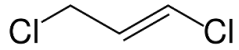
1. **Continuous year-round practice**
   - Pre-plant, during the crop, post-plant, in between crops
2. **Integrated approach**
   - Chemicals, biologicals, cover crops, resistant cv's, cultural methods

BUT reality in Florida for high-value crops – soil fumigation standard practice

Current fumigants for nematode management in Florida

Telone® II

SOIL FUMIGANT



PALADIN® PIC-21 BY ARKEMA

CORTEVA agriscience

Best nematicides

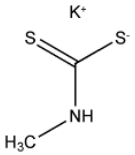
DOMINUS®

chloropicrin

Best fungicide

k-pam HL

AMVAC



More Broad spec

- Simple, organo-chlorine/sulfur compounds
- Effective but not as mobile as methyl bromide (less volatile); not as broad as methyl bromide (combine products); longer plant-back, less forgiving

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Table 1. Physical and Chemical properties of various soil fumigants.

Fumigant	**Boiling Point (°C)**	Molecular Weight	**Vapor Pressure (mm/Hg)**	Henry's Constant	Soil Degradation Half-life (d)	Solubility (mg L^{-1})
1,3–Dichloropropene	120	111	28	0.06	3-5	2250
Chloropicrin	112.4	164	18	0.07	1-2	2270
Methyl Bromide	**3.6**	95	**1420**	0.25	12-22	13400
Methyl Iodide	42	142	400	0.22	4 - 40	14200
Metam Sodium	112	129	0.04	0.01	25 min	578290
Metam Potassium	114	145	24			complete
Methylisothiocyanate	112	73	20	0.01	4-5	89400

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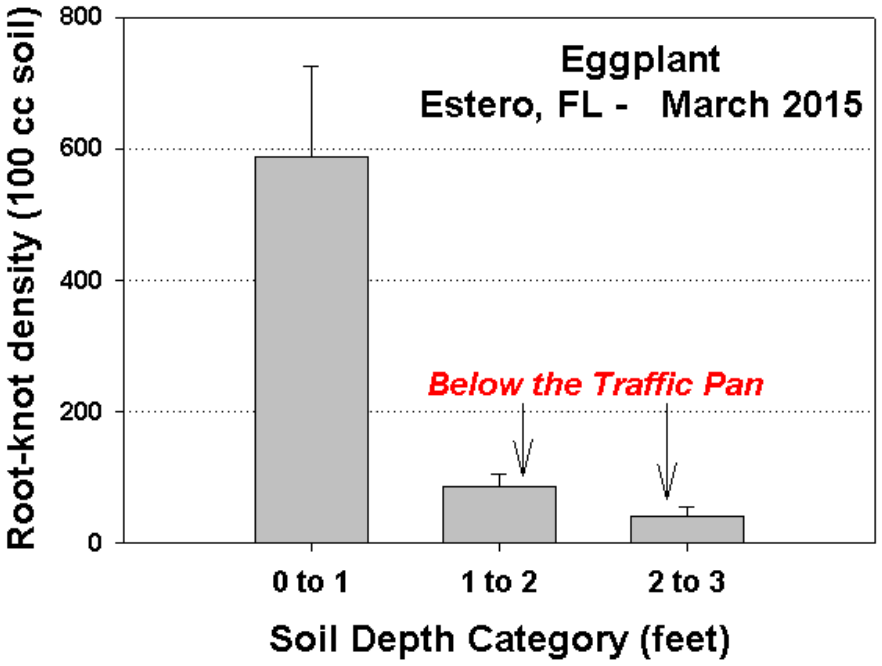
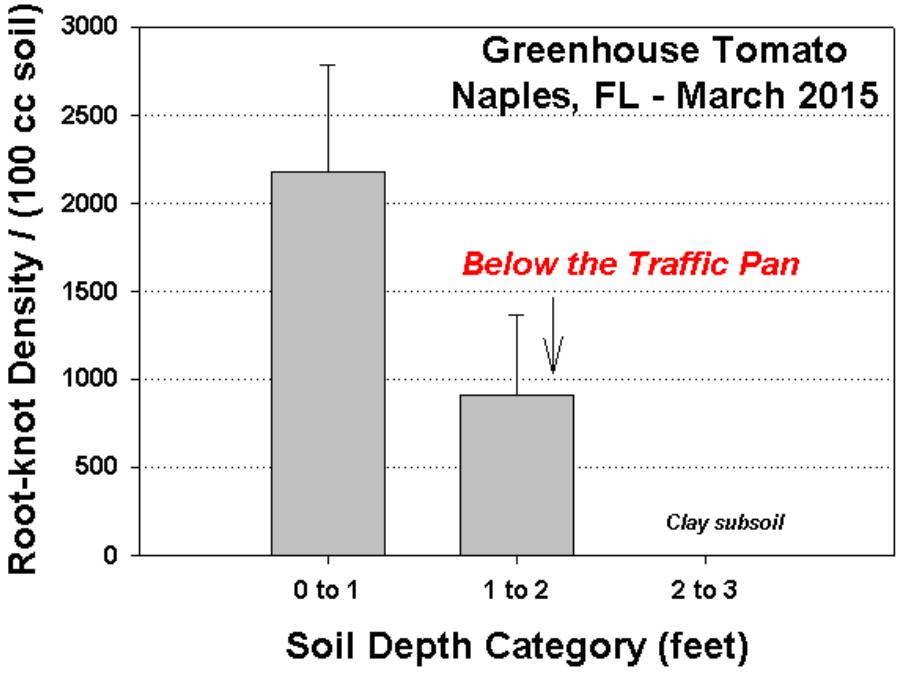
Traffic Pan

- *All fields, unless subsoiled, have a compacted zone (traffic pan) just below the depth of the deepest tillage implement used in the field.*
- *Traffic pan occurs just below the base of the raised, plastic mulch covered bed.*
- *Unavoidably cause changes in soil hydraulic conductivity, diffusion of fumigant gases, and thus fumigant efficacy and field distribution of nematodes and crop damage.*

Dealing with a Traffic Pan is a new issue in Post Methyl Bromide era Florida !

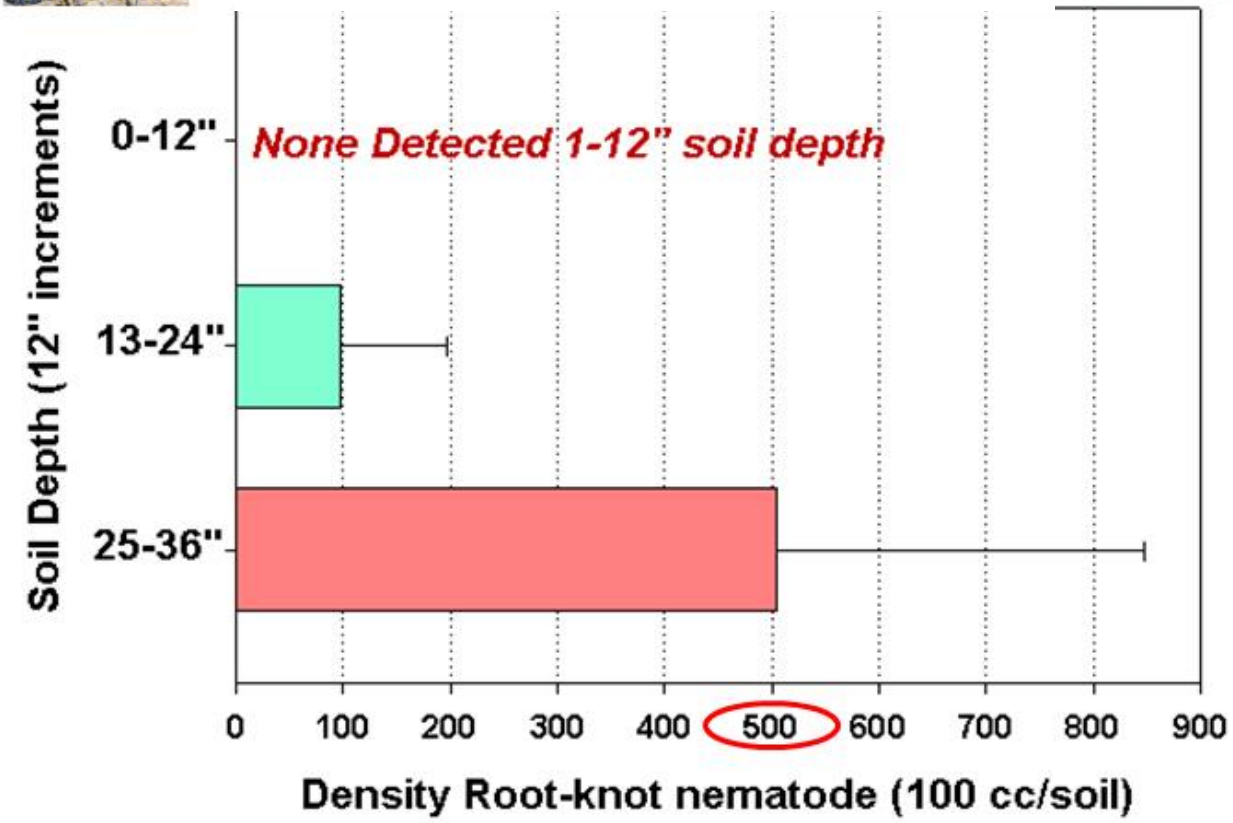
Depth Distribution of *root-knot nematodes in two Florida crops on coastal flatwood soil*





- *Root-knot nematode observed well below traffic pan !*

Late June sampling in old strawberry bed, Barberville, FL



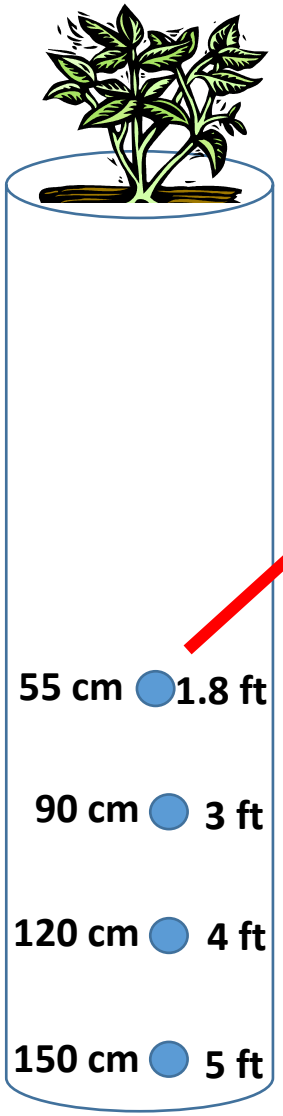
G.H. Godfrey (1924) stated that:

In any measure taken to decrease the number of root-knot nematodes in the soil, one of the factors that must be taken into consideration is the depth at which they occur.

... abundance of infestations present in deep soil, well below the ordinary plow depth

Seasonal Migration of *root-knot nematode* and its Role in Potato Production

Mojtahedi et.al., 1991



9 days after placement at the "bottoms" of tubes, *Meloidogyne chitwoodi* had moved 22 inches (2.5"/day)

Inoculum placed at 90, 120, and 150 cm caused significant potato root infection losses in potato tuber quality in the field

Lower vapor pressure + traffic pan + nematodes moving up and down

NO SEASON LONG CONTROL WITH CURRENT FUMIGANTS

By H. W. Lembright,* M. J. Healy,**
and M. G. Norris**
The Dow Chemical Company

1964

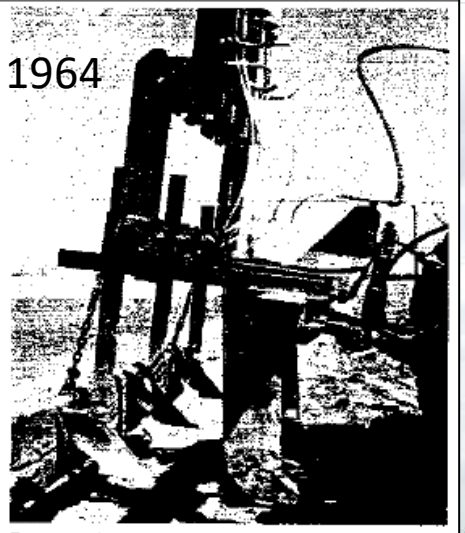


Figure 4—Subsoil chisels equipped for deep placement of TELONE fumigant from gravity flow equipment.

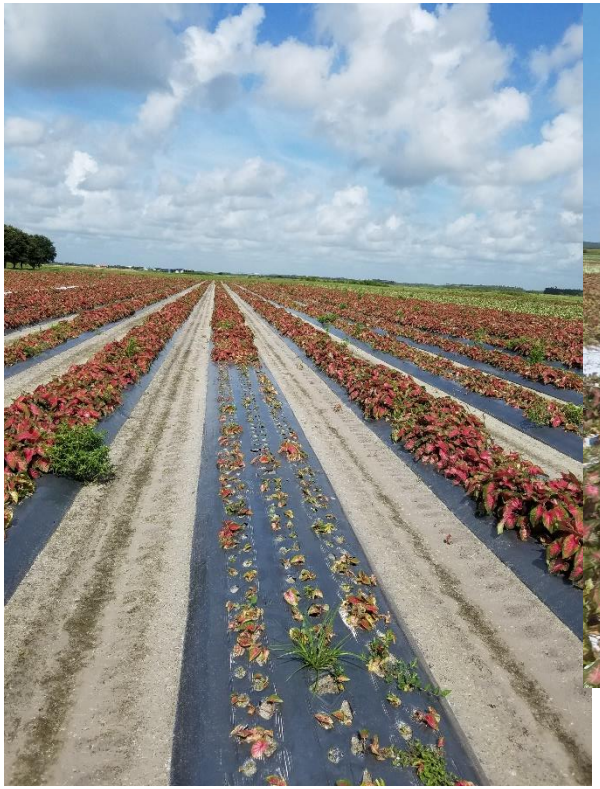
Subsurface

50 acre **cucumber field,** Parrish**,** spring 2017 (deep shank Telone II across rows fb in bed Picclor80) What happened?

Northern root-knot nematode – common in strawberry fields – damage often only recognized on a double-crop - only damaging in cooler soils – oversummer in subsoil

BUT nematodes will find a way –
Caladium field fumigated with methyl bromide and/or deep shank Telone – 2019

Root-knot nematode damage



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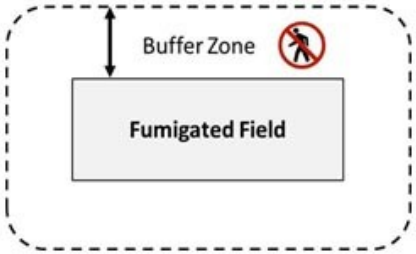
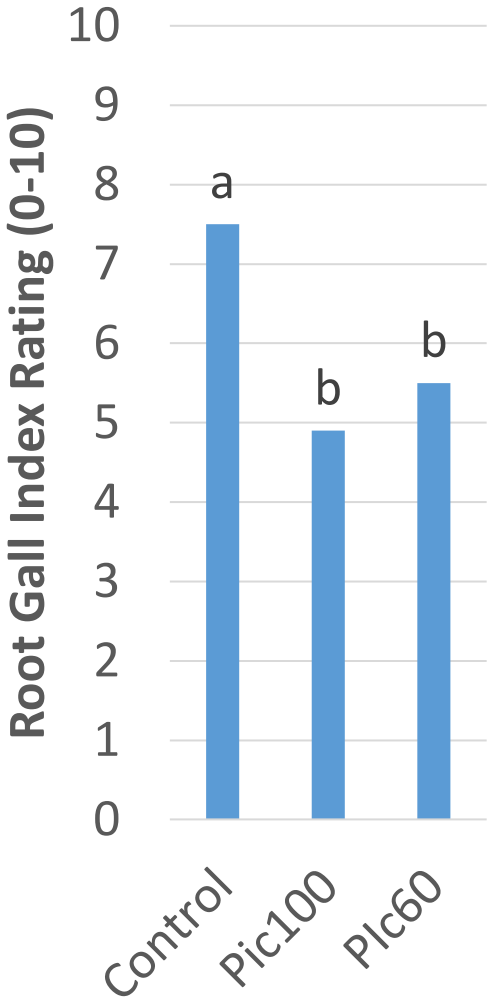
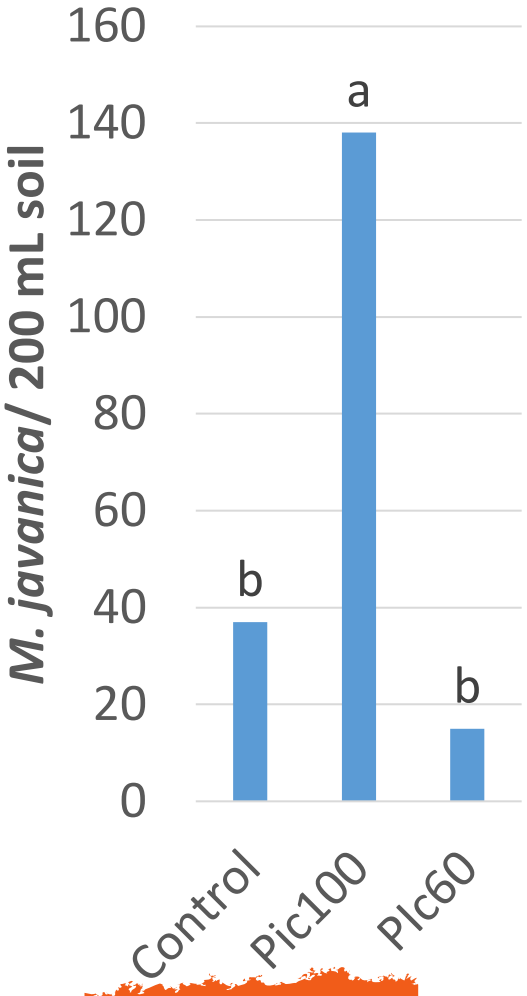
Downsides of soil fumigants …

- Not cheap
- Toxic - proper PPE, FMPs, waiting periods ...
- Buffer zones – residential areas, groundwater restrictions
- Not popular with the public - regulatory and societal pressure (ex. Paladin)
- Collateral damage – impact beneficial soil organisms and reduce natural soil suppressiveness



END-OF-SEASON NEMATODE INFECTION OF TOMATO





No effect of nematicides (*P*-value>0.05)

- Fumigation with Pic100 and Pic60 reduced root gall index ratings
- Soil populations of *J2*-stage *M. javanica* were high in soil fumigated with Pic100

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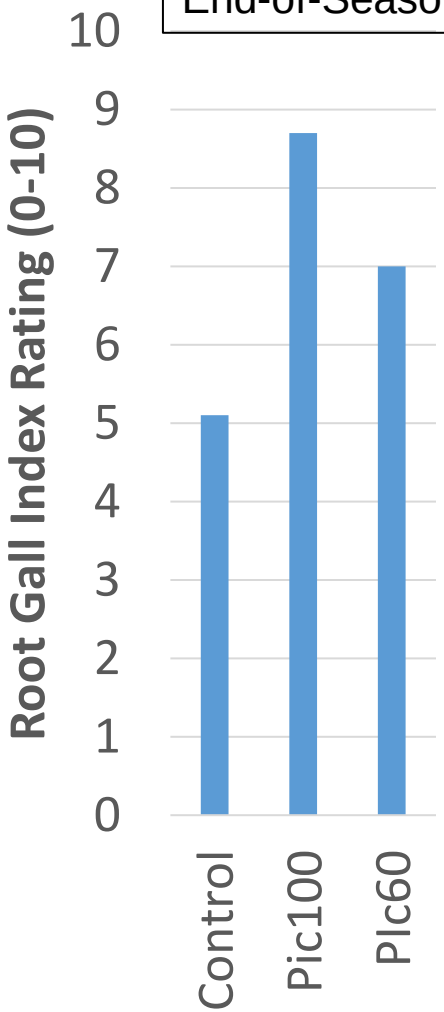
Desaeger and Watson, 2019; *Pest Man. Sci*.

NEGATIVE EFFECT ON DOUBLE-CROPPED CUCUMBER

End-of-Season



Fumigation with especially Pic100 increased root gall index ratings and reduced fruit yield

↓natural suppressiveness of soil

Desaeger and Watson, 2019; *Pest Man. Sci*.

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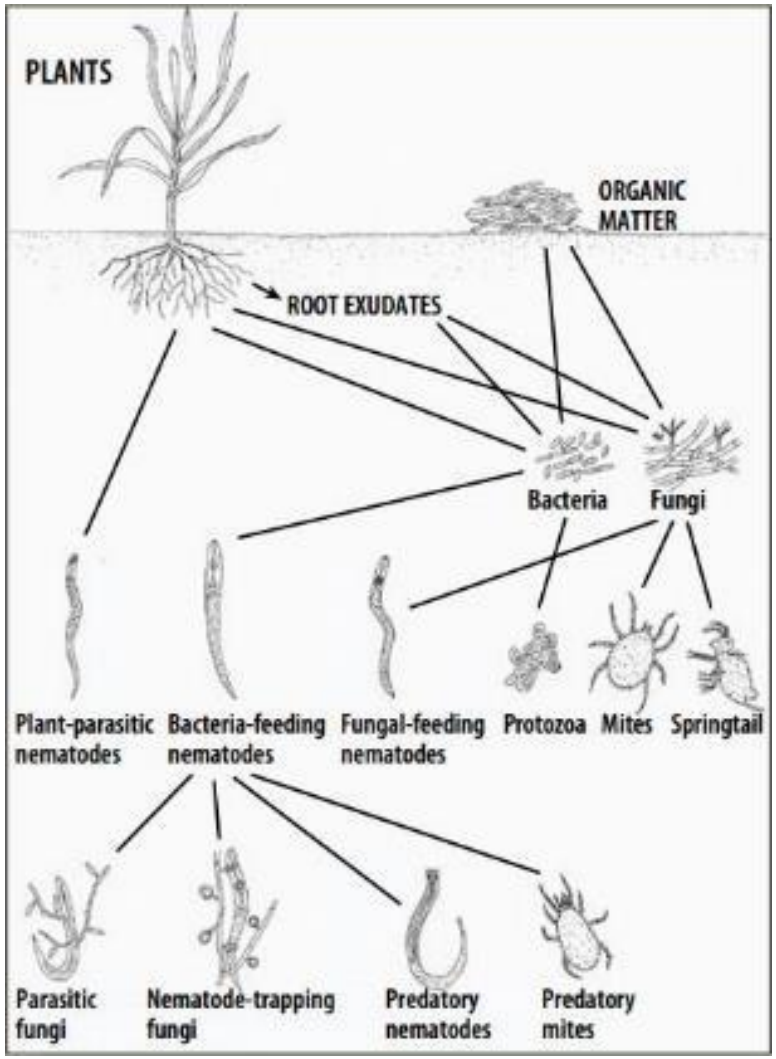
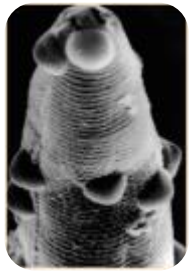
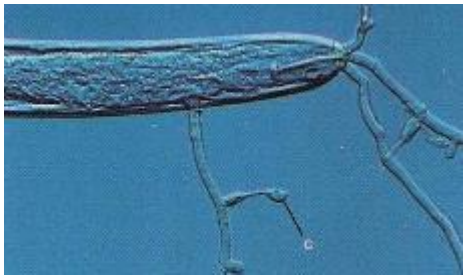
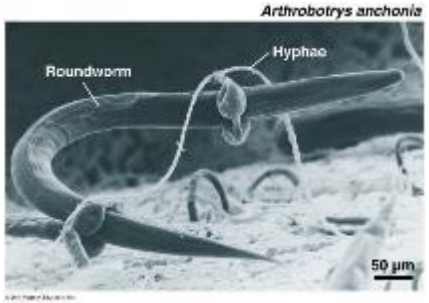
SOIL SUPRESSIVENESS LINKED TO BENEFICIAL SOIL ORGANISMS









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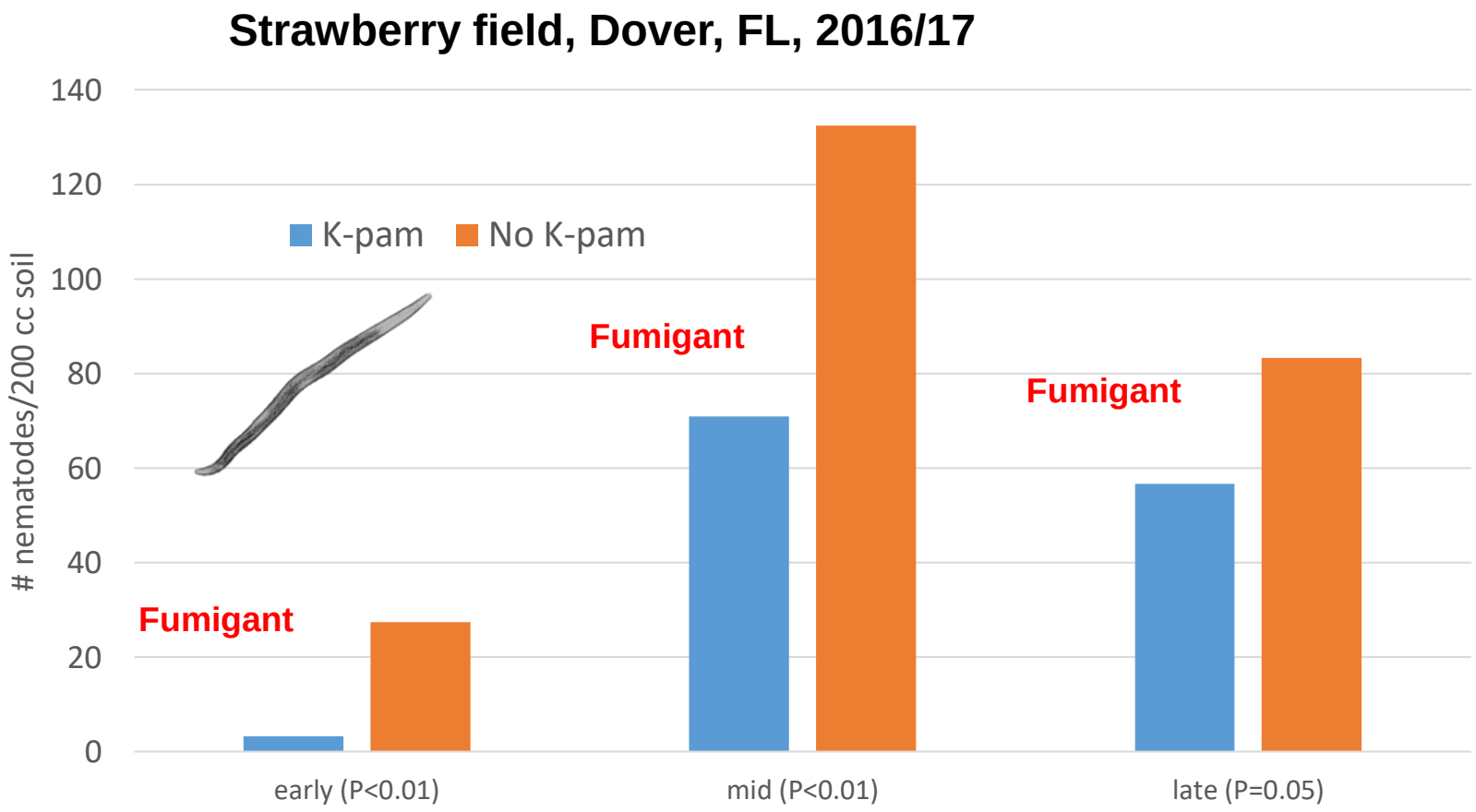
Suppressiveness and Microbial Diversity

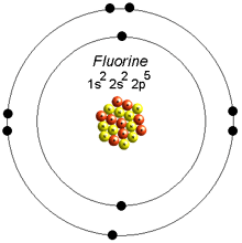
(differential gall development in steamed and untreated soil)

Location	Crop	Management	Suppressiveness (%)	Bacterial Diversity	Fungal Diversity
Site 1	Strawberry	Organic	50.0 a	5.74 a	3.64 a
Site 2	Strawberry	Organic	53.9 a	5.83 a	3.81 a
Site 7	Strawberry	Conventional	25.5 b	5.60 b	3.02 b
Site 8	Natural Ecosystem	-	43.6 a	5.50 b	4.47 a

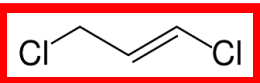
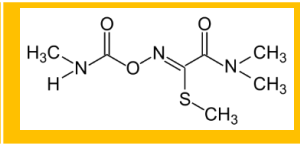
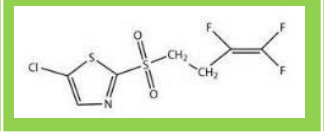
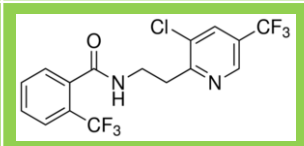
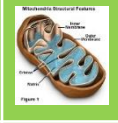
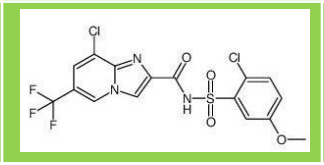
- Greatest suppressiveness in organic strawberry and natural ecosystem
- Reduced bacterial and fungal diversity in conventional strawberry (Dr. Sarah Strauss, UF)

COLLATERAL DAMAGE: FUNGIVOROUS NEMATODES





Until recently few options other than fumigants ...

Chemical name	Trade name	Structure	Soil movement / solubility (water)	Soil ½ life / persistence	Mode of Action	Toxicity Category
Fumigants (1,3-D, metam, pic)	Telone, Kpam, Pic		Good- Gas	Short < 14 d	Multi-site	Danger
Oxamyl	Vydate		Good- 240,000 ppm	Short 7 d	AChel 	Danger
Fluensulfone 	**Nimitz**		Medium- 545 ppm	Medium 15 d	Fatty acid B-oxidase	Caution
Fluopyram 	**Velum**		Poor – 10 ppm	Long > 200 d	SDHII 	Caution
Fluazaindolizine	**Salibro (2020?)**		Medium - 2000 ppm	Medium 30 d	?	TBD

New products are less toxic and more selective; New modes of action; Different soil behavior

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BIOLOGICAL NEMATICIDES

Majestene

MAJESTENE™ BIONEMATICIDE

KYTE-GOLD™ BIOLOGICAL INOCULANT

Bacterial toxins, *Burkholderia* spp.; no live organism

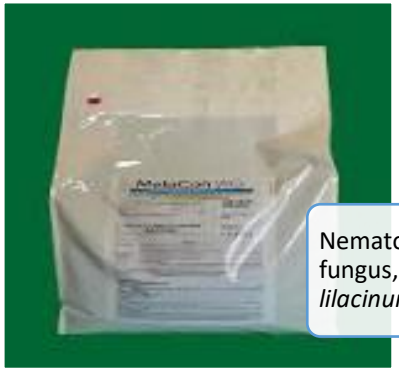
Dazitol

Capsacin (Capsicum) and allyl isothiocyanate (mustard oil)

ECOZIN® PLUS

PRO MAX® BIOPESTICIDE

Melocon

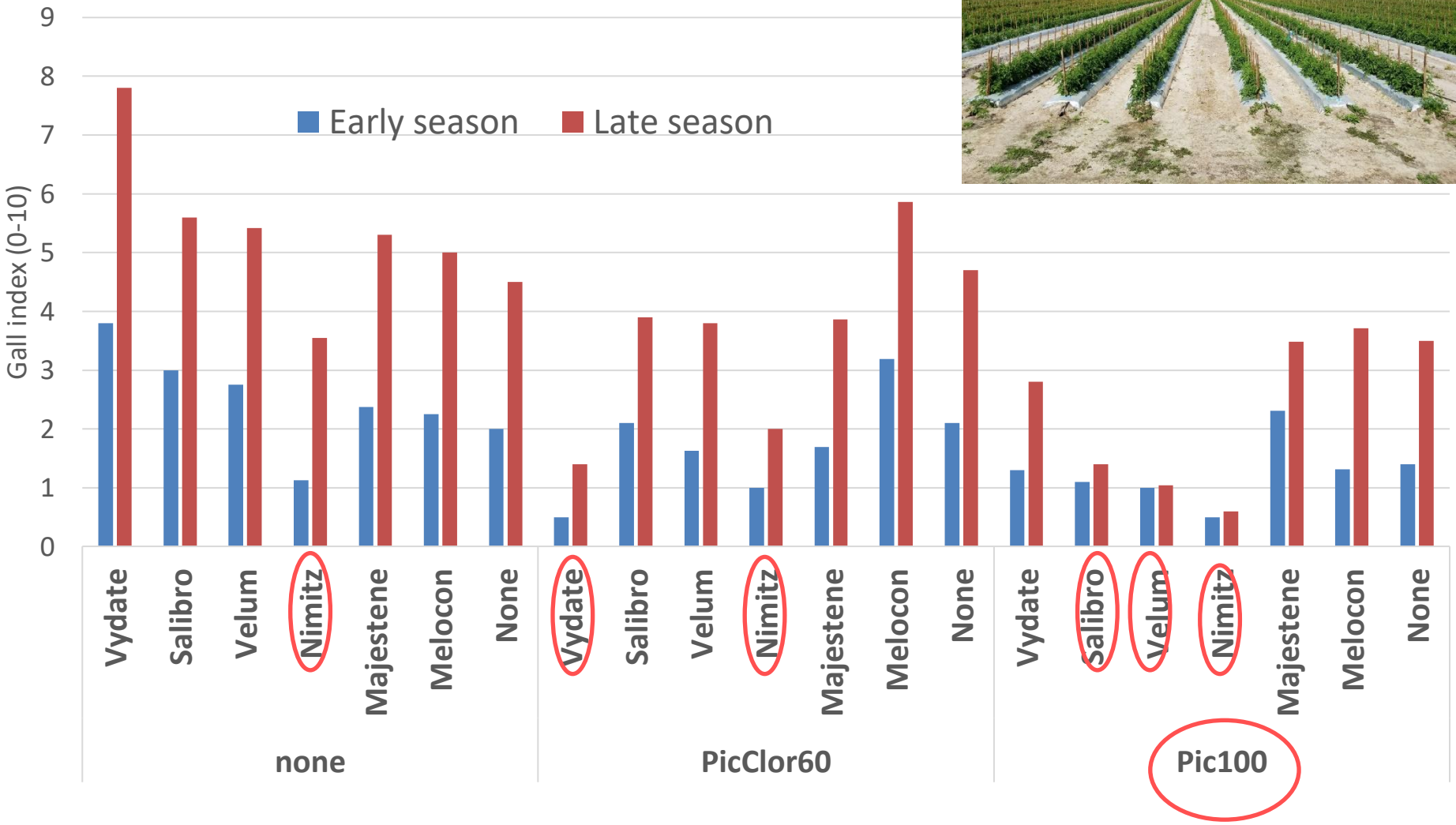


Nematode parasitic fungus, *Purpureocillium lilacinum*

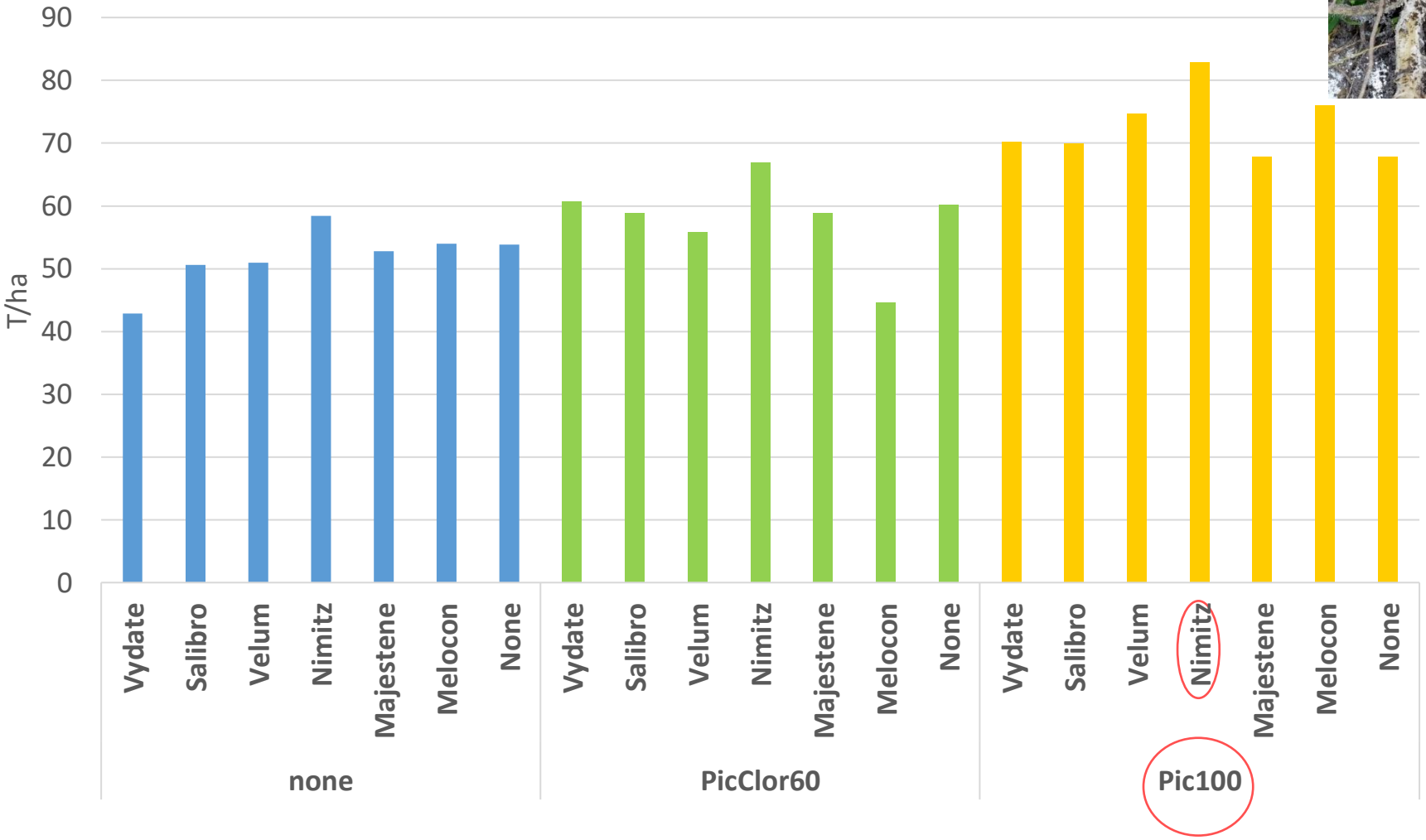
NemaKill

Cinnamon, clove and thyme oil

Root-knot damage, tomato, GCREC, fall ‘17



Tomato Fruit Yield, GCREC, Fall'17



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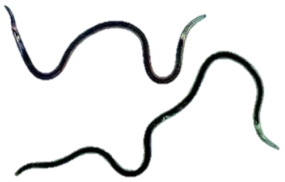
Strawberry Sting nematodes Dover, Florida, 2017-18



Nematicides (sub-plots):

- Control (CTRL)
- Dazitol (DAZ)
- Majestene (MAJ)
- NemaKill (NK)

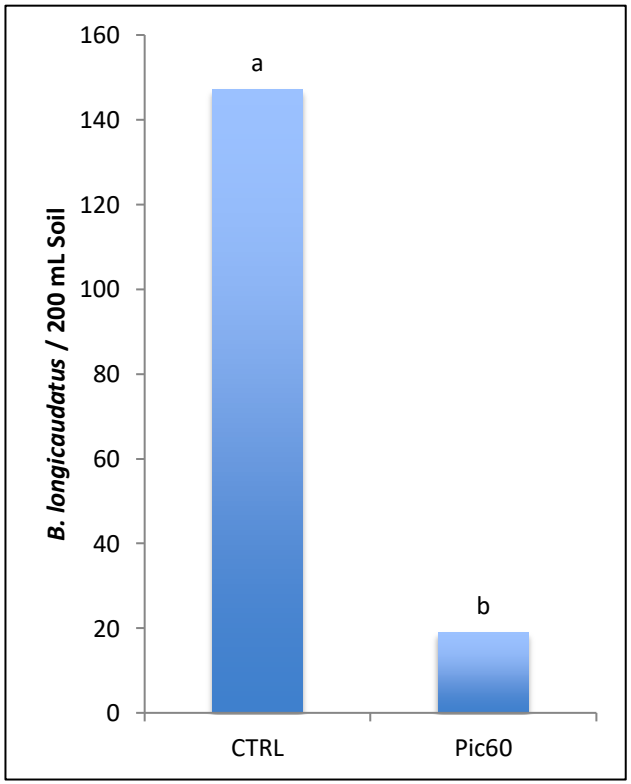
3 apps

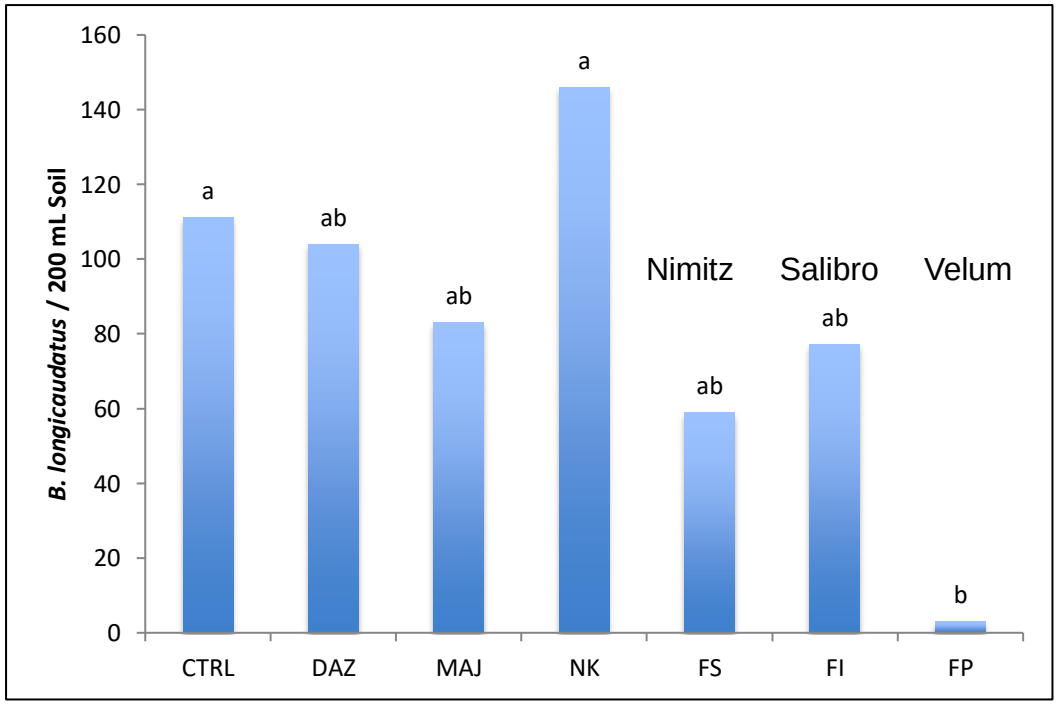
Nimitz • Fluensulfone (FS) — **1 app**

Salibro • Fluazaindolizine (FI)
Velum • Fluopyram (FP) — **2 apps**

Fumigant (whole-plots):

- Control (CTRL)
- 1,3-dichloropropene + chloropicrin (Pic60)





NEMATICIDE RESCUE TREATMENTS IN CUCURBITS ON COMMERCIAL FARMS

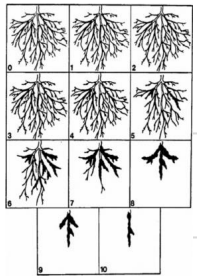
- **Nematicides: labeled for in crop use in vegetables – applied thru drip**
  - Vydate (oxamyl) – nematicide/insecticide
  - Velum (fluopyram) – nematicide/fungicide
  - Nimitz (fluensulfone) - nematicide
  - Majestene (Burkholderia toxins) – biological nematicide/insecticide

- **Cantaloupe, cucumber, squash, watermelon (2017-19) – commercial farms Hillsborough County**

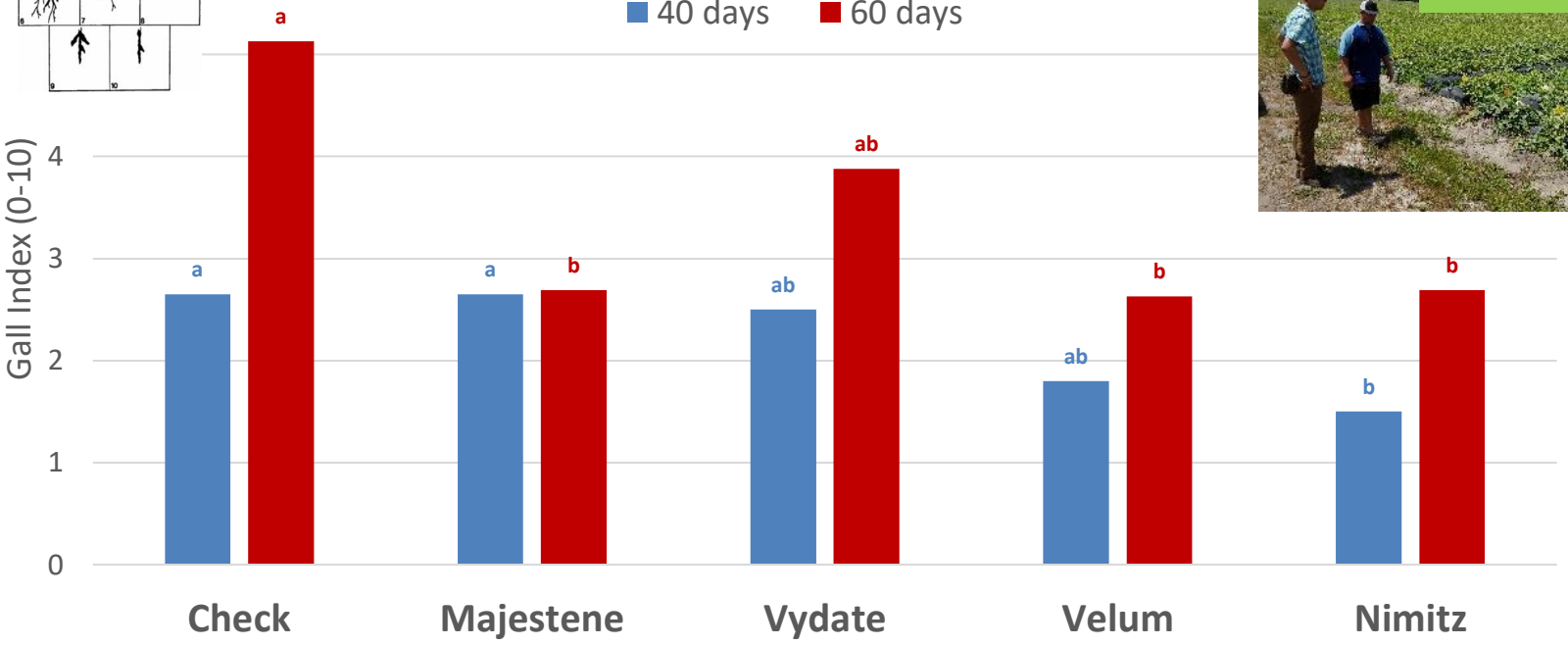
- **Root-knot nematode (northern RKN, *Meloidogyne hapla*, and Javanese RKN, *M. javanica*)**

AG Farm, Cantaloupe spring 2017, northern root-knot nematode, *Meloidogyne hapla*

Replanted after applying 1) **Nimitz**, 2) **Velum,** 3) **Vydate** (oxamyl), and 4) **Majestene**
T1 and T2: 1 application, T 3 and 4: 2 apps (at plant and at 6 weeks)

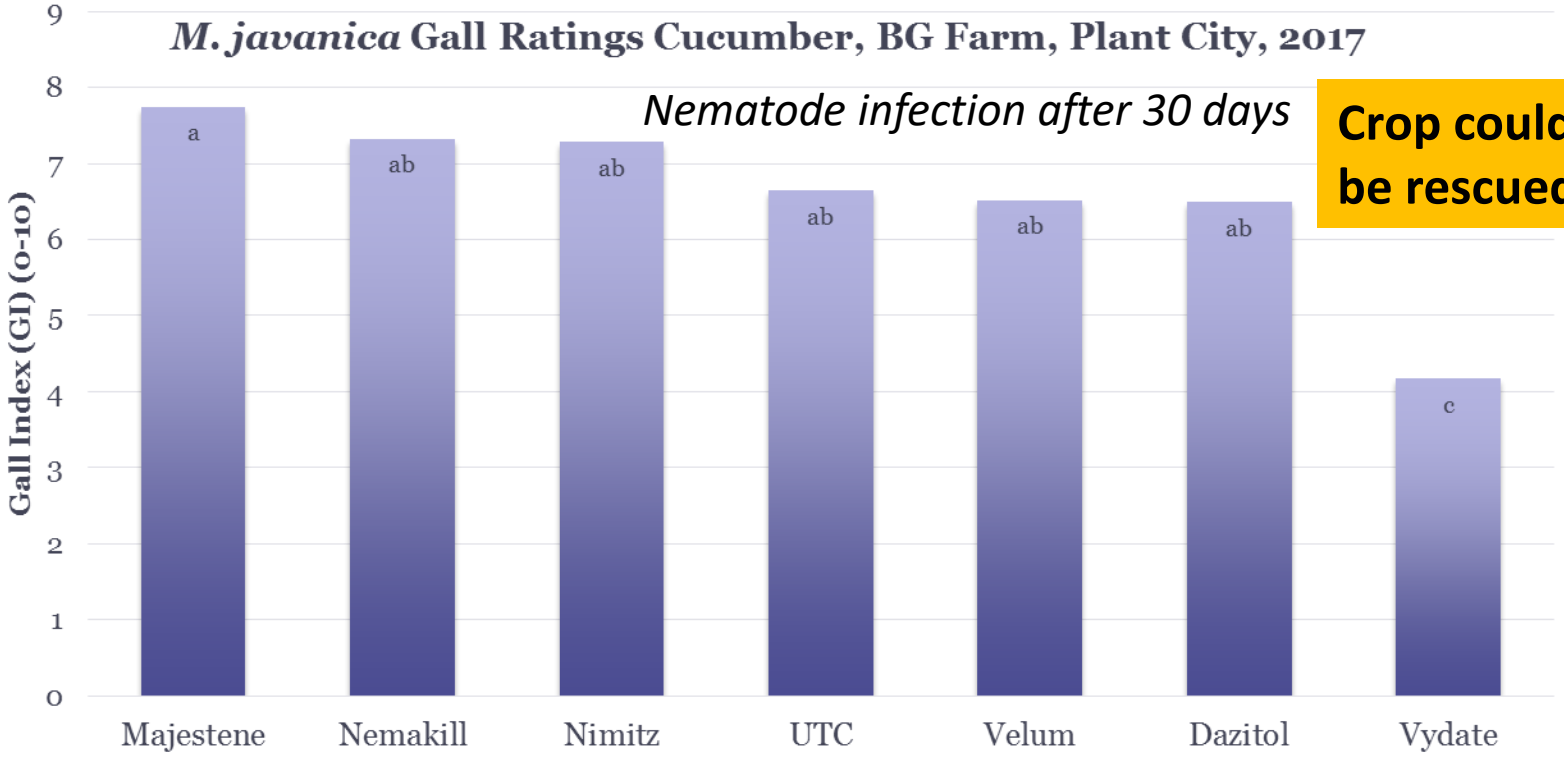


Crop was rescued



BG FARM, CUCUMBER, SPRING 2017, *MELOIDOGYNE JAVANICA* – JAVANESE ROOT-KNOT

High nematode Pressure - Replanted after applying nematicides



Crop could not be rescued

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CURRENT NEMATICIDE OPTIONS

1. Telone / 1,3-D – best product if nematodes are primary concern

2. Kpam (Metam/MITC) – good nematode/disease/weed spectrum

3. Chloropicrin – some nematode control, but rapid resurgence, good for soil disease but harsh on beneficial organisms

4. Vydate and new nematicides (Nimitz/Velum/Salibro at some point) – good (root-knot) nematode control unless nematode pressure is very high, no disease control (Velum?); mixtures and multiple applications may work better

5. Biologicals – low nematode pressure; multiple applications needed; mixtures with other biologicals or chemical nematicides will improve nematode control

Other options than nematicides:
Root-knot resistant cultivars - Tomato

1940's – RKN resistance from wild sp. *Solanum peruvianum* - *Mi-1* gene

Solanum peruvianum

www.lomasdeatiquipa.com

Resistance to 3 spp. *M. incognita*, *M. javanica*, and *M. arenaria*

Florida: little interest in using root-knot nematode resistant tomato cultivars

California: majority of processing tomato are resistant cultivars

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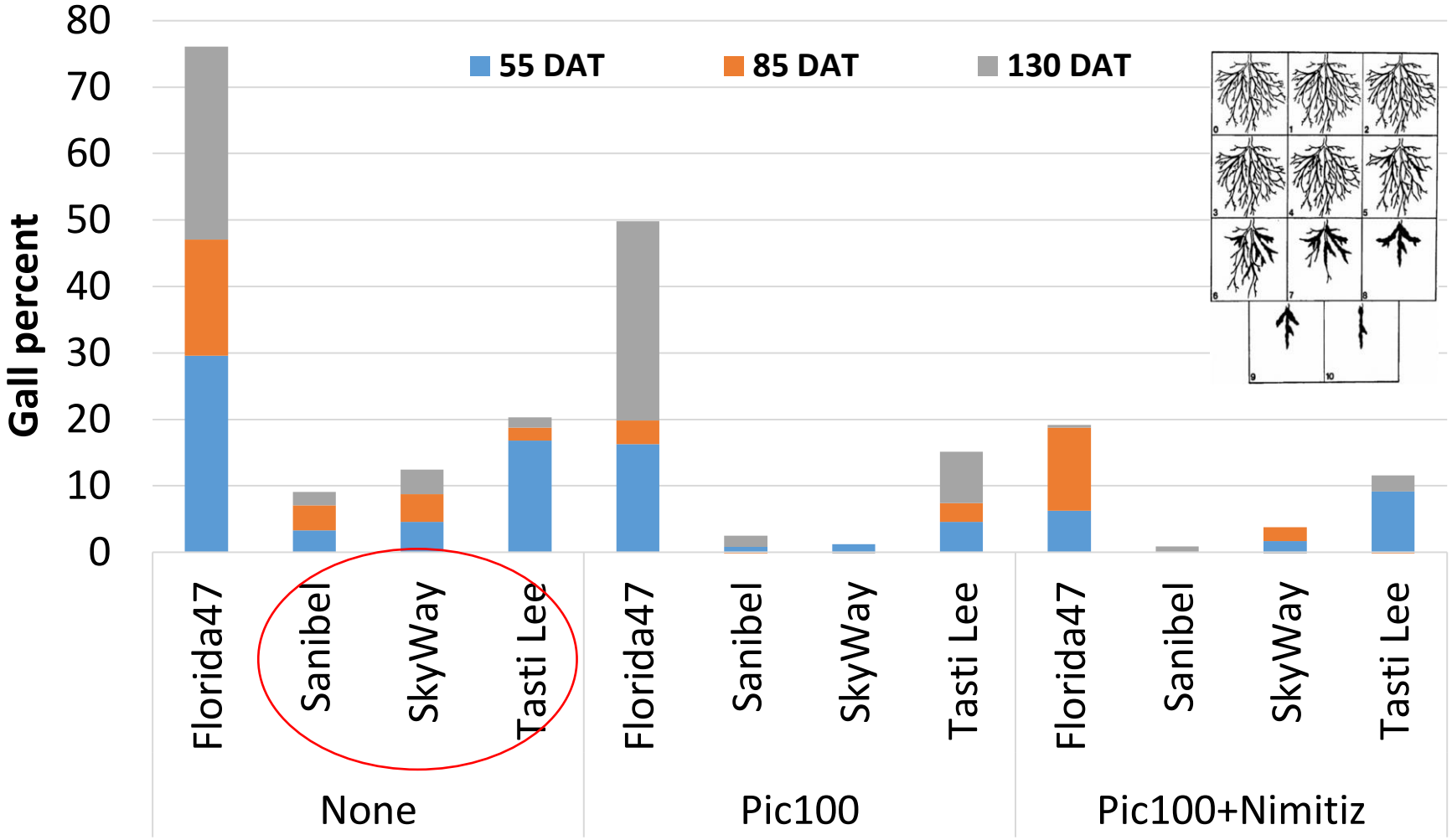
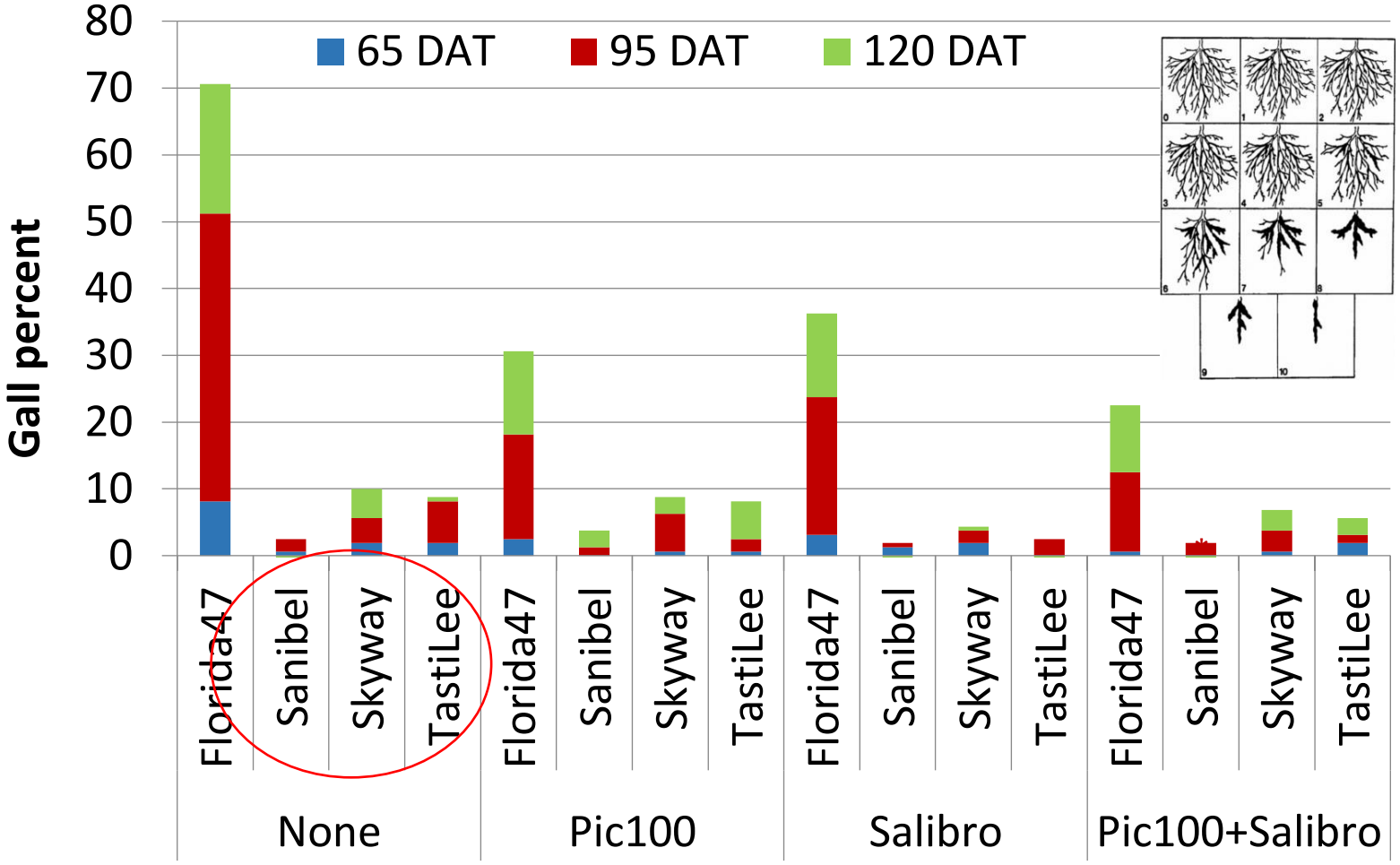
Root-knot gall severity for different cv's and nematicides,
Fall 2017, GCREC



Root-knot gall severity for different cultivars and nematicides, **spring 2018**



Other Options:
Summer Cover Crops for Nematode Management


Buckwheat


Goat's Rue


Marigold


Mexican Sunflower


Millet

Crop	Cultivar	Species
Buckwheat	VNS	*Fagopyrum esculentum*
Goat's Rue	VNS	*Tephrosia virginiana*
Marigold	Nana Champion Flame	*Tagetes patula*
Mexican Sunflower	VNS	*Tithonia diversifolia*
Millet	German Foxtail	*Setaria italica*
Pearl Millet	Wonderleaf	*Pennisetum glaucum*
Radish	VNS	*Raphanus sativus*
Sesame	VNS	*Sesamum indicum*
Sorghum Sudangrass	AS 6201	*Sorghum x drummondii*
Sorghum Sudangrass	AS 6401	*Sorghum x drummondii*
Sourthern Peas	Iron & Clay	*Vigna unguiculata*
Sugar Beet	BL 47150	*Beta vulgaris*
Sunflower	Peredovic	*Helianthus annuus*
Sunnhemp	VNS	*Crotalaria juncea*


Sunnhemp


Pearl Millet


Sunflower


Radish


Sugar Beet

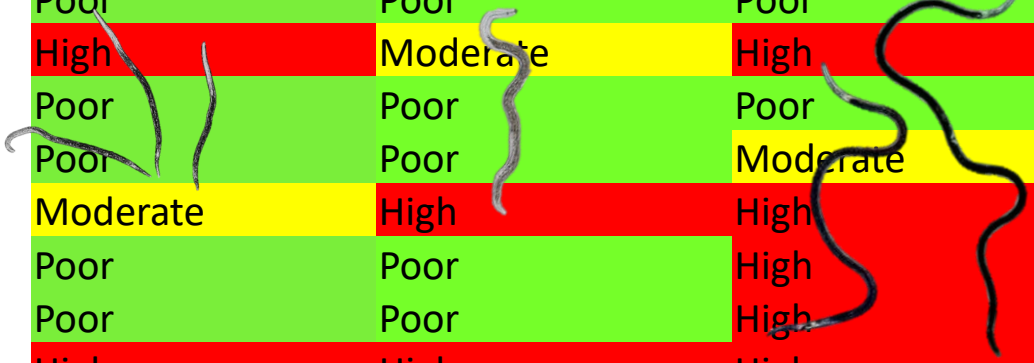

Southern Pea


Sorghum Sudangrass


Sesame

Host Status of Cover Crops for Root-knot (*M. hapla),* lesion *(P. penetrans)* and sting *(B. longicaudatus)*

Crop	*M. hapla*	*P. penetrans*	*B. longicaudatus*
Fallow	Poor	Poor	Poor
Buckwheat	High	Moderate	High
Goat's Rue	Poor	Poor	Poor
Marigold	Poor	Poor	Moderate
Mexican Sunflower	Moderate	High	High
Millet	Poor	Poor	High
Pearl Millet	Poor	Poor	High
Radish	High	High	High
Sesame	Moderate	Moderate	Poor
Sorghum Sudangrass (AS6201)	Poor	Moderate	High
Sorghum Sudangrass (AS6401)	Poor	Moderate	High
Southern Pea	High	Poor	High
Sugar Beet	Poor	Poor	Poor
Sunflower	Poor	High	High
Sunnhemp	Poor	Moderate	Poor
Strawberry	High	High	High



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Nematode Management post methyl bromide again needs to become more integrated

Good agronomy

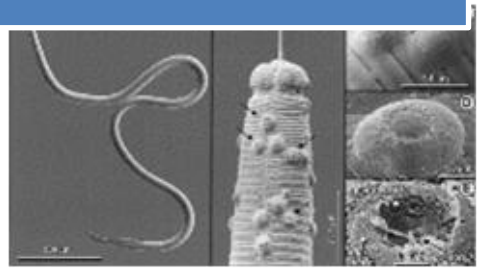
Tillage

Steaming / Solarization / ASD

Nematicides

Resistance

Stimulate soil suppressiveness



Cover crops

Crop rotation

Nematode-free plants

Nematology Lab

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https://gcrec.ifas.ufl.edu/research-programs/entomology-and-nematology-/

https://uflnematodes.wordpress.com/

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