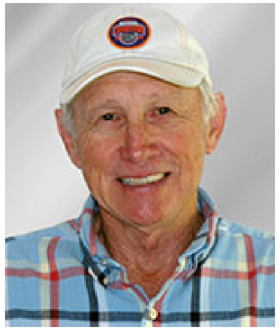
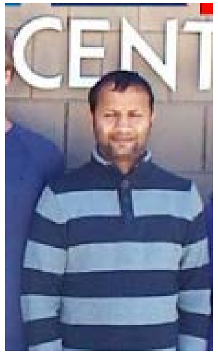


Using Resistance to Combat Root-Knot Disease in tomato

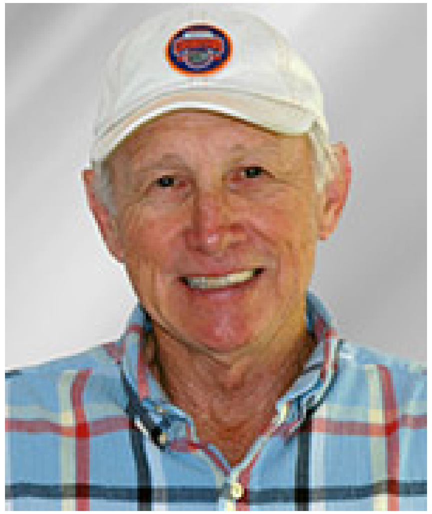
Johan Desaeger, Don Dickson, Homan Regmi and Silvia Vau

University of Florida



Florida Nematology Giants Retiring

Dr. Don Dickson



Dr. Joe Noling

Resistance to Combat Tomato Root-Knot Disease

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

- California: majority of processing tomato are resistant cultivars

- Why resistance?

- Viable alternative?

How was tomato resistant to root-knot nematode (RKN) developed:

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

Solanum peruvianum

www.lomasdeatiquipa.com

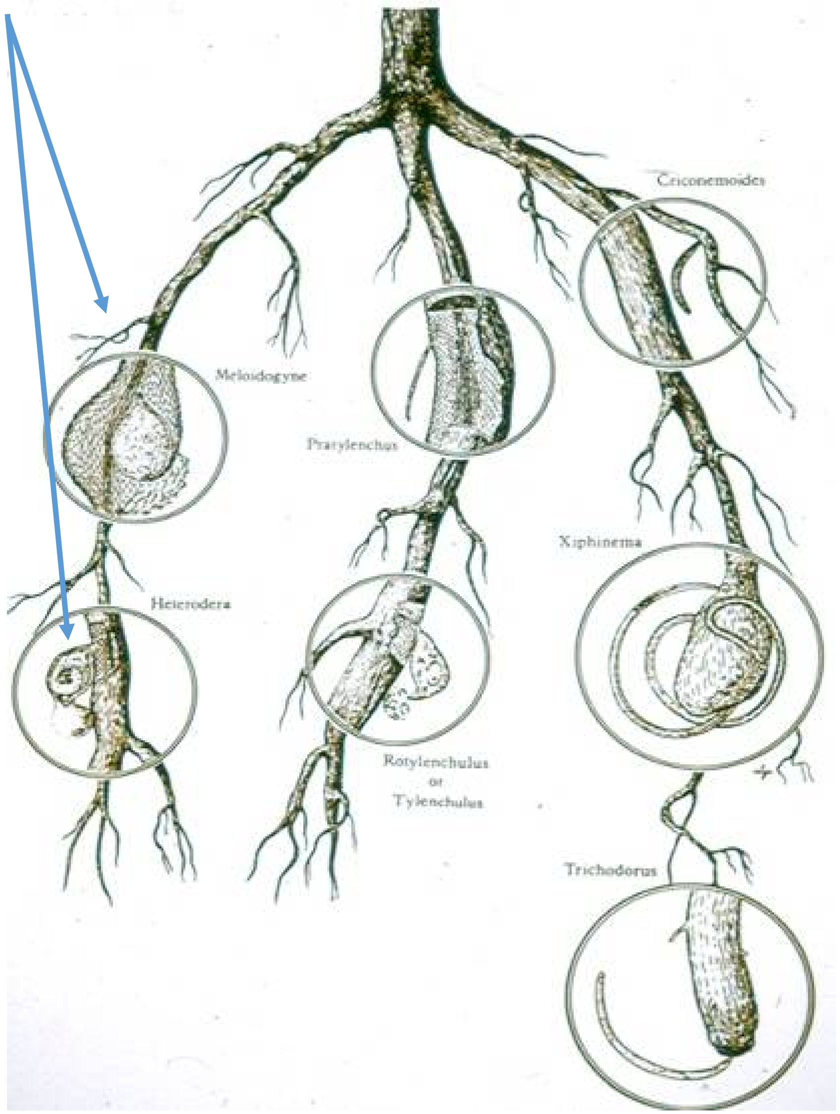
- Resistance to 3 spp. *M. incognita*, *M. javanica,* and *M. arenaria*

- *S*everal *Mi*-genes : *Mi-1* to *Mi-9* -only *Mi-1* incorporated in tomato cv's

Crops with nematode resistant genes - root-knot nematode

Almost all resistance against "endoparasitic" nematodes

Host plant	Gene or source	*Meloidogyne* spp.
Carrot	*Mj - 1*	Mi, Mj
Clover	*TRKR*	*M. trifoliophila*
Coffee	*Mex - 1*	*M. exigua*
Common bean	*Me 1, Me2, Me 3*	Mh, Mi, Mj
Cotton	*Rkn 1, RKN2*	Mi
Cowpea	*RK, Rk2, rk3*	Ma, Mh, Mi, Mj
Grape	*N, Mur1*	Ma, Mi
Lucerne	*Mj - 1*	Mh, Mi
Lima bean	*Mir -1, Mig- 1, Mjg- 1*	Mi, Mj
Groundnut (peanut)	***Arachis* spp. hybrids**	**Ma, Mj**
Pepper	*Me1, 3,4,7; Mech1,2*	Ma, Mi, Mj, *M. chitwoodi*
Potato	*Rmc1, MfaXIIspI*	*M. chitwoodi*, Mh, *M. fallax*, Mi
Prunus (peach)	***Ma***	**Mj, Mi, Ma, Mf**
Soybean	*2 QTLs*	Mj
Sugarbeet	*Beta vulgaris* spp.	Ma, *M. chitwoodi, Mh, M. fallax*
Sweet potato	*Mi, Mj, Ma*	
Tobacco	*Rk*	Mi
Tomato	***Mi1 – Mi9***	**Ma, Mi, Mj**
Wheat	*Triticum tauschii*	Mi, Mj, *M. chitwoodi*

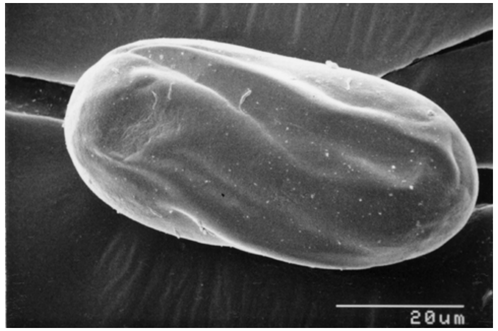


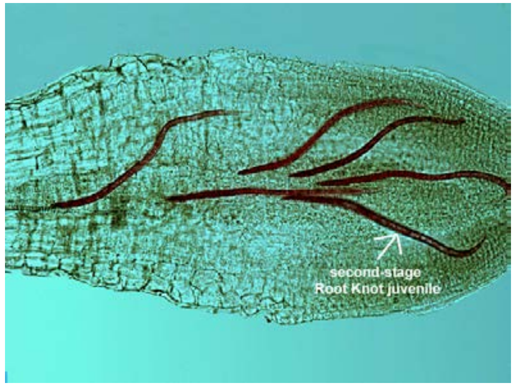
Root-knot nematodes

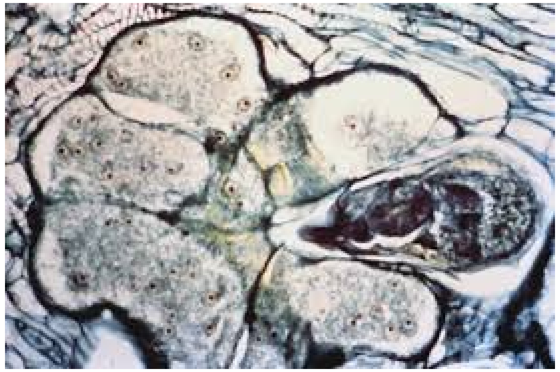
(*Meloidogyne* spp.)

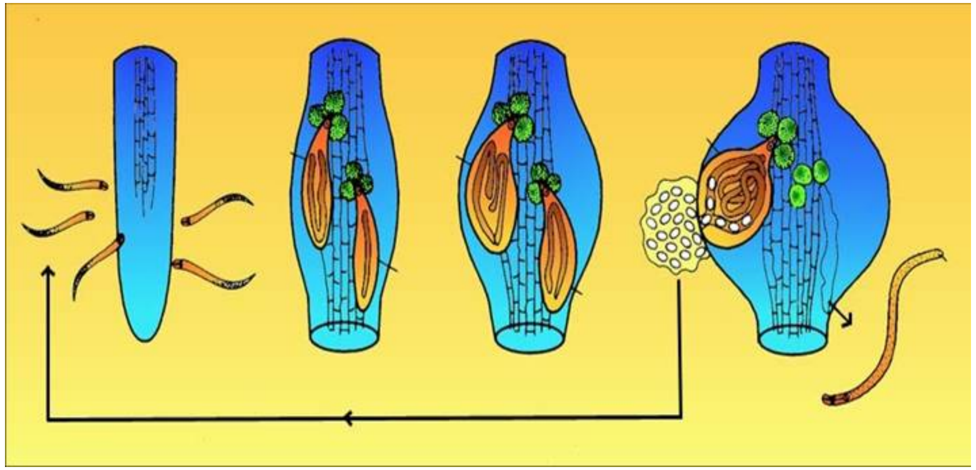
Distribution?

- **#1 nematode in Florida + the world, many crops, many species in FL,** *Meloidogyne arenaria, Meloidogyne incognita, Meloidogyne javanica, Meloidogyne enterolobii, Meloidogyne floridensis, Meloidogyne haplanaria, Meloidogyne hapla*



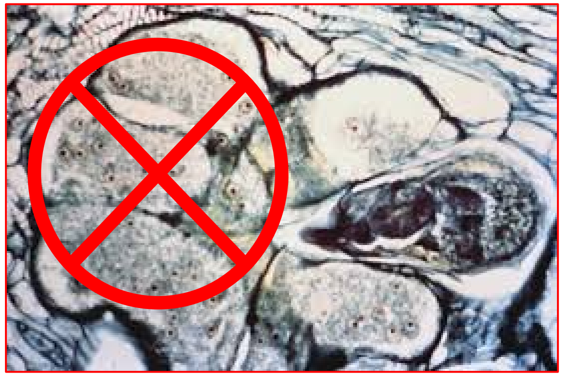


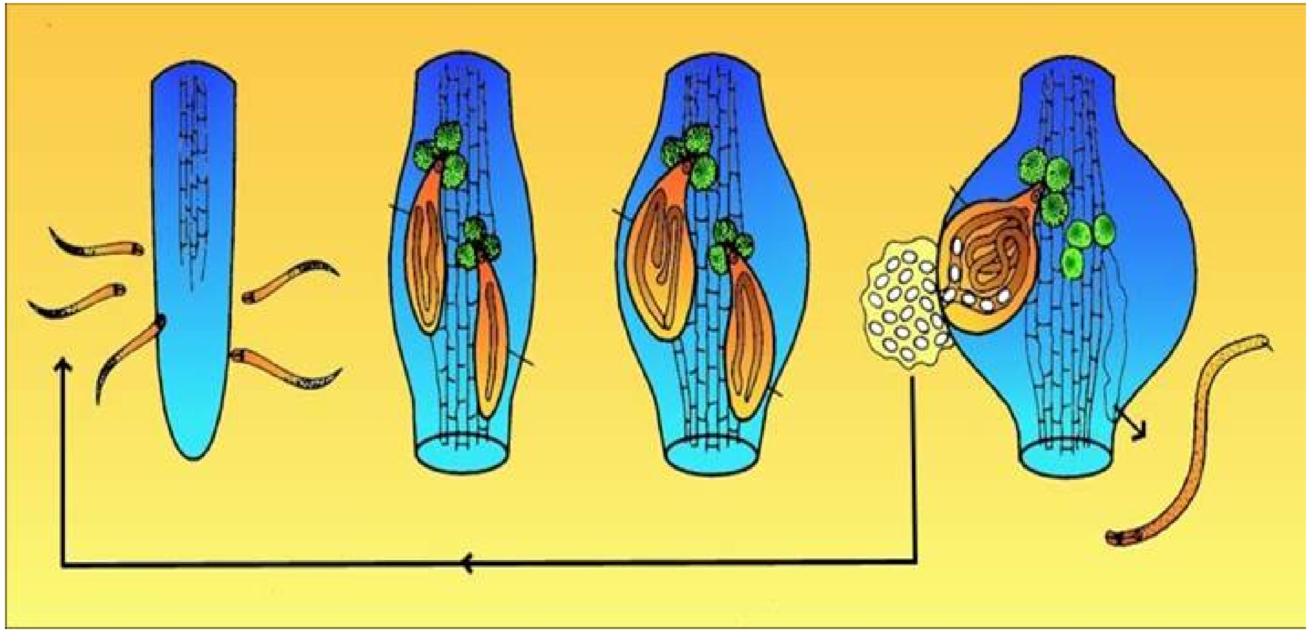




How does the *Mi-1* gene work:

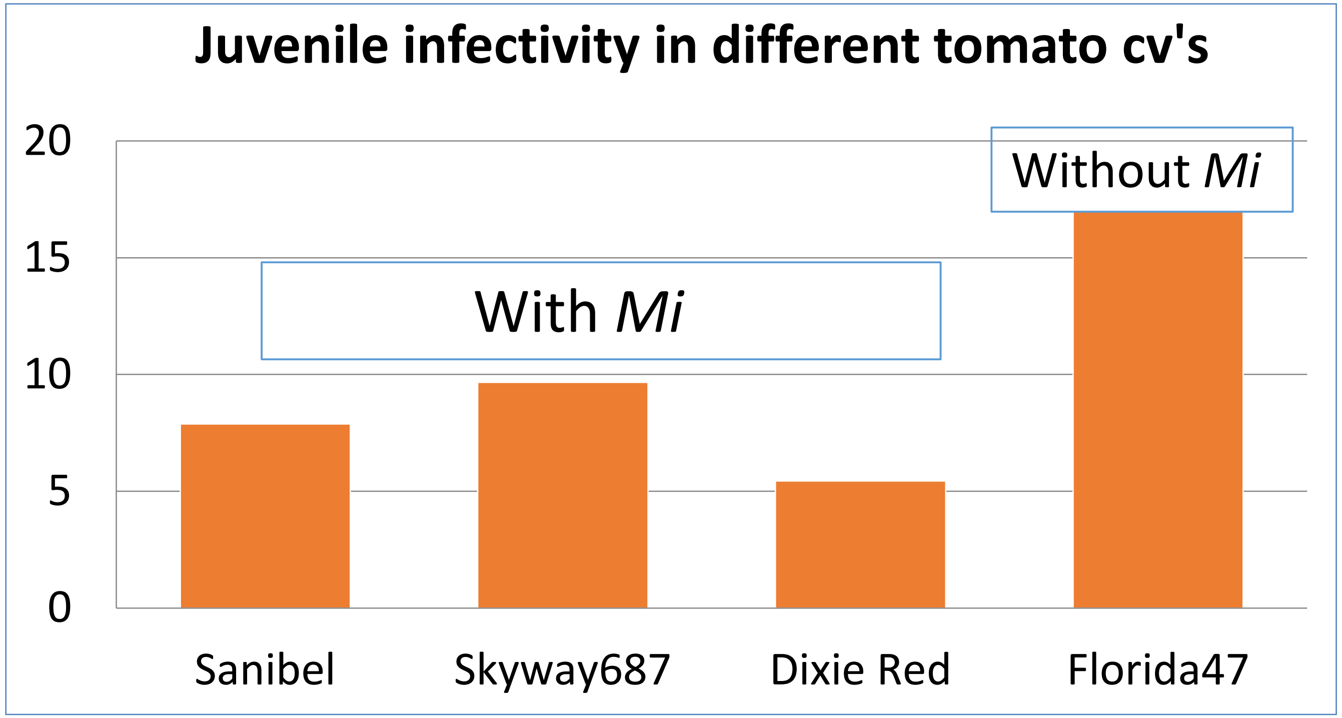
MI-1 gene prevents formation of specialized cells required by the nematode for feeding – w/o “giant cells” nematode is unable to feed

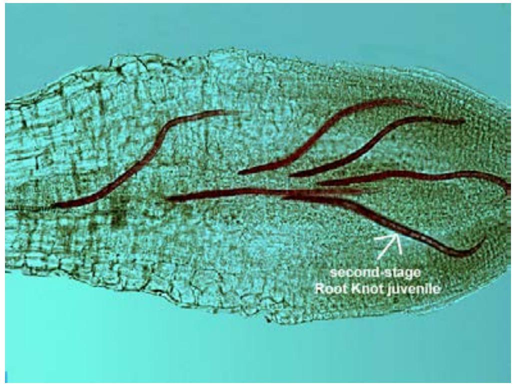




How does the *Mi-1* gene work:

Do RKN juveniles enter resistant tomato?

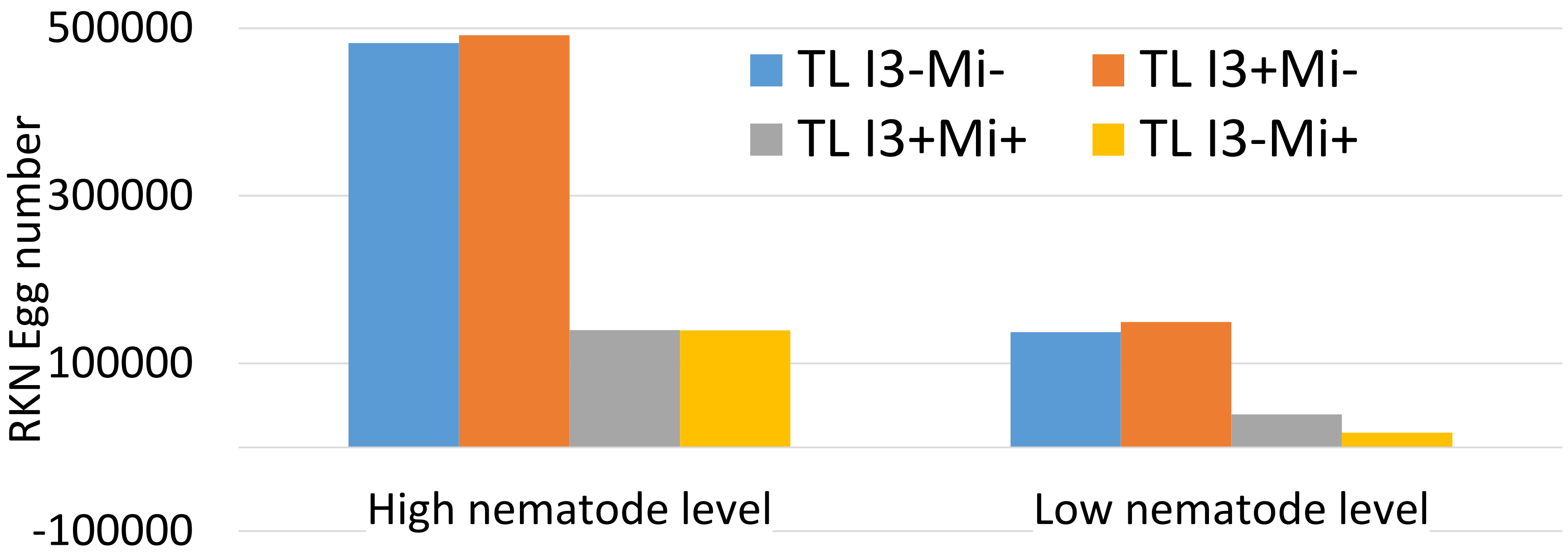




Regmi and Desaeger, 2018

Essence of Resistance? Effect on Reproduction

RKN reproduction on Tomato Tasti Lee lines with and w/o *Mi* gene (Dr. S. Hutton)



Regmi and Desaeger, 2018

There are limitations of the *Mi*-gene

Not effective against *Meloidogyne hapla*, *M. enterolobii* or *M. floridensis*

Brito et al., 2007

Known occurrences of resistance breaking populations of *M. incognita* and *M. javanica*

California (Kaloshian et al., 1996)

France (Castagnone-Sereno et al., 1994; Jarquin-Barberena et al., 1991)

Israel (Iberkleid et al., 2014)

Morocco (Eddaoudi et al., 1997)

Cyprus (Philis and Vakis, 1977)

Greece (Tzortzakakis et al., 2005)

Italy (Molinari and Miacola, 1997)

Spain (Ornat et al., 2001)

Temperature effects: temperatures above 28 °C are reported to cause gene to become nonfunctional

Discrepancy in reports about the loss of resistance:

≥ 32°C (Dropkins, 1969; Veremis and Roberts, 1996; Williamson, 1998)

< 32°C (Abdul-Baki et al., 1996; Ammati et al., 1986; Verdejo-Lucas et al., 2013)

Important questions for *Mi* tomatoes in Florida

1. Will high soil temperature under plastic mulch cause the resistant gene to become nonfunctional?
2. What degree of root galling will occur on resistant tomato?
3. Do both resistant and susceptible cultivars respond to soil fumigation?
4. What is the yield potential of a resistant versus a susceptible cultivar without and with soil fumigation?
5. What is the likelihood that fields in Florida transplanted with RKN resistant cultivars result in a resistant breaking race of *Meloidogyne* sp?
6. What RKN species are present in grower tomato production fields and why is this important for growers that want to use a RKN resistant cv?

DWD - Field evaluations of rkn resistant tomato cultivars, Citra, FL

Example of 1 of 5 field trials

Treatment	Vigor Rating (0-10)	XL (Kg/ha)	L (Kg/ha)	M (Kg/ha)	Marketable yield (Kg/ha)	Galling index (0-100%)
BHN 602						
Nontreated	4.8 c	4,001 bc	4,433 c	6,018 b	14,452 c (60)	58 a
1,3-D + chloropicrin 300 lbs	9.7 a	8,506 a	12,974 a	14,632 a	36,112 a (0)	1 b
Amelia						
Nontreated	4.2 c	3,027 c	3,892 c	6,199 b	13,118 c (64)	1 b
1,3-D + chloropicrin 300 lbs	8.6 ab	5,839 b	9,371 b	14,777 a	29,987 b (17)	0 b
Red Bounty						
Nontreated	4.8 c	4,505 bc	3,640 c	6,199 b	14,344 c (60)	0 b
1,3-D + chloropicrin 300 lbs	8.4 b	9,118 a	8,001 b	13,154 a	30,273 b (16)	0 b

Tomato Field Experiments: Fall 2017, Spring 2018, GCREC

Cultivars	Chemicals
Florida 47 (*Mi* -)	Pic100 (200 lb/acre)
Sanibel (*Mi* +)	Pic100 (200 lb/acre) + Nematicide (Nimitz, 2017; Salibro (exp), 2018)
Skyway (*Mi* +)	Nematicide only (2018)
Tasti Lee (*Mi* +)	None

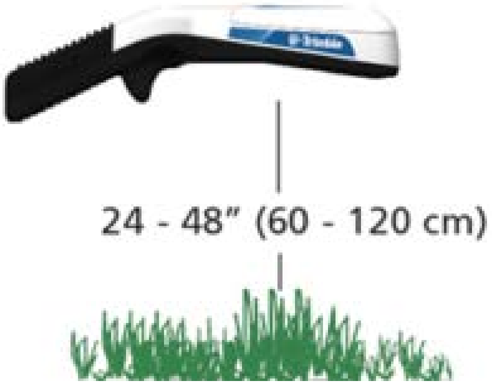
GCREC farm, root-knot nematode species = *Meloidogyne javanica*

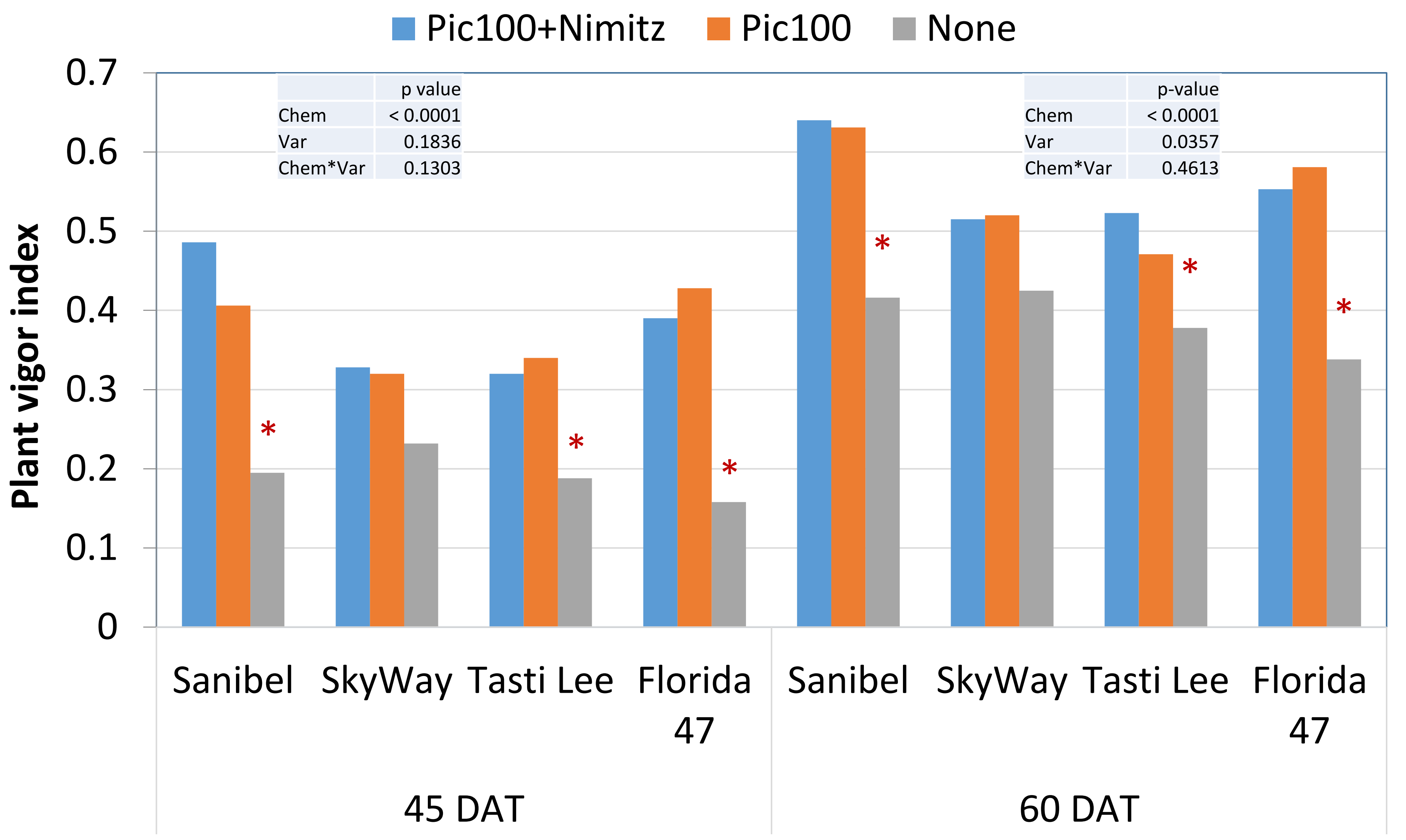
Effect of fumigation on plant growth and development, fall 2017

Fumigated bed (left) versus non-fumigated bed (right) 55 DAT (cv. FL47)

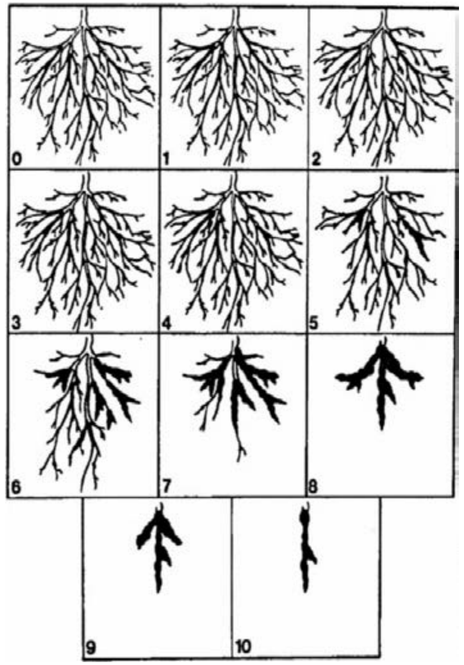
Non-fumigated bed (left) versus fumigated bed (right) 75 DAT (cv. FL47)

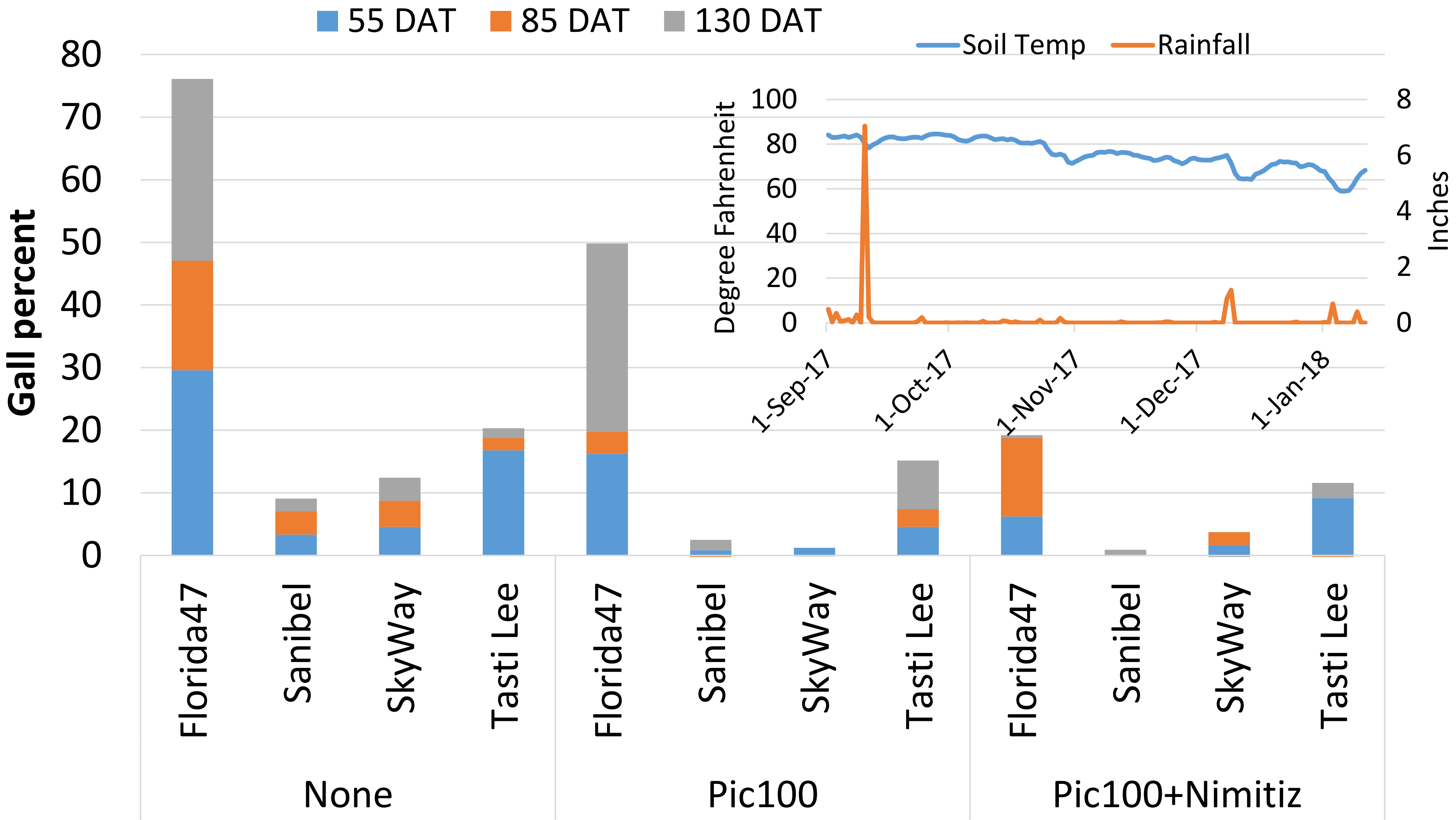
Plant vigor for different cv’s and nematicides, fall 2017



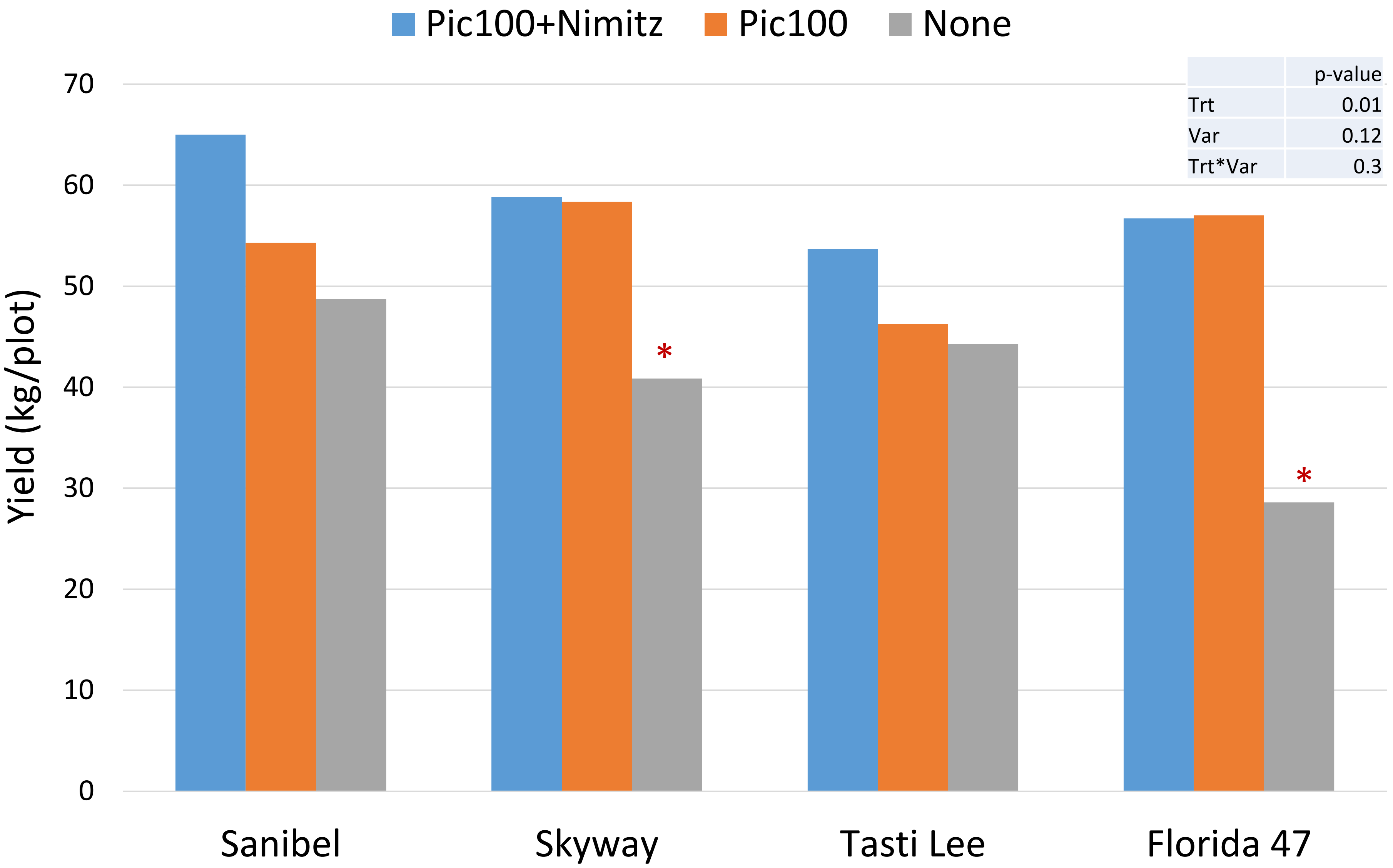


RKN gall severity for different cv's and nematicides, fall 2017



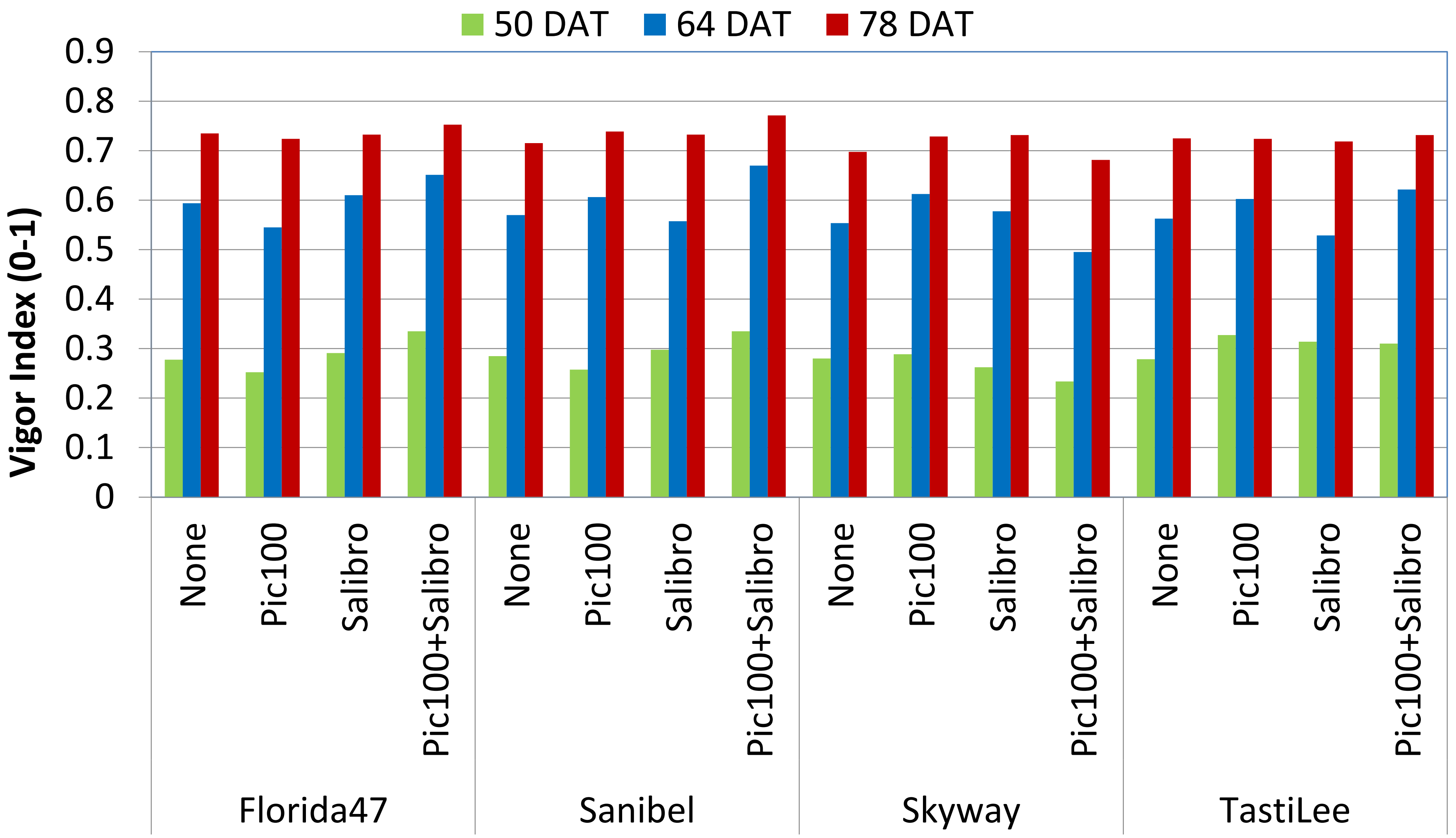


Yield for different tomato cultivars/nematicides, fall 2017

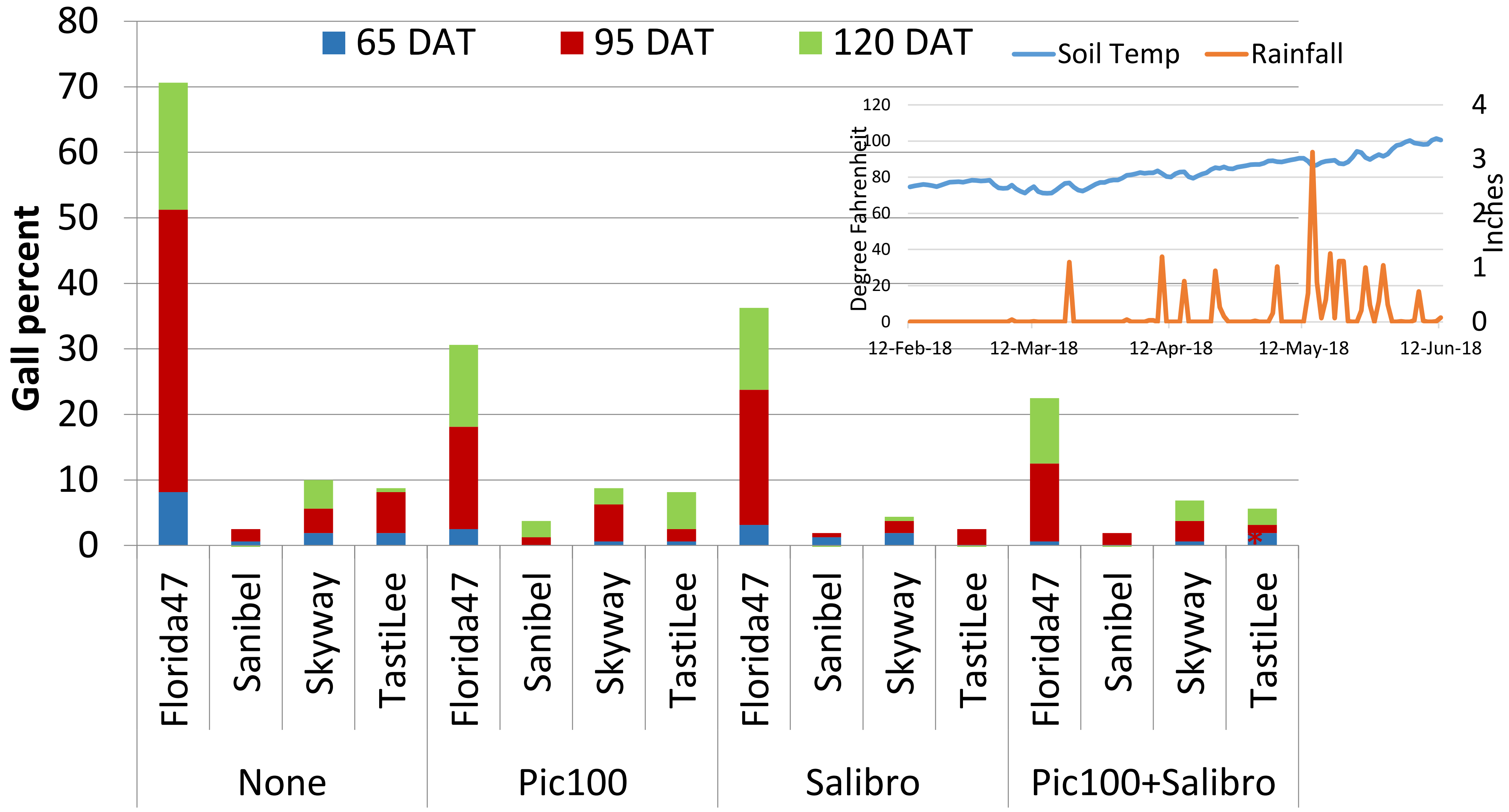


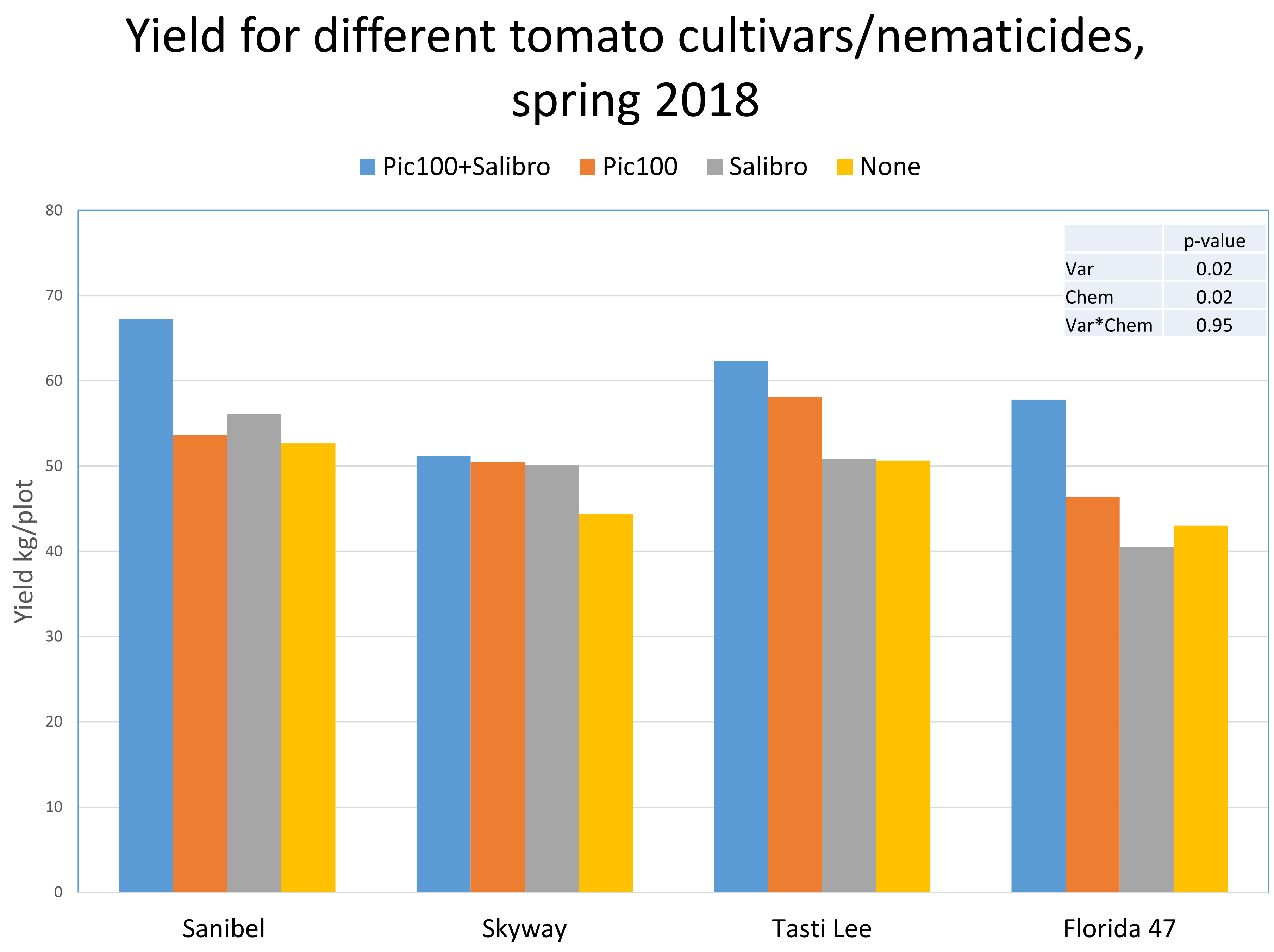
	p-value
Trt	0.01
Var	0.12
Trt*Var	0.3

Spring 2018 - Tomato plant vigor for different cv's / nematicides



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




Yield for different tomato cultivars/nematicides, spring 2018
Pic100+Salibro
Pic100
Salibro
None
80
70
60
50
40
30
20
10
0
Yield kg/plot
p-value
Var 0.02
Chem 0.02
Var*Chem 0.95
Sanibel
Skyway
Tasti Lee
Florida 47

Future for Root-Knot Resistant Tomato in Florida

- ***Mi* works well in Florida … no heat sensitivity issues**
- **New tomato cv's with root-knot resistance**
- **Potential of *Mi* in IPM**
  - Mi-1.2 gene also can confer resistance against potato aphid *Macrosiphum euphorbiae* and the whitefly *Bemisia tabaci*
- **Research Needs - Host Plant Resistance**
  - novel gene source identification and development
  - genetic studies on tolerance traits, nematode parasitism, virulence factors
  - Novel gene transfer techniques … CRISPR project – Dr. Lee
  - Other potential areas such as induced resistance through elicitors

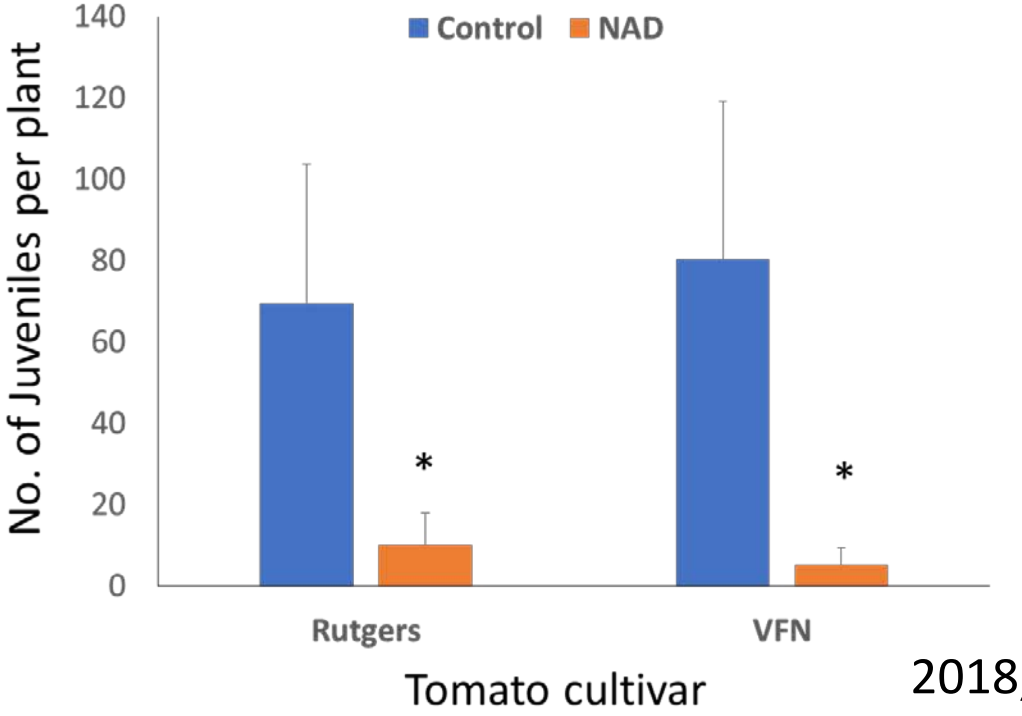
‘Elicitors’ can Induce Resistance in Plants against Pathogen Infection

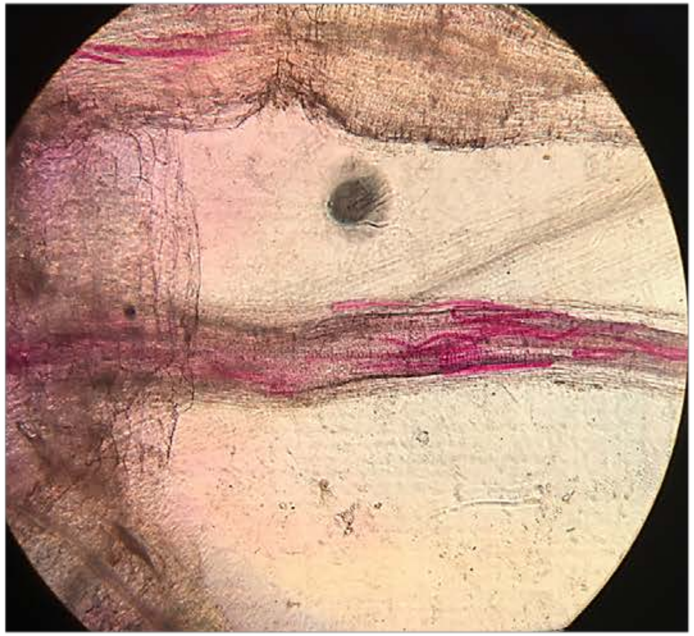
- Elicitors are compounds > activate chemical defense in plants.
  - salicylic acid, methyl salicylate, benzothiadiazole, benzoic acid, chitosan, …
  - use in crop protection and pest management is still in the very early stages

- Nicotinamide adenine dinucleotide (NAD) is a chemical elicitor of plant innate immunity and regulates plant defense responses to multiple biotic stresses

Tomato seedlings exposed to NAD for 24hrs by soil drench before nematode inoculation showed reduced nematode penetration 48hpi with RKN

NAD treatment on host plants reduces *M. hapla* penetration





2018, N. Abdelsamad, H. Regmi, J. Desaeger, and P. DiGennaro

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Mi gene

Introduced from *Solanun peruvianum* into *S. esculentum* by embryo rescue of interspecific cross (Smith, 1944)

Gene	Source	Properties	Genetics
***Mi* (*Mi*-1)**	*Solanum peruvianum* PI128657	Resistant to: *Ma; Mi, Mj*; resistance lost at >28 °C	Mapped to short arm of chromosome 6; Cloned
***Mi* – 2**	PI270435-2R2	Resistant to *Mi* at 32 °C Resistant to: *Ma; Mi, Mj, Mh*	Not linked to *Mi* or *Mi*-3, linked to *Mi*-8
***Mi* – 3**	PI126443-1MH	Resistant to *Mi*-virulent *Mi* 557R	Mapped to short arm of chromosome 12; linked to *Mi*-5
***Mi* – 4**	LA1708-1	Resistant to *Mi* and *Mj* at 32 °C	
***Mi* – 5**	PI126443-1MH	Resistant to *Mi* and *Mj* at 32 °C	linked to *Mi*-3, linked on chromosome 12
***Mi* – 6**	P1270435-3MH	Resistant to *Mi* at 32 °C	linked to *Mi*-7
***Mi* – 7**	PI270435-3MH	Resistant to *Mi*-virulent *Mi* 557R at 25°C	linked to *Mi*-6
***Mi* – 8**	PI270435-2R2	Resistant to *Mi*-virulent *Mi* 557R at 25°C	linked to *Mi*-2
***Mi – 9**	LA2157	Resistant to *Ma; Mi, Mj* at 32°C	Mapped to short arm of chromosome 6

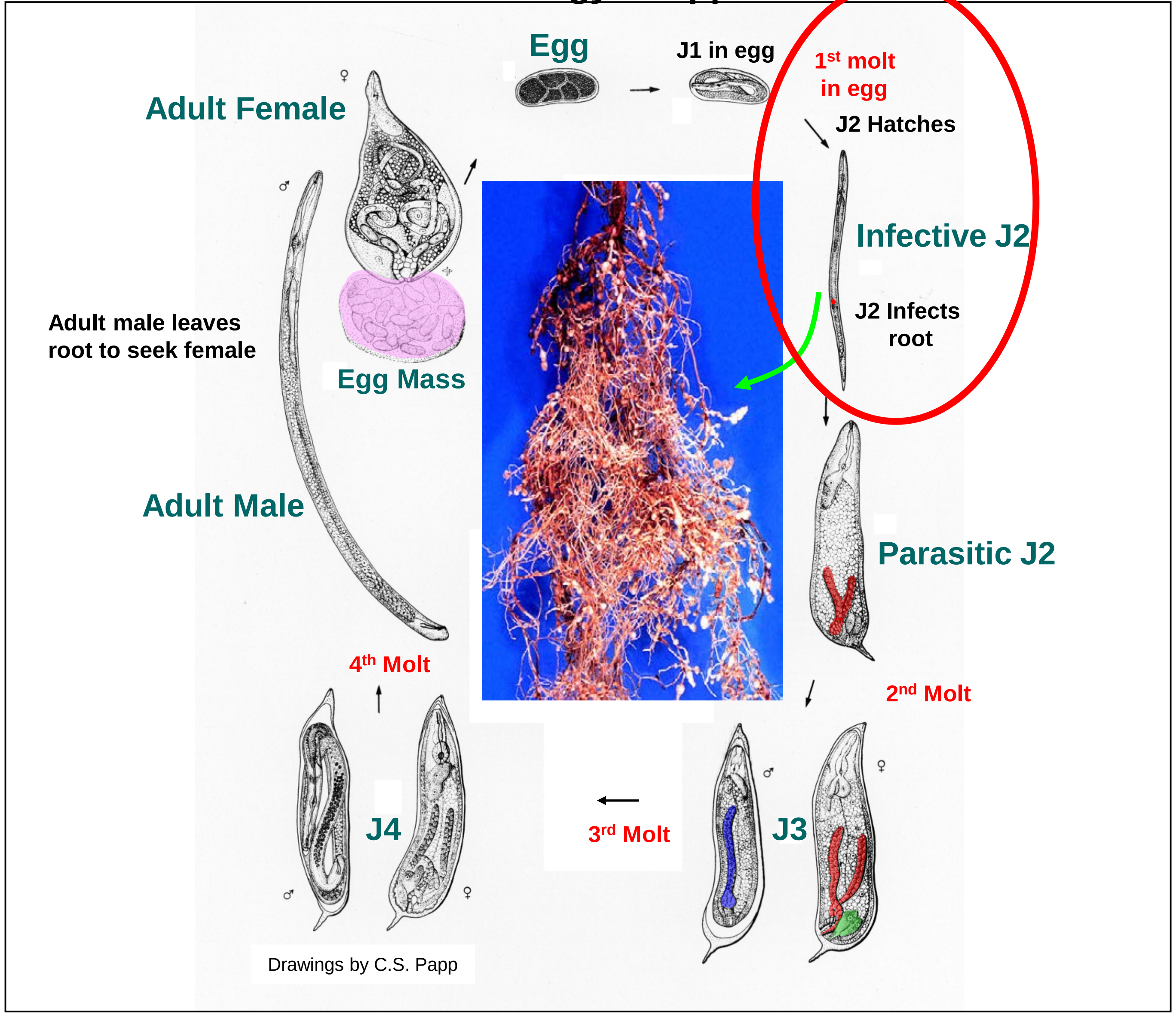
Solanum peruvianum

www.lomasdeatiquipa.com

(Adapted from: Williamson, 1998; *Ammiraju *et al.*, 2001)

Root-knot Nematode Life Cycle

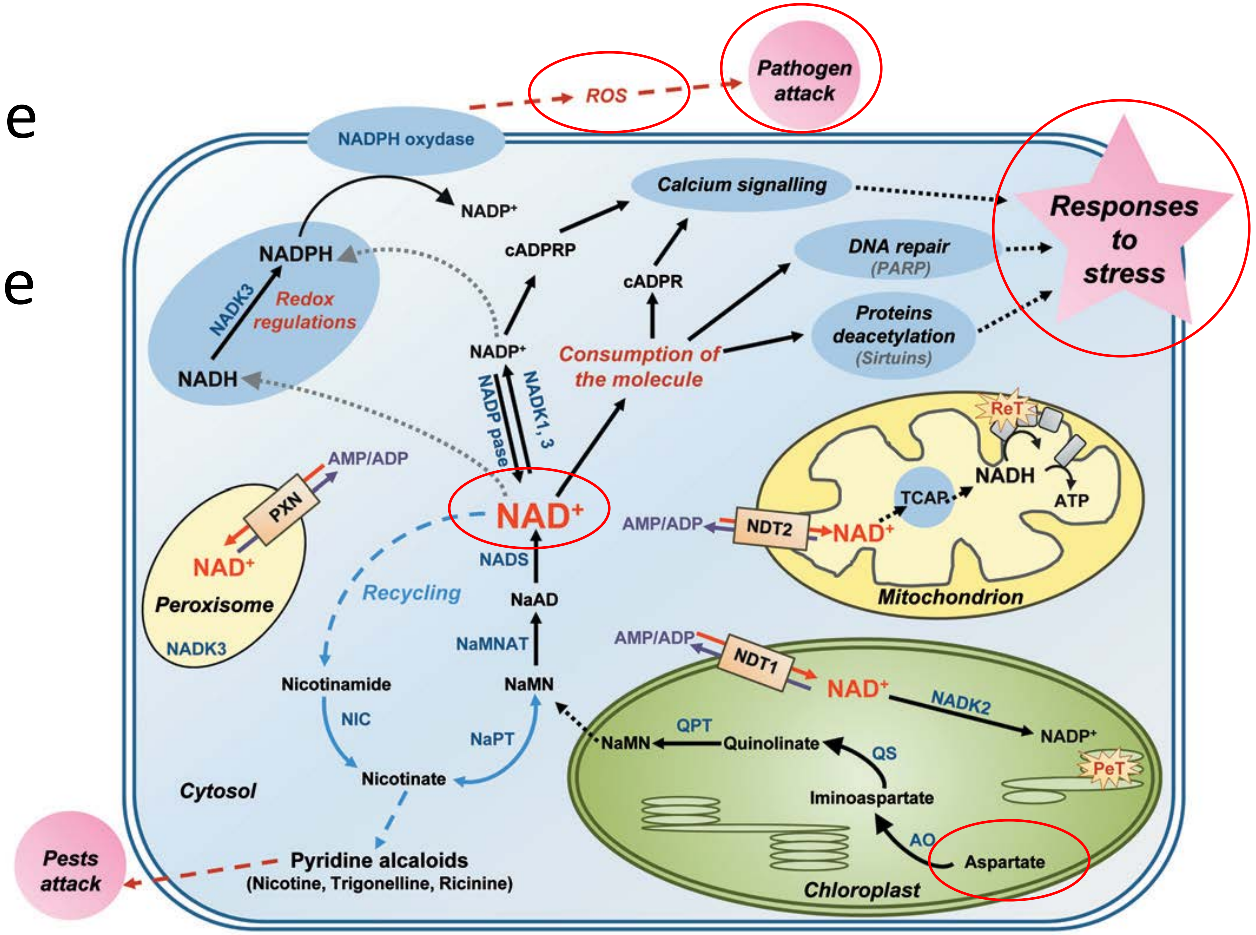
***Meloidogyne* spp.**



Nicotinamide Adenine Dinucleotide (NAD)

- Pyridine nucleotide
- Primary metabolite
- Produced from

  Aspartate
- Ca^{2+} signaling
- ROS production



(Pétriacq *et al.*, 2013)