Characterizing the significance of *Pratylenshus penetrans* on soybean

Kanan Saikai

Exit seminar – 12/03/2019

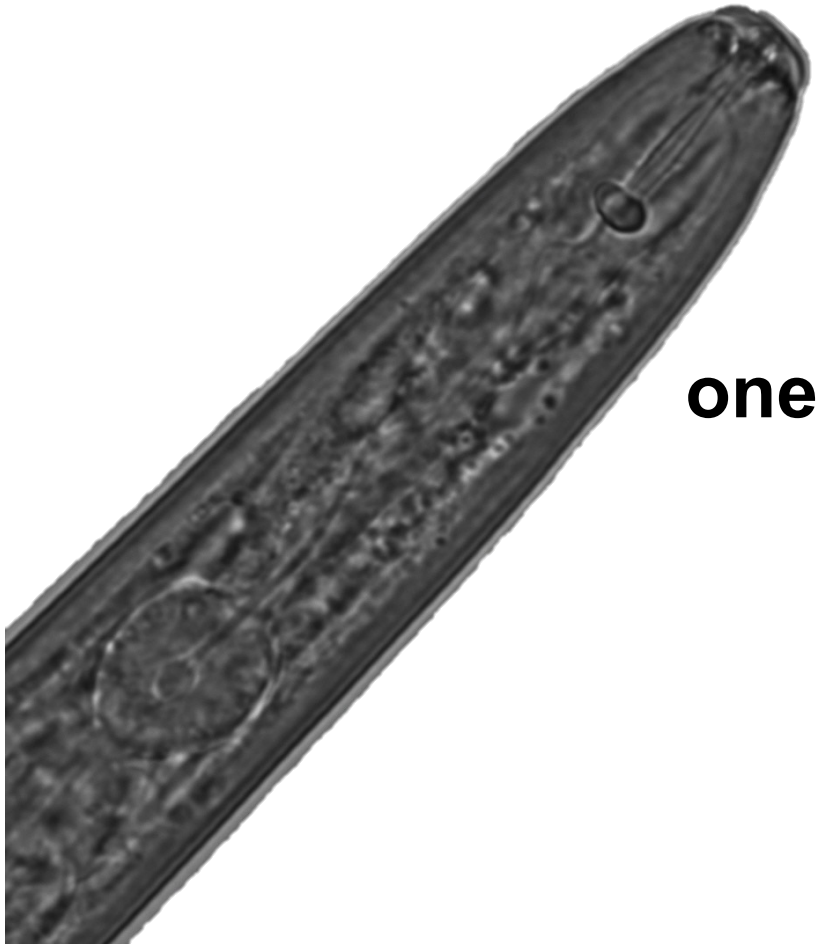
Soybean

Soybean is the leading U.S. agricultural export, valued at more than $23 billion

In Wisconsin:
There are **11,000 soybean growers**.
2.2 million acres planted with soybean
produced **106 million bushels/acre**
in 2018

USDA-NASS (2019)

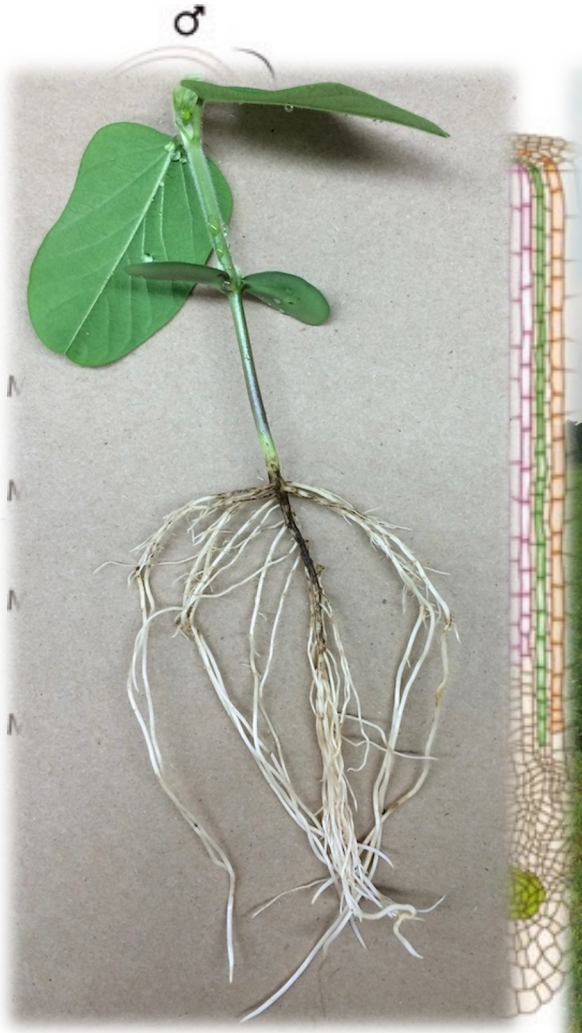
Pratylenchus penetrans (RLN)



Pratylenchus is the **third most economically important genus** with very wide host range and worldwide distribution.

P. penetrans has been recognized as **one of the most damaging species of *Pratylenchus*** and it is frequently detected on soybean fields in Wisconsin.

Life cycle and symptoms of *P. penetrans*



Source: Jones, M. G. K. and Fosu-Nyarko, J. 2014. Molecular biology of root lesion nematodes (*Pratylenchus* spp.) and their interaction with host plants. Annals of Applied Biology 164:163-181.
Photo credit (pea): Ann MacGuidwin

P. penetrans on soybean

Ecology and Epidemiology

Role of *Pratylenchus penetrans* in the Potato Early Dying Disease of Russet Burbank Potato

A. E. MacGuidwin and D. I. Rouse

Development of a Damage Function Model for *Pratylenchus penetrans*

Ann E. MacGuidwin and **Breann E. Bender,** Department of Plant Pathology, University of Wisconsi

Damage and Reproductive Poten
and P. penetrans

D. P. Schmitt an

Abstract: Damage and reproductive potential
on soybean, *Glycine max,* cvs. Essex, Forrest, an
Cultivar Essex was generally tolerant to *P. brachy*
with increasing P_i's in the sandy soil ($r = -0.92$) and
erate P_i's in the sandy clay loam gave an increase in
todes. Yield was not affected by this nematode in m
in microplots. Yield vs. P_i was fitted by a
sharply as P_i's were increased. The reprod
Lee 68 was a good host for *P. penetra*
P. brachyurus. Key words: Glycine ma
factors.

Several *Pratylenchus* species, including, *P. brachyurus* (Godfrey) Filipjev and Schuurmans-Stekhoven (10), *P. scribneri* Steiner (17,18), *P. agilis* Thorne and Malek

suppress N_2 fixation (8). Soybean yield losses resulting from these nematodes vary with nematode species, cultivar, and season. For example, *P. brachyurus* had no effect on

+

= Yield Loss ?

Outline

Chapter 1. Soybean response to *P. penetrans* in field and greenhouse environments.

Chapter 2. Gonochoristic species of *Pratylenchus* in soybean cropping systems in Wisconsin.

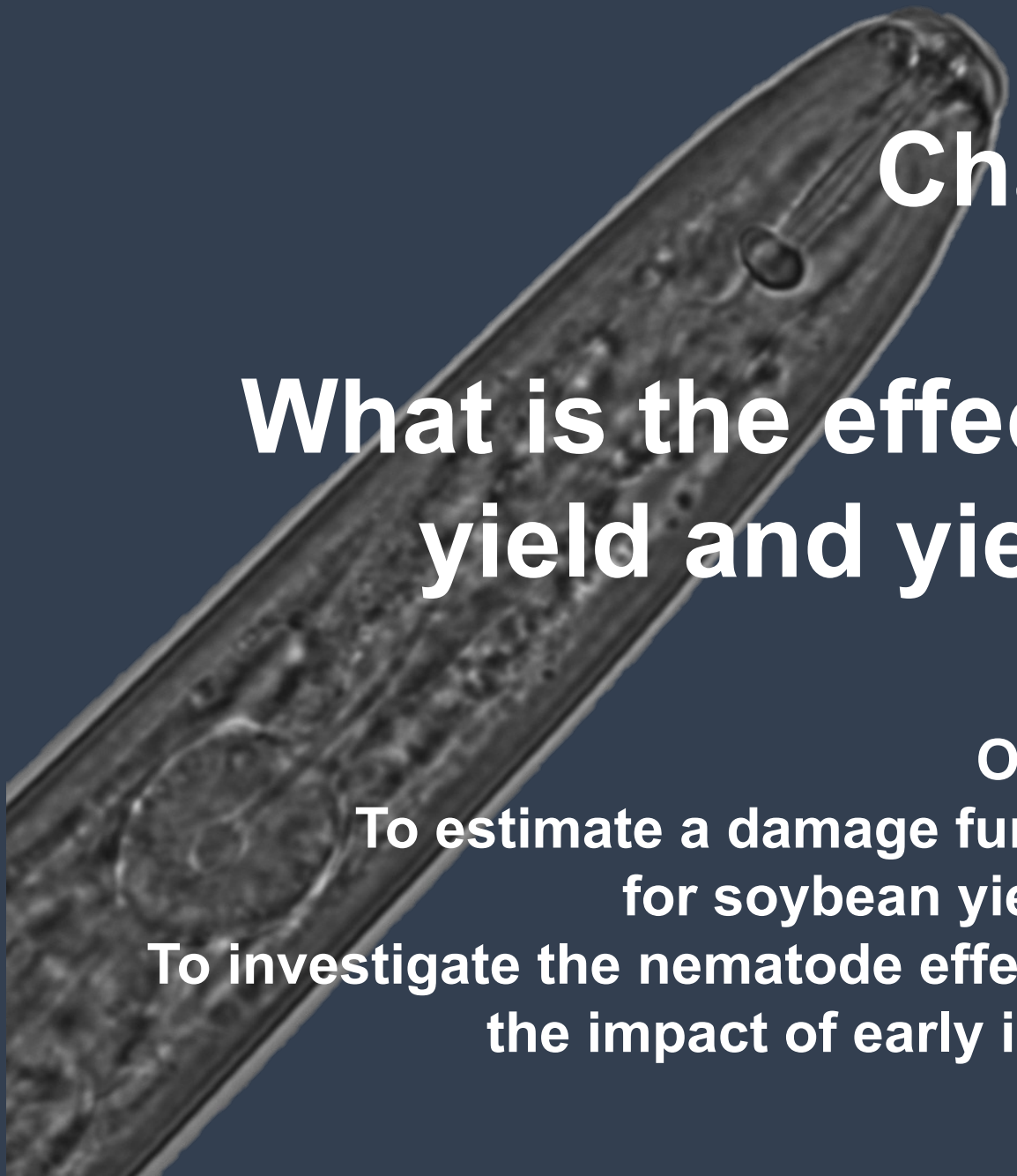
Chapter 3. Gender difference of *P. penetrans* for symptom development and severity.

Outline

Chapter 1. Soybean response to *P. penetrans* in field and greenhouse environments.

Chapter 2. Gonochoristic species of *Pratylenchus* in soybean cropping systems in Wisconsin.

Chapter 3. Gender difference of *P. penetrans* for symptom development and severity.



Chapter 1.

What is the effect of *P. penetrans on* yield and yield components?

Objectives:

To estimate a damage function of *Pratylenchus penetrans* for soybean yield and its components

To investigate the nematode effect on soybean plants at the V2 stage and the impact of early infection on final seed yield.

Field study

Conducted at Hancock Agricultural Research Station in 2017 & 2018.

Emergence stage

- Two-meter plots were established.
- Soil samples (Pi)

Second Trifoliate Stage (V2)

- 2 plant samples

Root biomass

Shoot biomass

Shoot : total biomass

Final maturity

- Harvest plots

Grain yield

Pod number/ plant

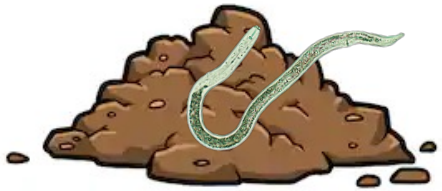
Seed mass

(100 seed wt.)

Field study models

Generalized Linear Mixed Model (GLMM) using PROC GLIMMIX in SAS.

Pi models



\+

RLN/ plant at V2 models

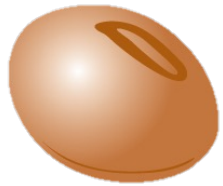
Plant biomass at V2 models

Lognormal

—

Grain Yield (t/ha)
- Lognormal
Relative yield (%)
- normal

Pod/ plant
lognormal



Seed mass
(100-seed wt.)
lognormal

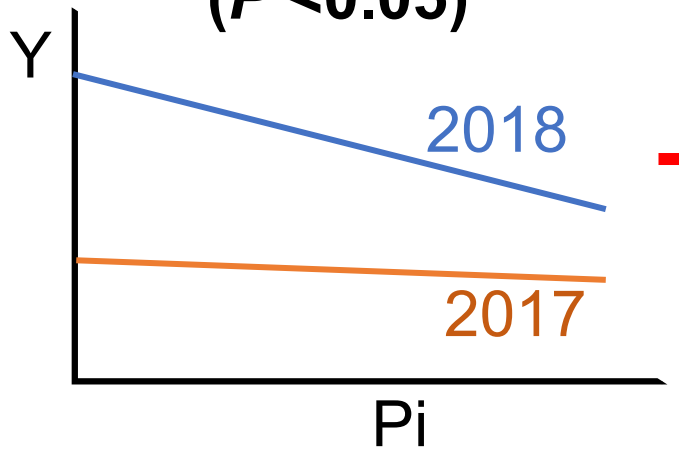
Field study models

Preliminary model run

Y = Pi + Year + Pi x Year

Random:
Research field (Year)

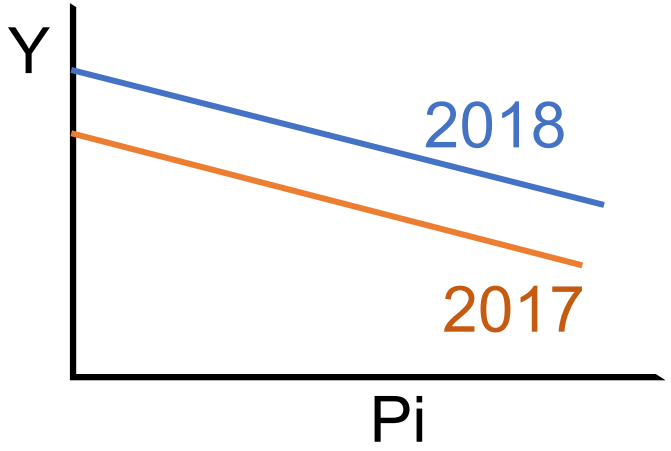
Interaction is significant
(*P* <0.05)



Final model

2017: Y = Pi
2018: Y = P
Random: Research field

Interaction is NOT significant

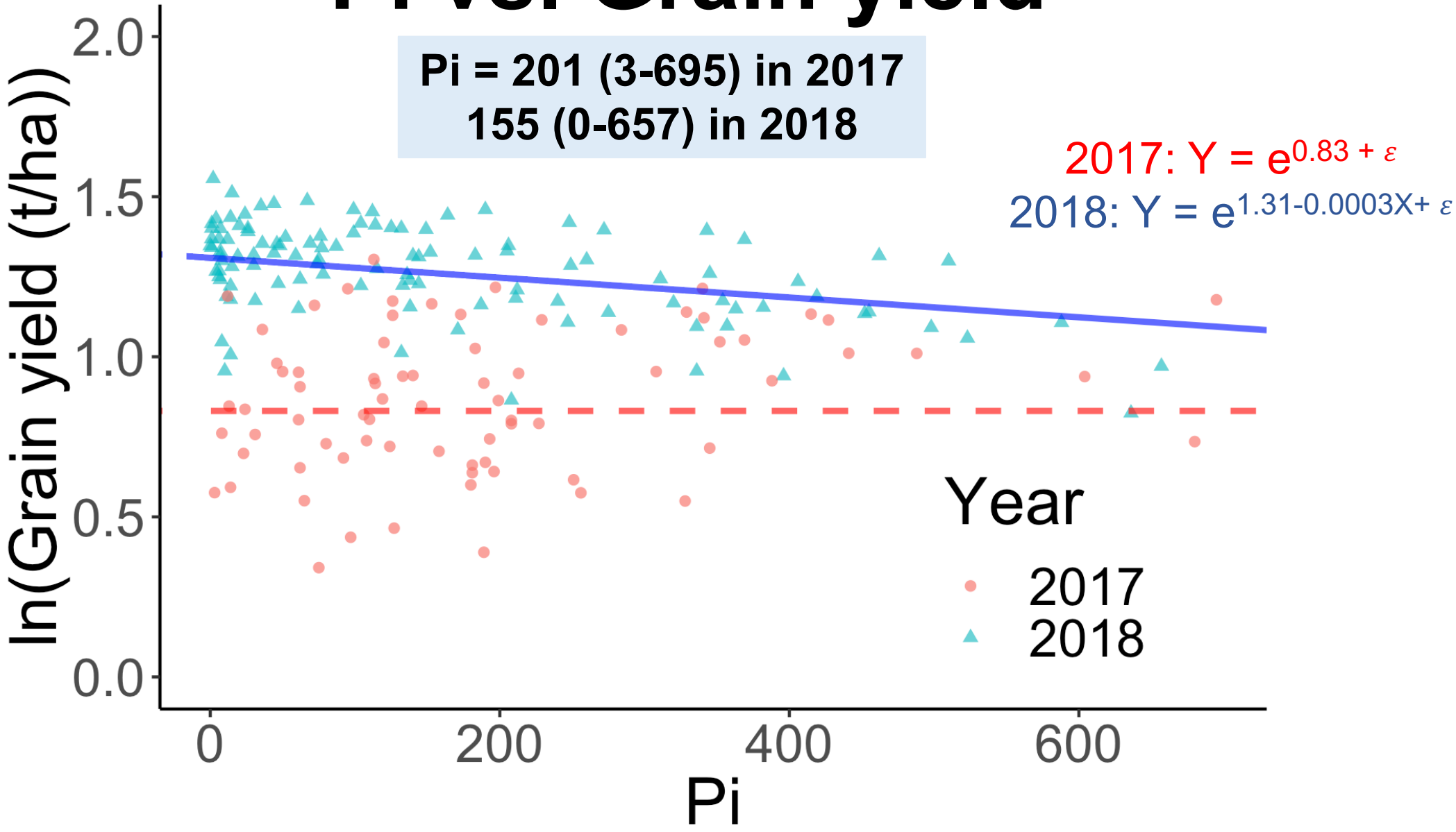


Final model

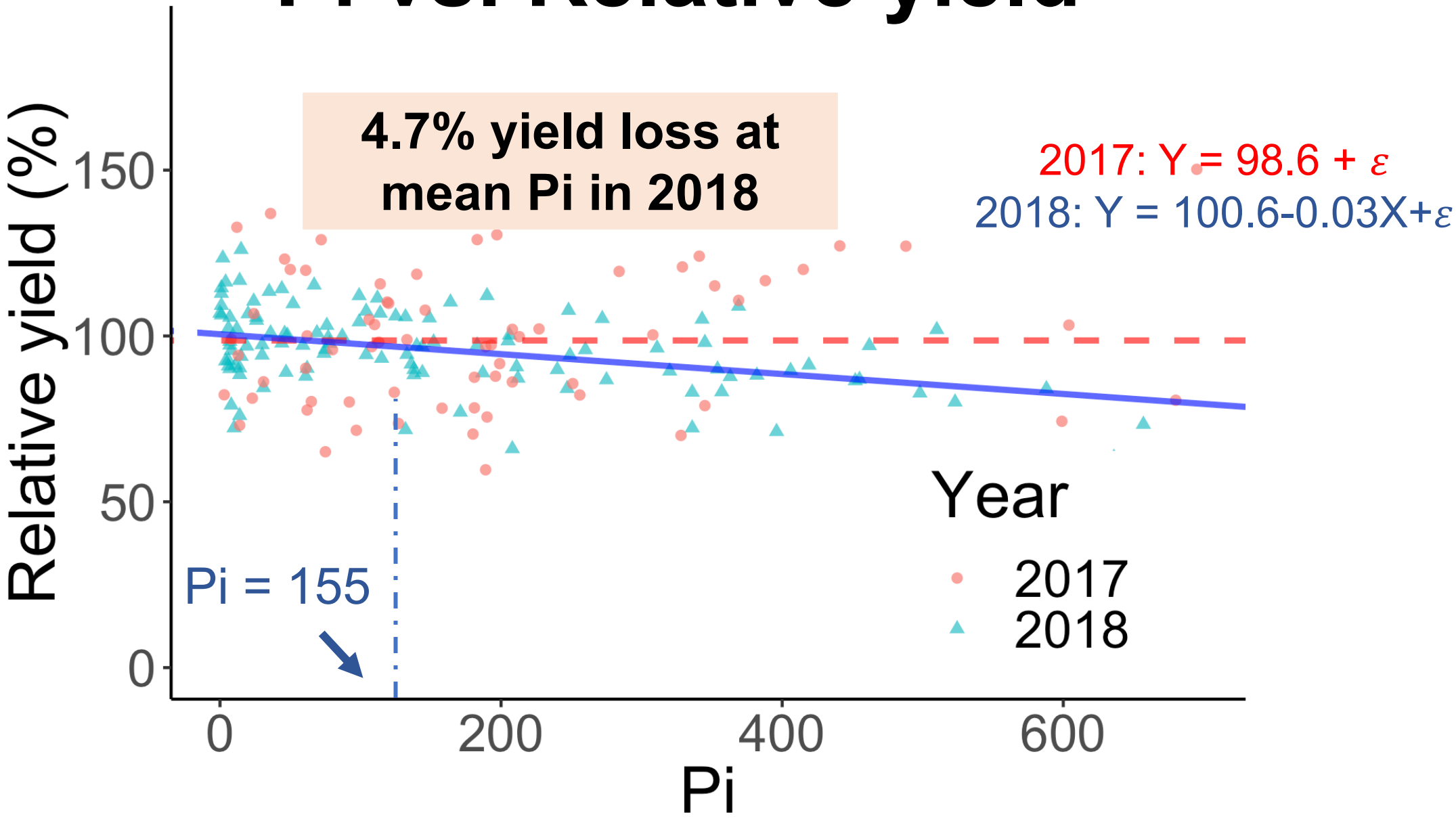
Y = Pi

Random: Year,
Research field (Year)

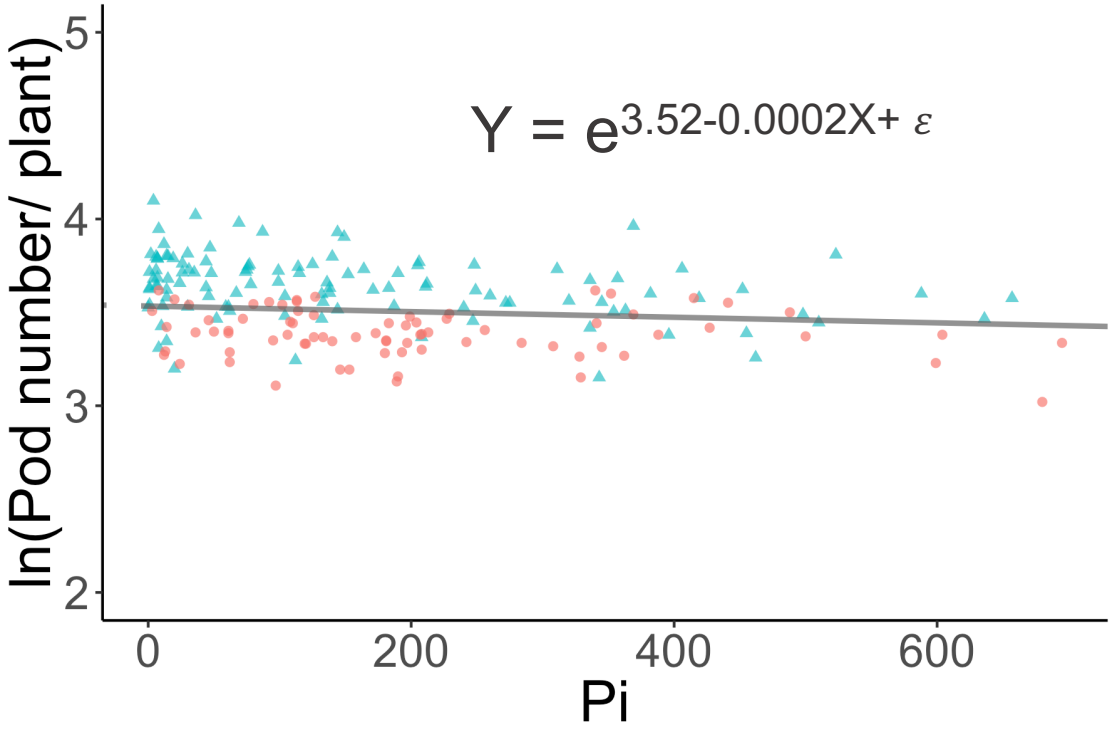
Pi vs. Grain yield

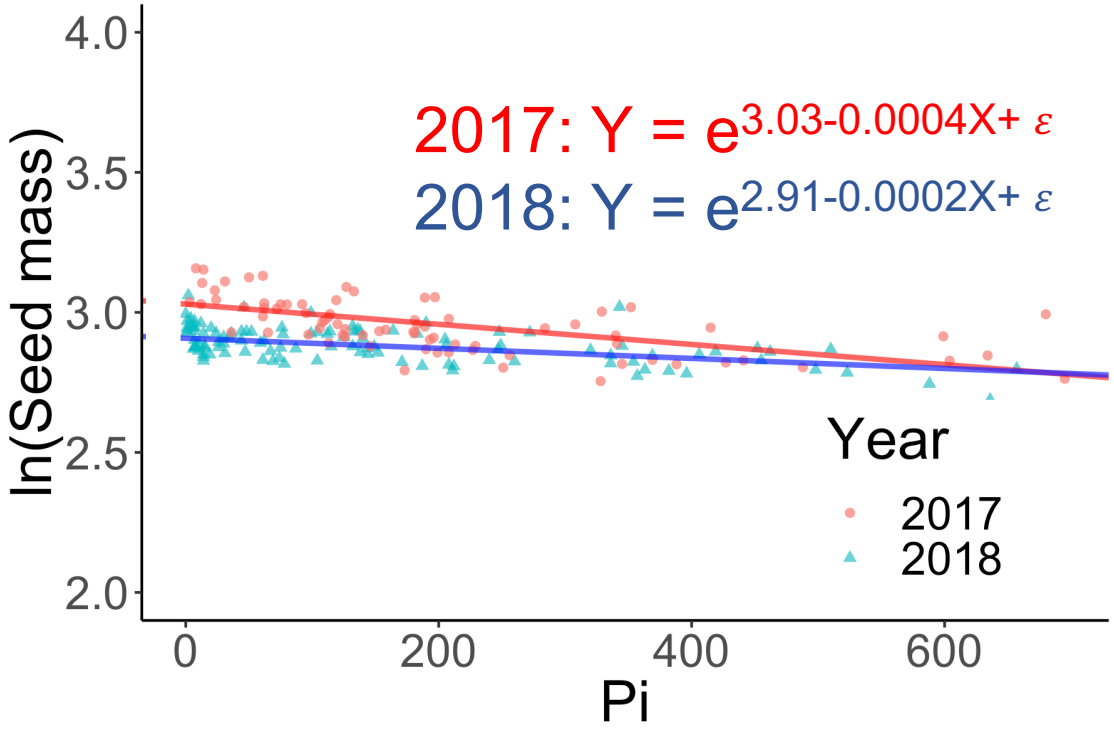


Pi vs. Relative yield

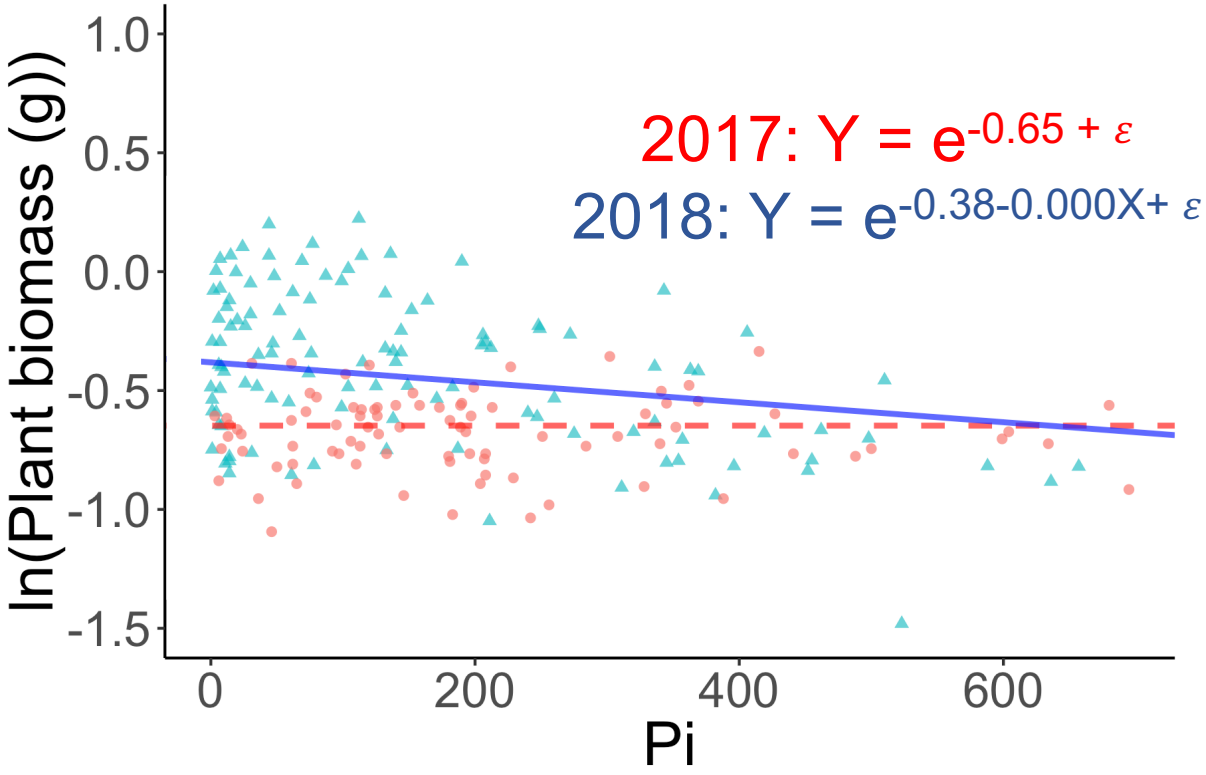


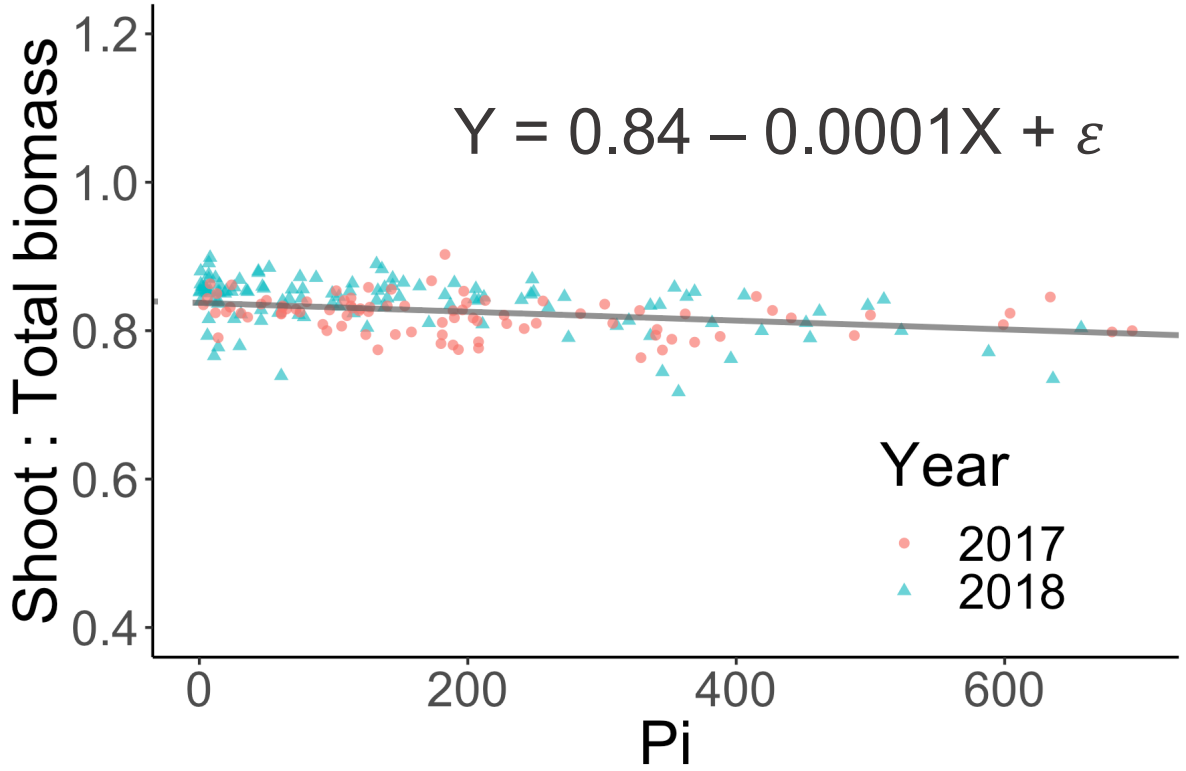
Pi vs. yield components



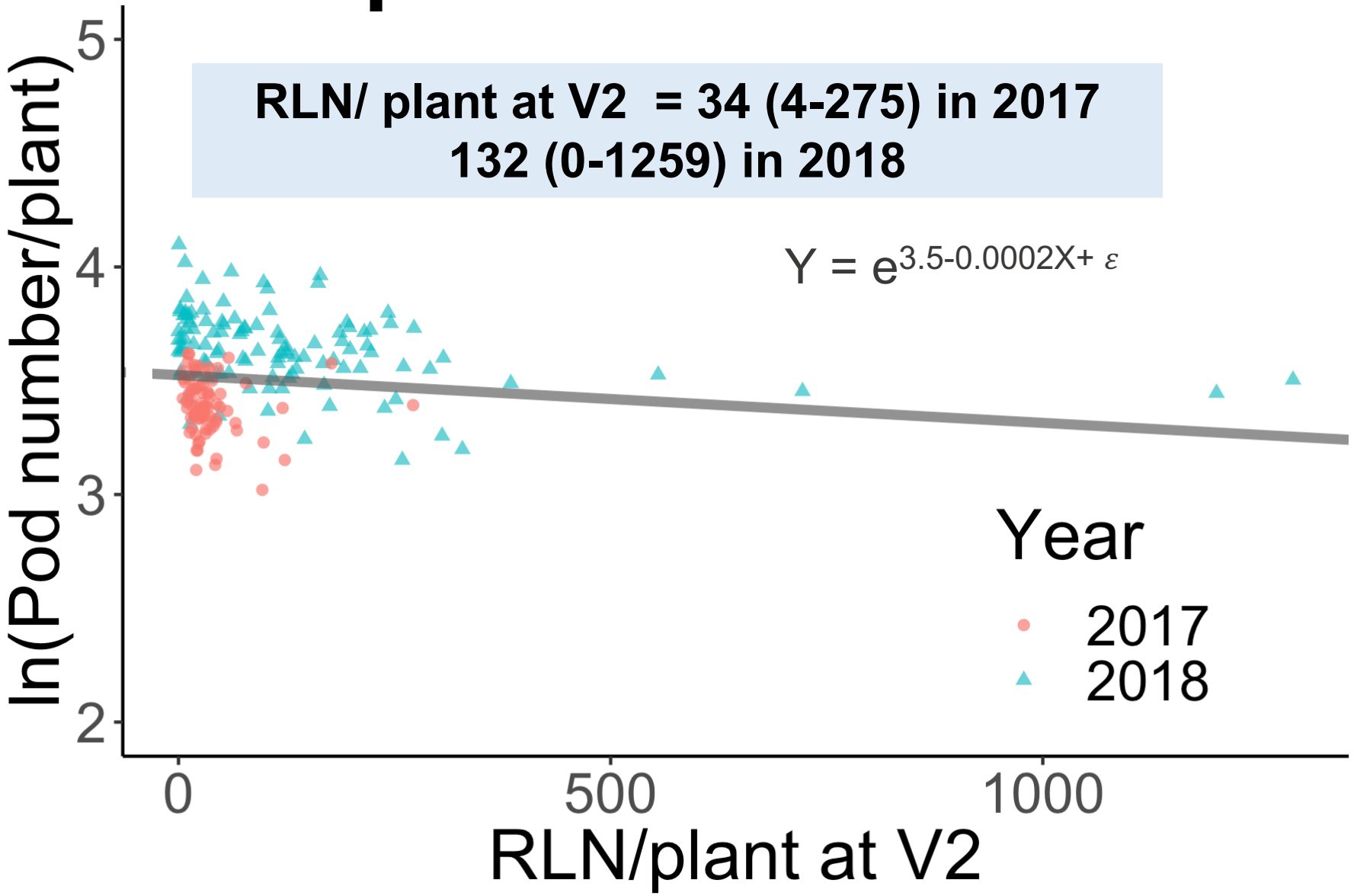


Pi vs. Plant biomass at V2

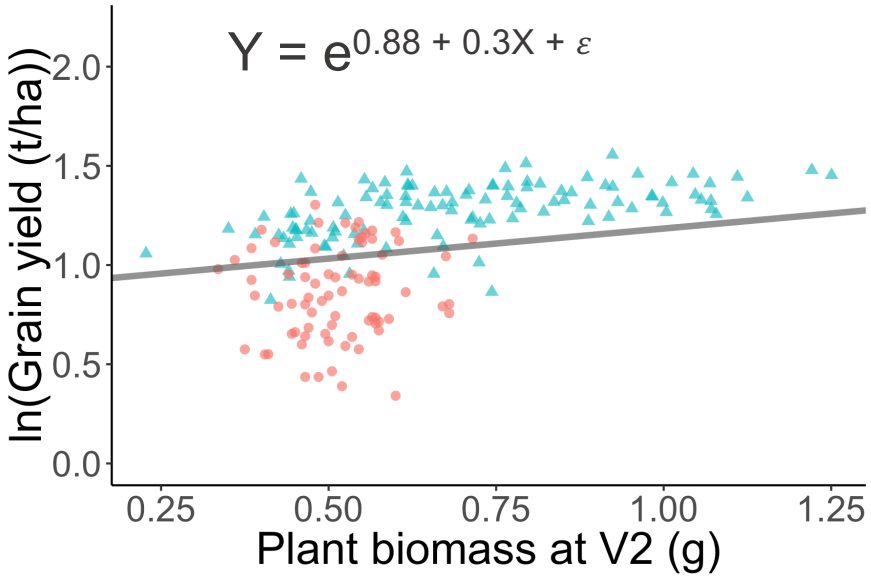


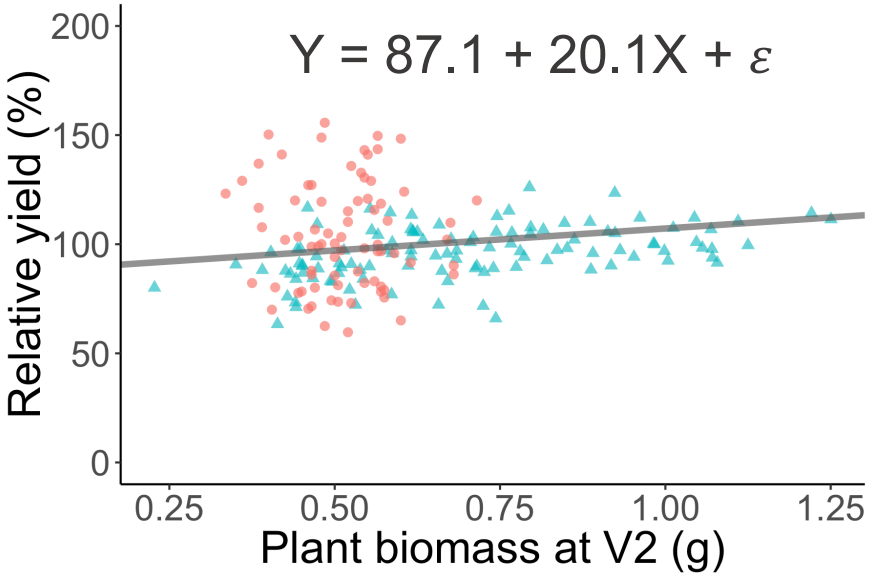


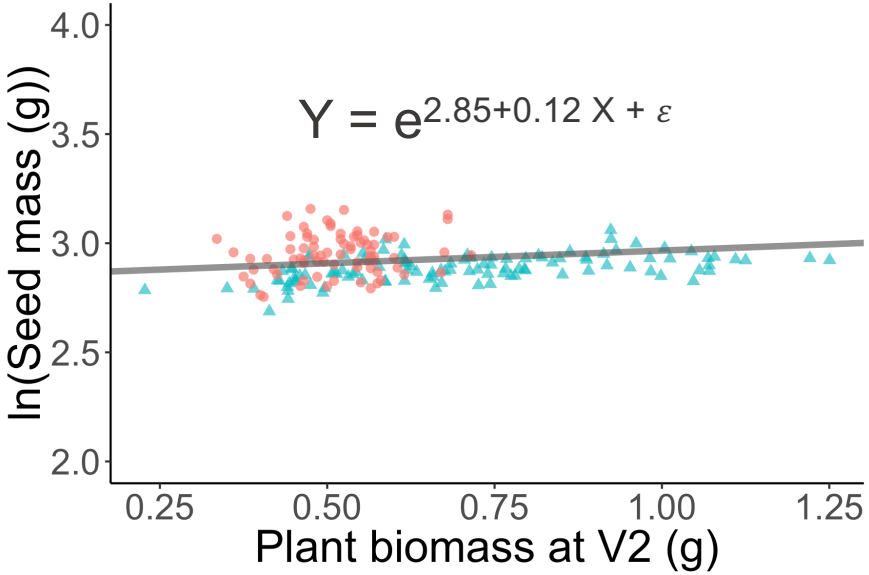
RLN/plant at V2 vs. Yield



Plant biomass at V2 vs. Yield



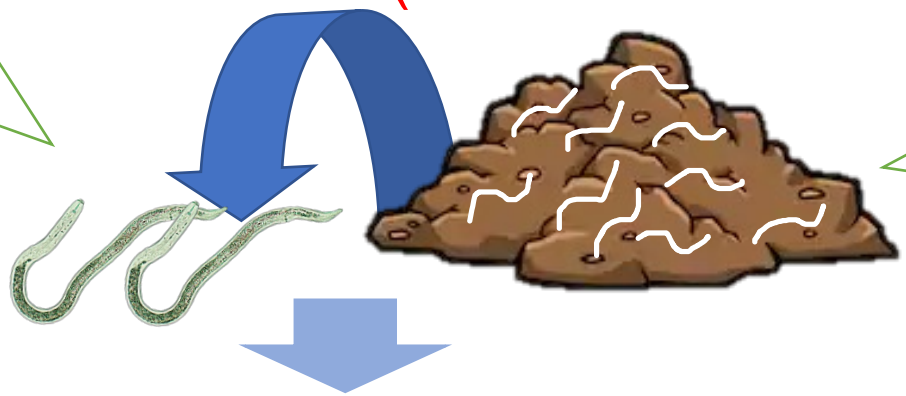




Greenhouse study

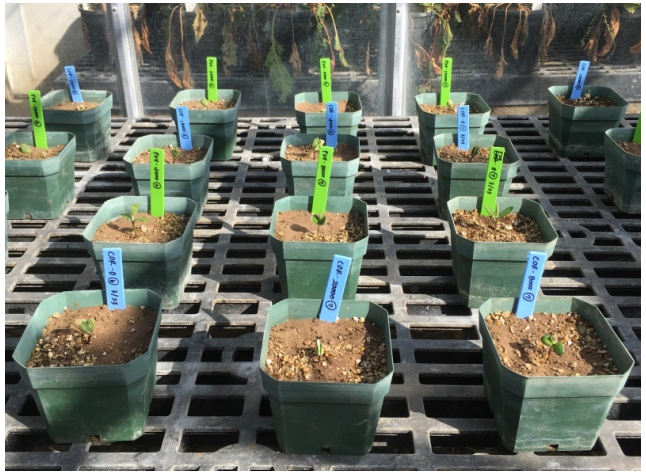
20% extraction efficiency
(MacGuidwin 1989)

Field Pi =
201 (3-695) in 2017
155 (0-657) in 2018



Total nematodes in 100cm^3 soil: 0 – 3475

Planted in pasteurized 500 cm^3 soil



Dose Level	Trial 1 - Pi	Trial 2 - Pi
Control	0	0
1	1927±168	2066±191
2	3853±534	3995± 225
3	8330±510	7233±285
4	11889±208	11764±300
5	16161±367	18403±297
6	20819±1017	20323±313

Greenhouse study

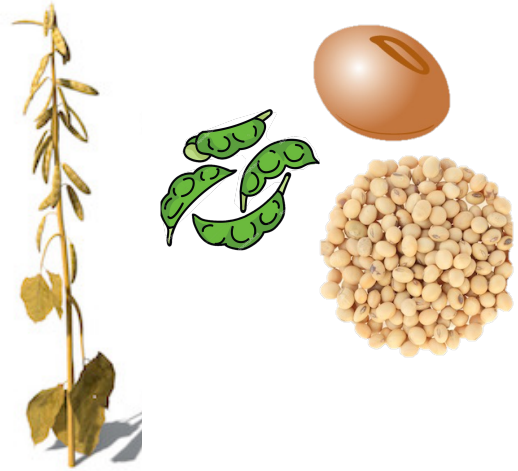
1. Nematode inoculation

2 soybean genotypes
8 replications/ dose level

2. First harvest at V2 (Rep. 1-3)

Data collection on plant biomass

3. Second harvest at R8 (Rep. 4-8)



Data collection on accumulative plant biomass
Yield and yield components

Pi vs. Plant biomass

At V2

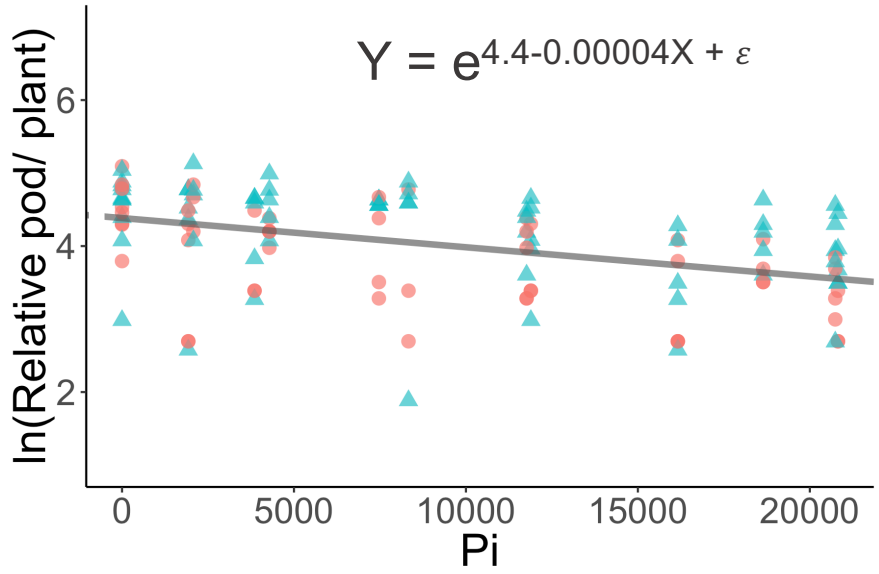
Response variable	Distribution	MS estimate	p
Relative total biomass	lognormal	-0.00001	0.007
Relative shoot biomass	lognormal	-0.00001	0.002
Relative root biomass	normal	-0.00030	NS

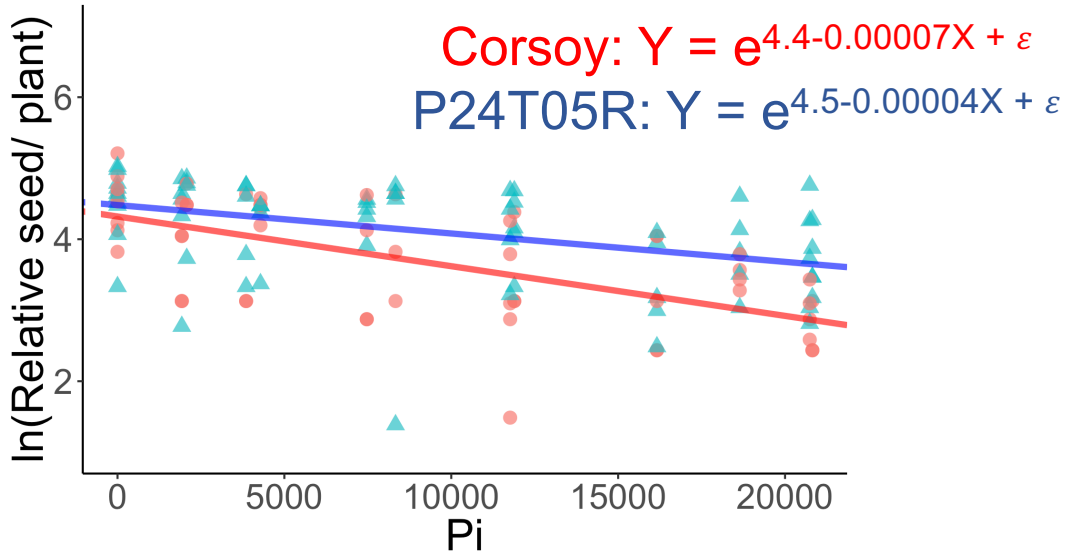
***P. penetrans* reduce shoot biomass but has no effect on root biomass.**

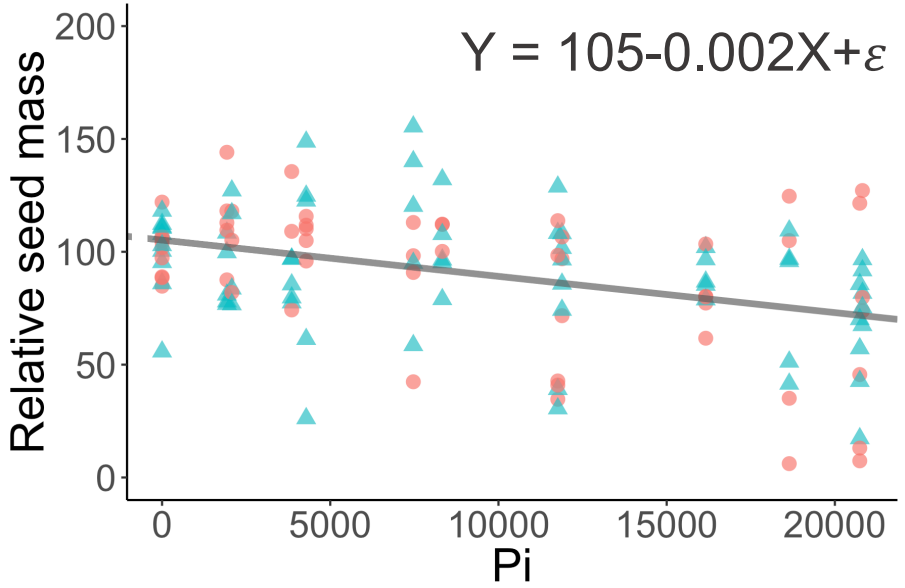
At R8

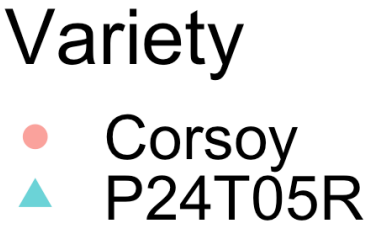
Response variable	Distribution	Genotype	MS estimate	p
Relative total biomass	lognormal	Random	-0.00003	< 0.0001
Relative shoot biomass	lognormal	Random	-0.00001	< 0.0001
Relative root biomass	normal	Corsoy	-0.00200	0.0003
		P24T05R	-0.00080	NS

Pi vs. Yield components

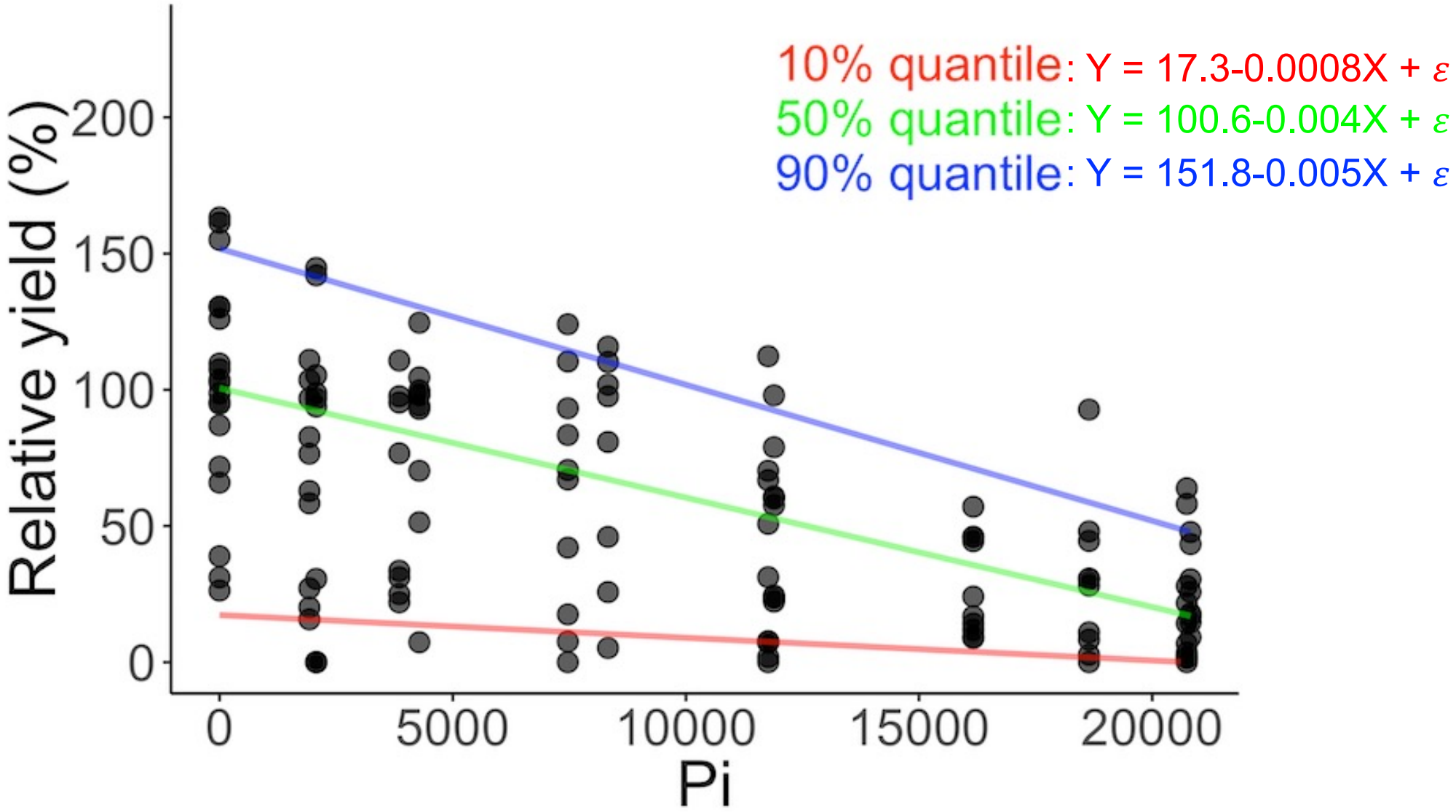




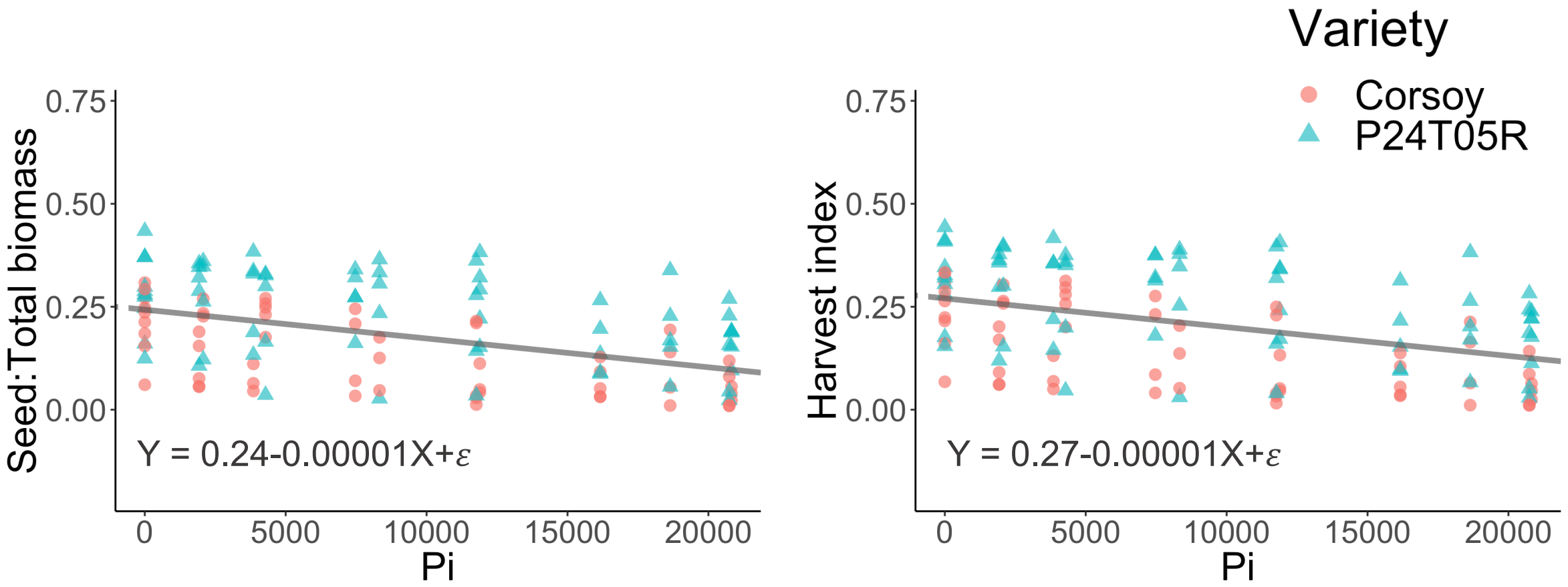




Pi vs. Relative yield



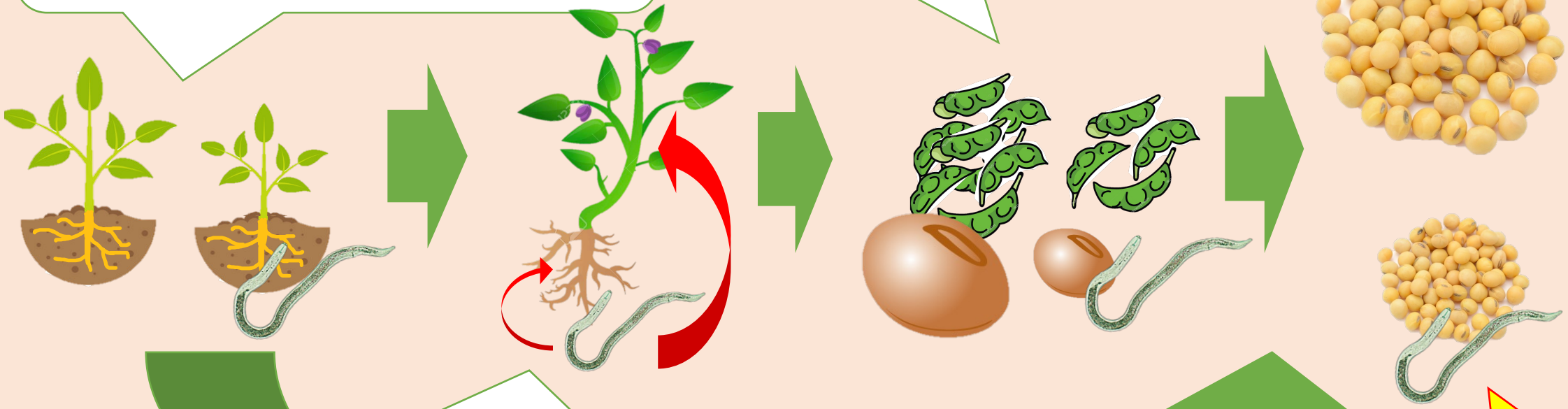
Effect of Pi on resource partitioning



Chapter 1 - Summary

Reduced shoot biomass but maintained root biomass.

Reduced pod number and seed mass



Manipulated the energy partitioning of plants toward plant growth over reproduction

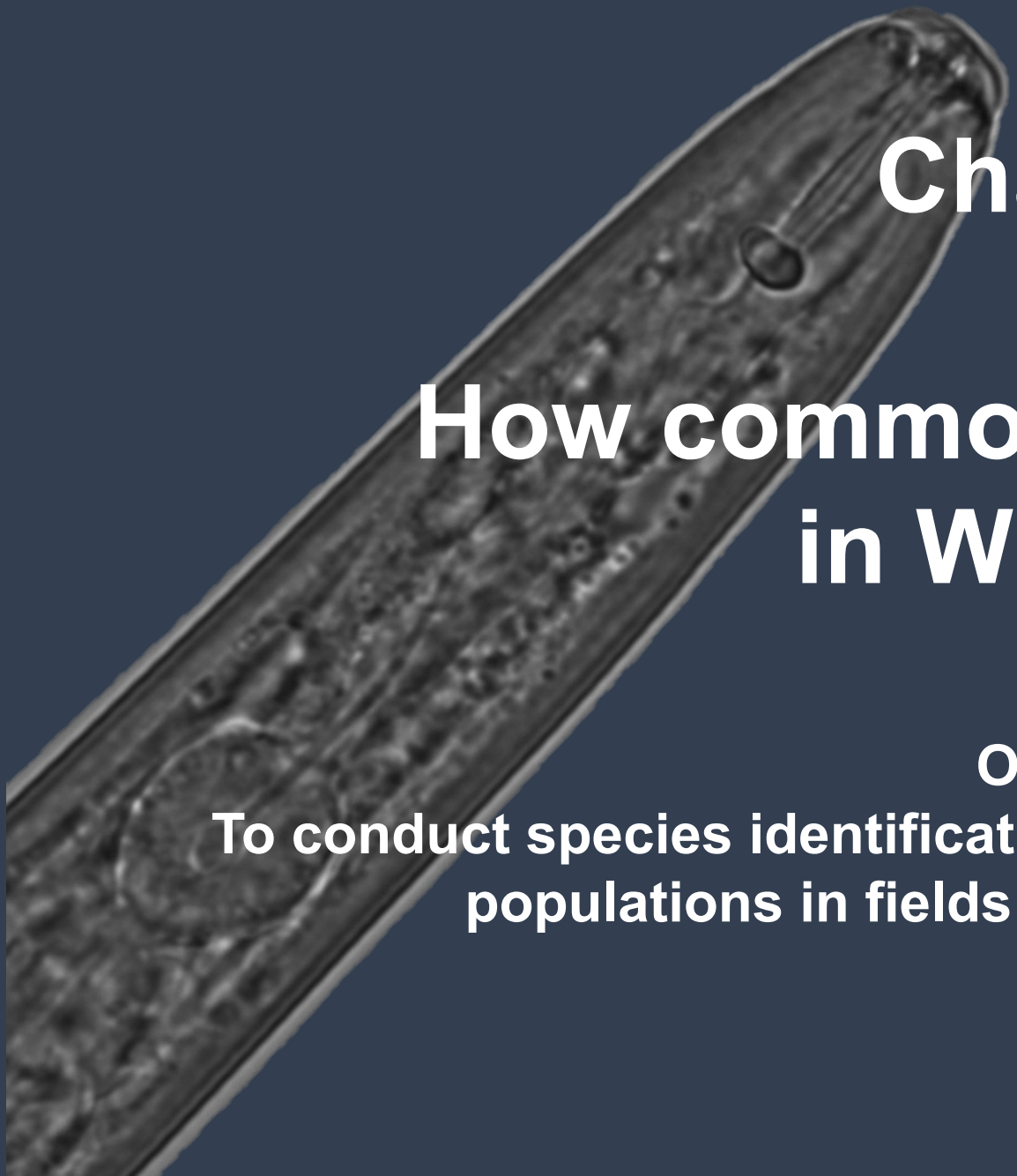
Yield loss

Outline

Chapter 1. Soybean response to *P. penetrans* in field and greenhouse environments.

Chapter 2. Gonochoristic species of *Pratylenchus* in soybean cropping systems in Wisconsin.

Chapter 3. Gender difference of *P. penetrans* for symptom development and severity.



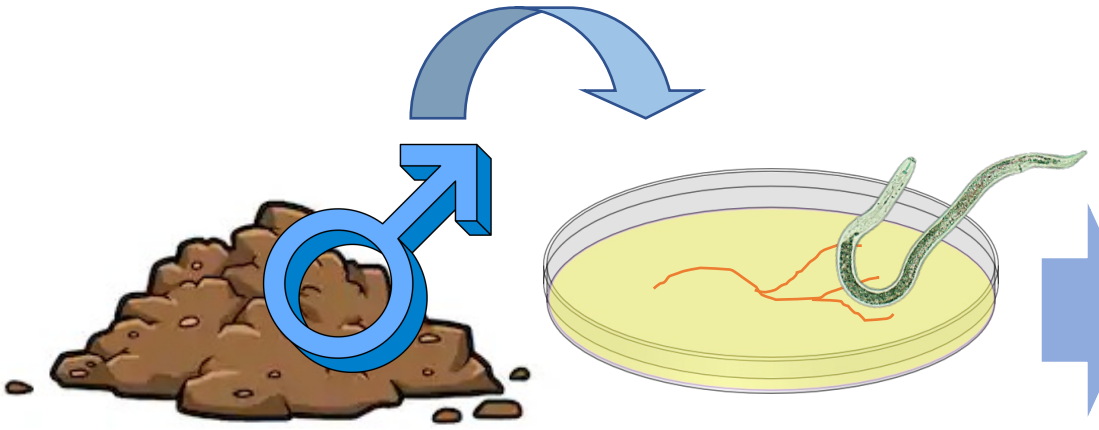
Chapter 2.

How common is *P. penetrans* in Wisconsin.

Objectives:
To conduct species identification of individual male nematodes from populations in fields with soybean in the rotation.

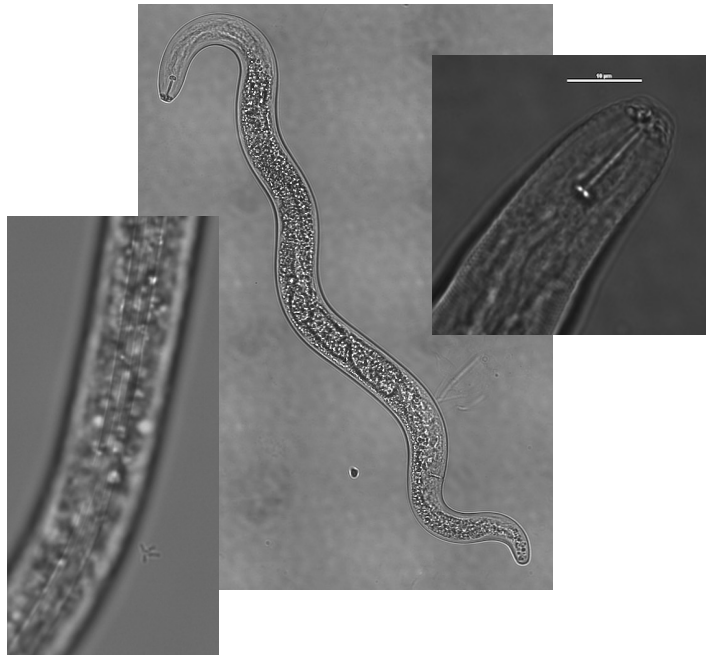
RLN isolation and characterizations

1. RLN isolation

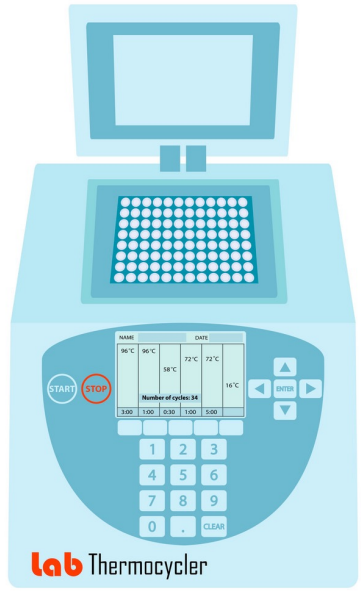


15 isolates (11 counties) +
2 Wisconsin isolates
of *P. penetrans*

2. Morphological characterization

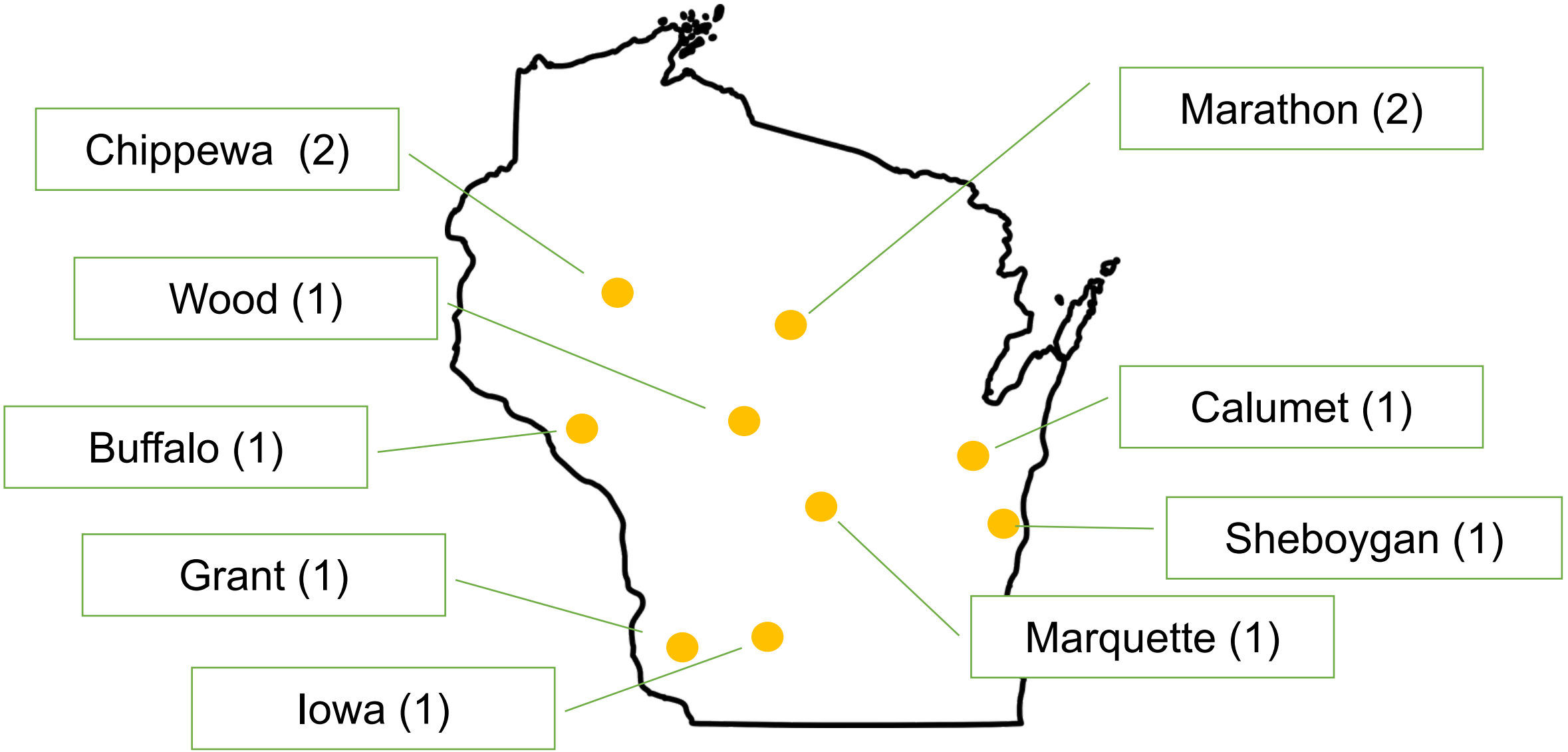


3. Molecular characterization

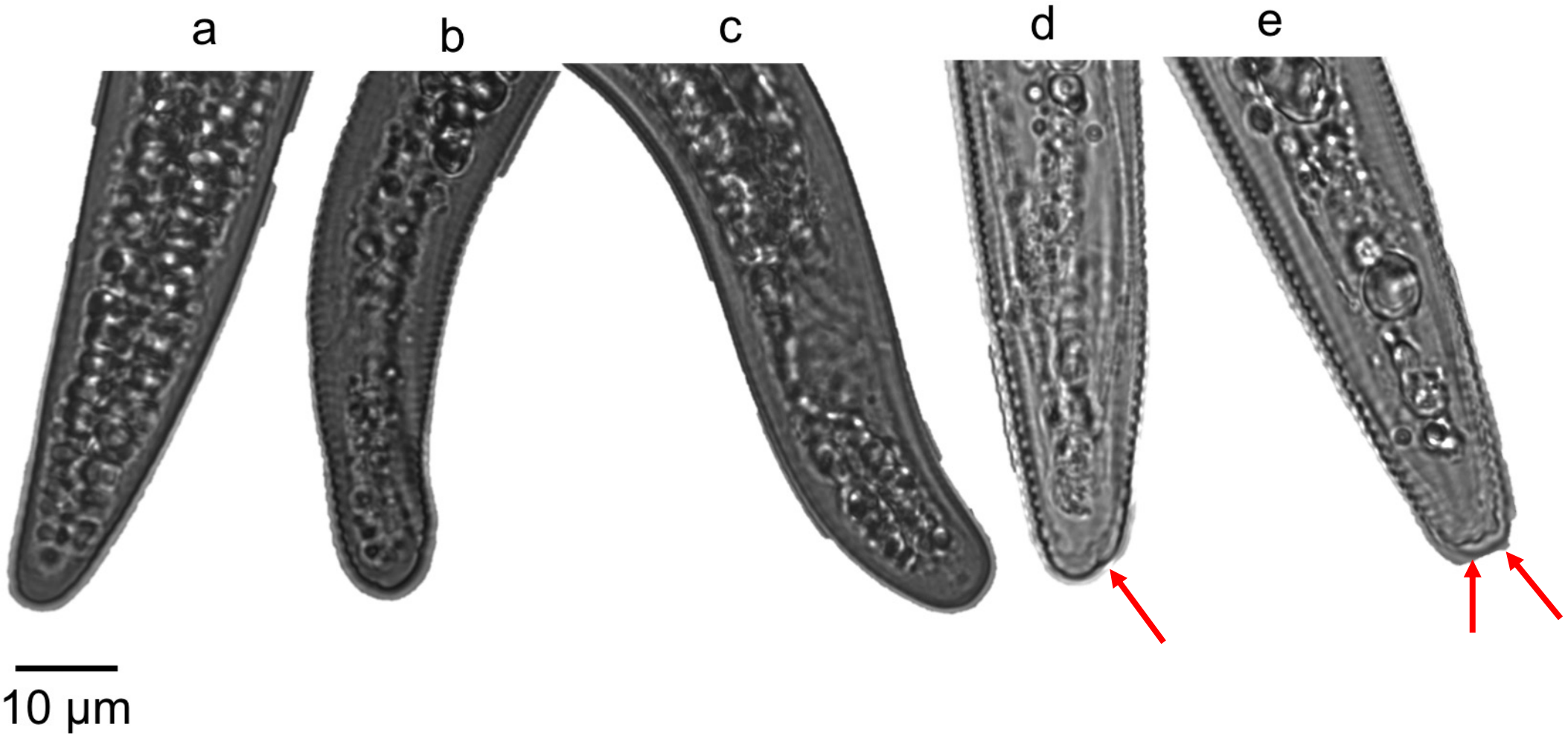


18S, 28S rDNA
COI mtDNA

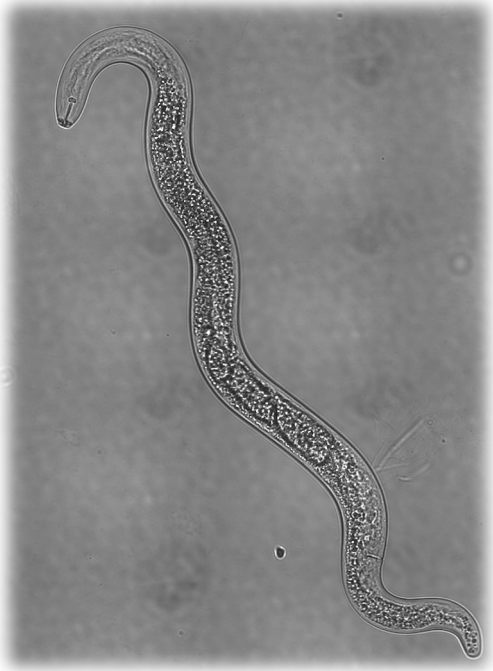
Cultured isolates – *P. penetrans*

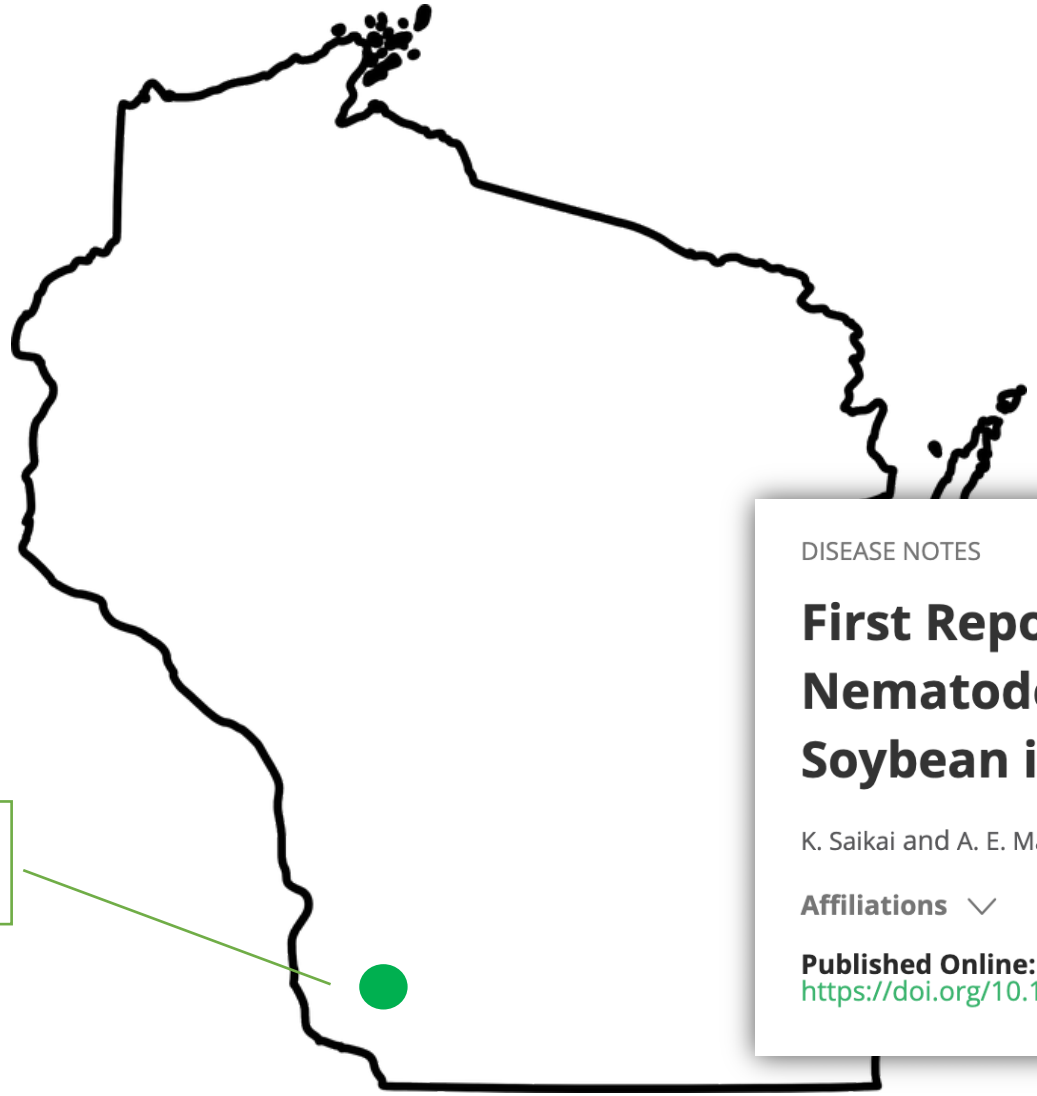


Variations in tail shapes of *P. penetrans*



Cultured isolates – *P. alleni*





Grant

DISEASE NOTES

OPEN

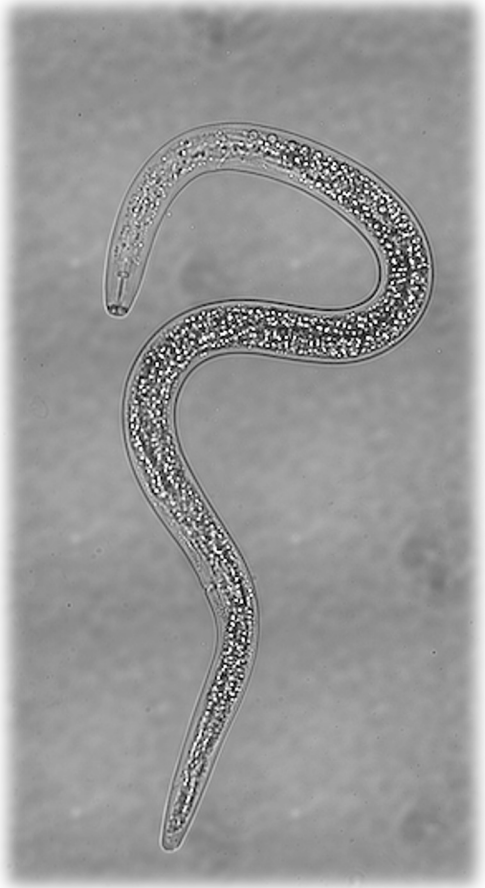
First Report of the Root-Lesion Nematode, *Pratylenchus alleni*, on Soybean in Wisconsin, U.S.A.

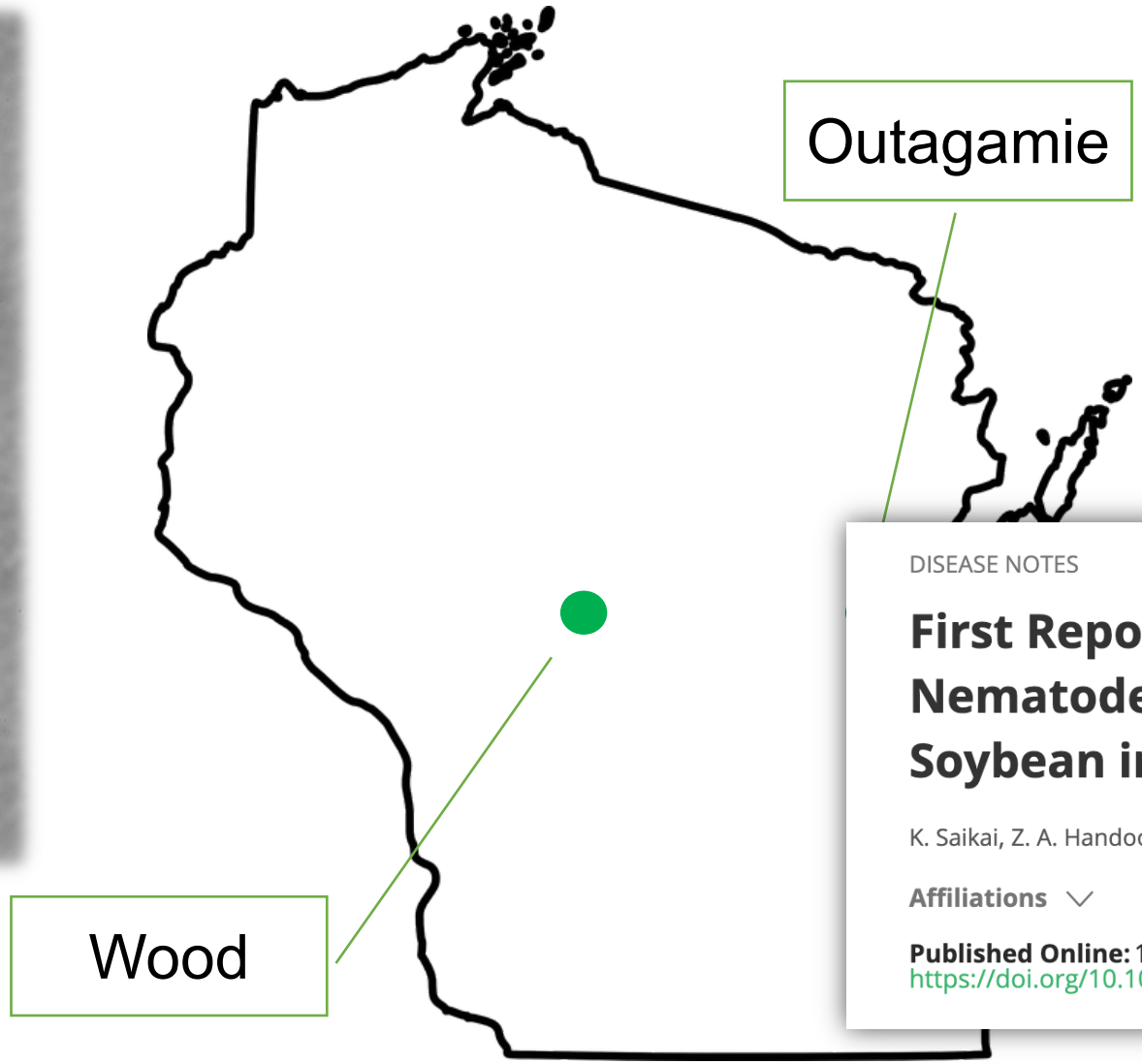
K. Saikai and A. E. MacGuidwin

Affiliations

Published Online: 13 Jun 2019 | https://doi.org/10.1094/PDIS-03-19-0501-PDN

Cultured isolates – *P. fallax*





DISEASE NOTES

OPEN

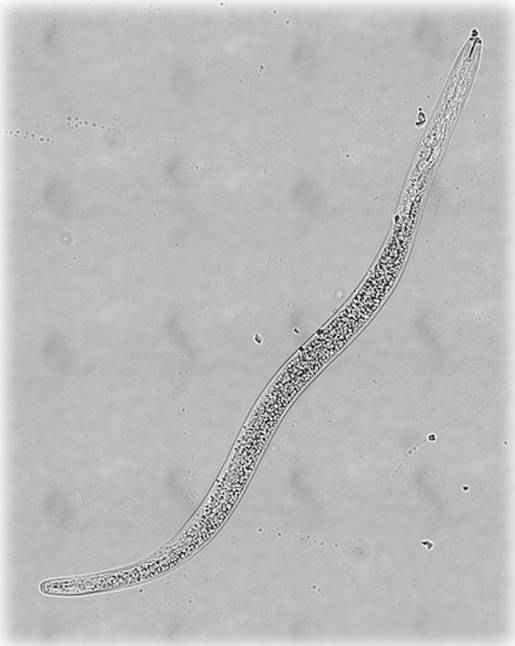
First Report of the Root-Lesion Nematode, *Pratylenchus fallax*, on Soybean in Wisconsin, U.S.A.

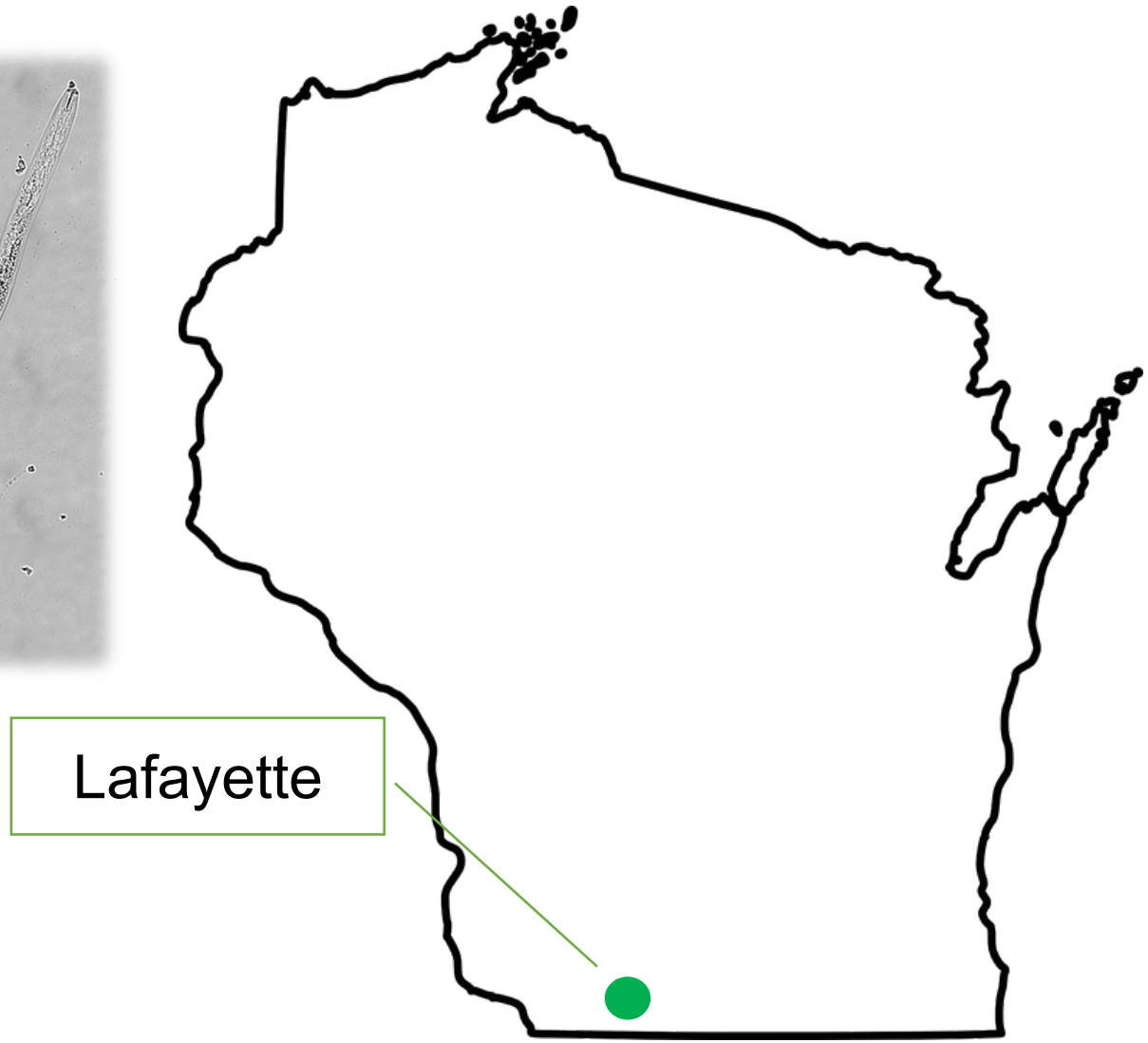
K. Saikai, Z. A. Handoo, and A. E. MacGuidwin

Affiliations

Published Online: 13 Jun 2019
https://doi.org/10.1094/PDIS-02-19-0288-PDN

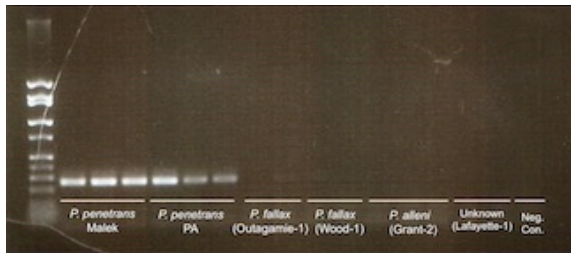
Cultured isolates – unknown



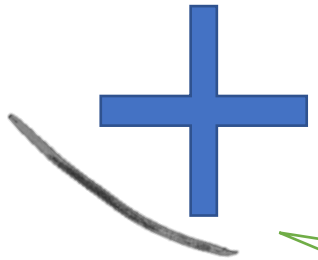


Survey Process

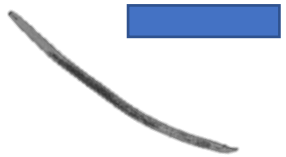
Test species-specific primer

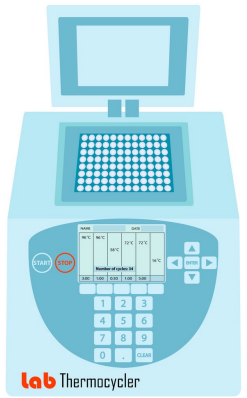


1-2 samples/ county
47 samples from
31 counties



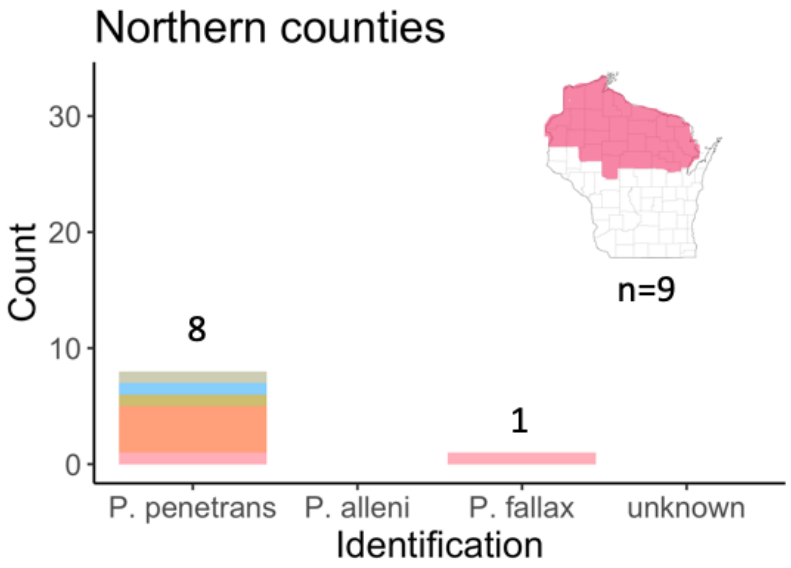
P. penetrans

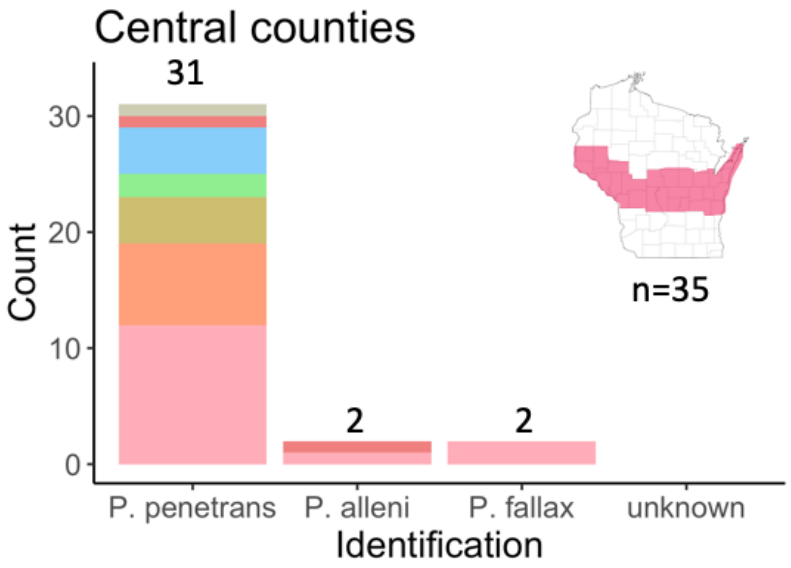


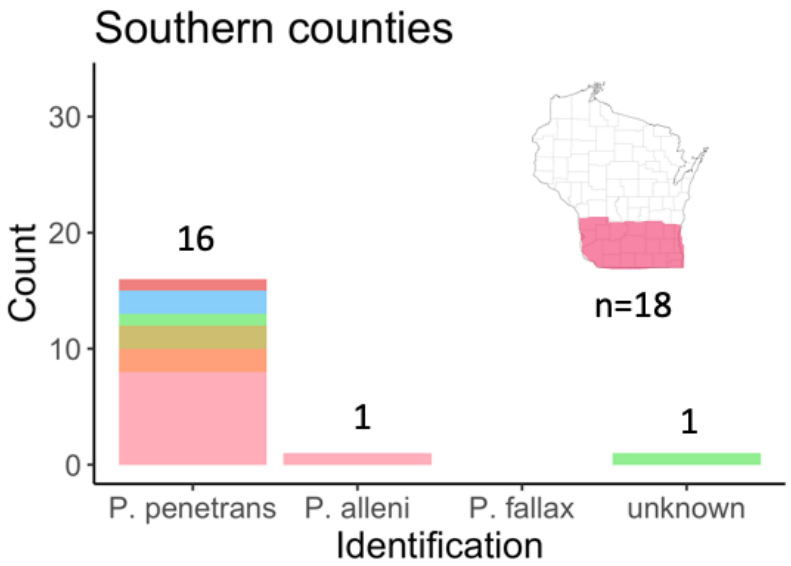


28S rDNA
COI mtDNA

Survey Results

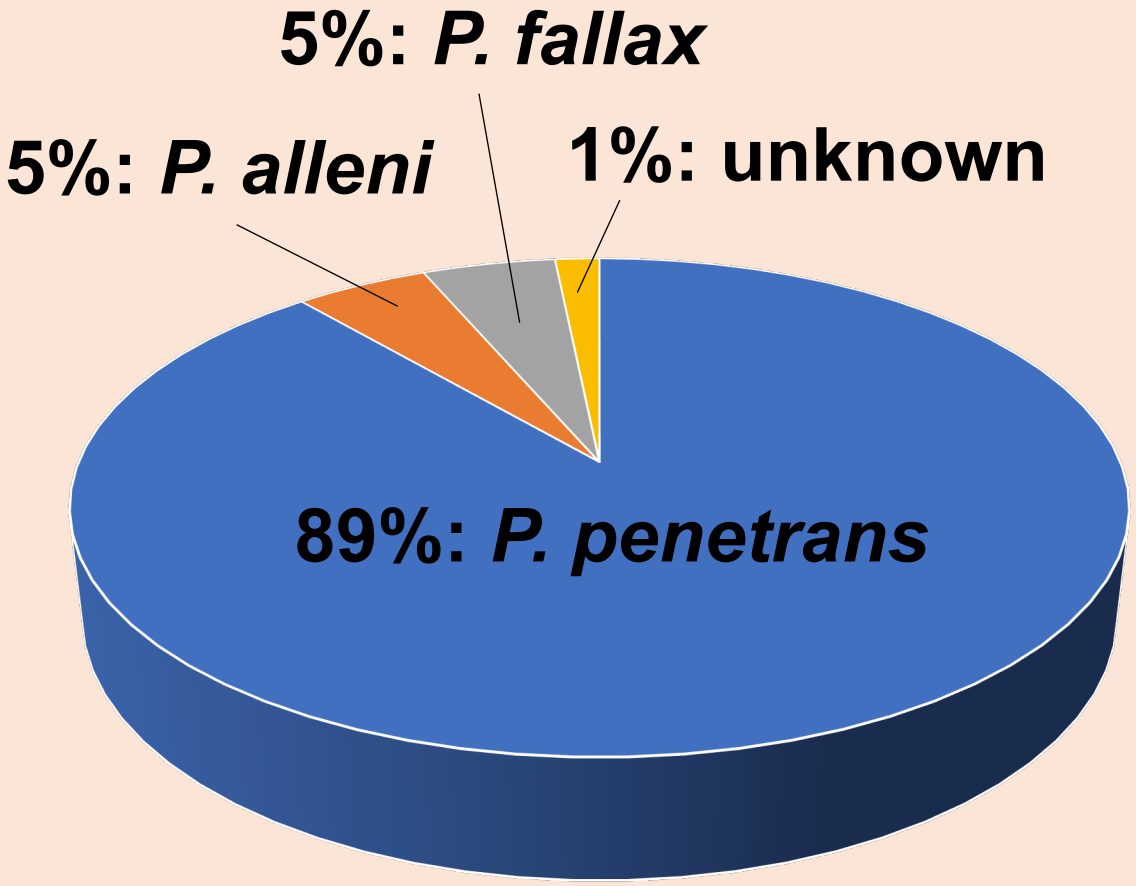






62 samples,
61 farms in
41 counties in WI.

Chapter 2 Summary



A good rule of thumb for diagnostic labs to assume that **a sample with males is likely to be *P. penetrans.***

P. penetrans was found from 42 counties on all soil textures.

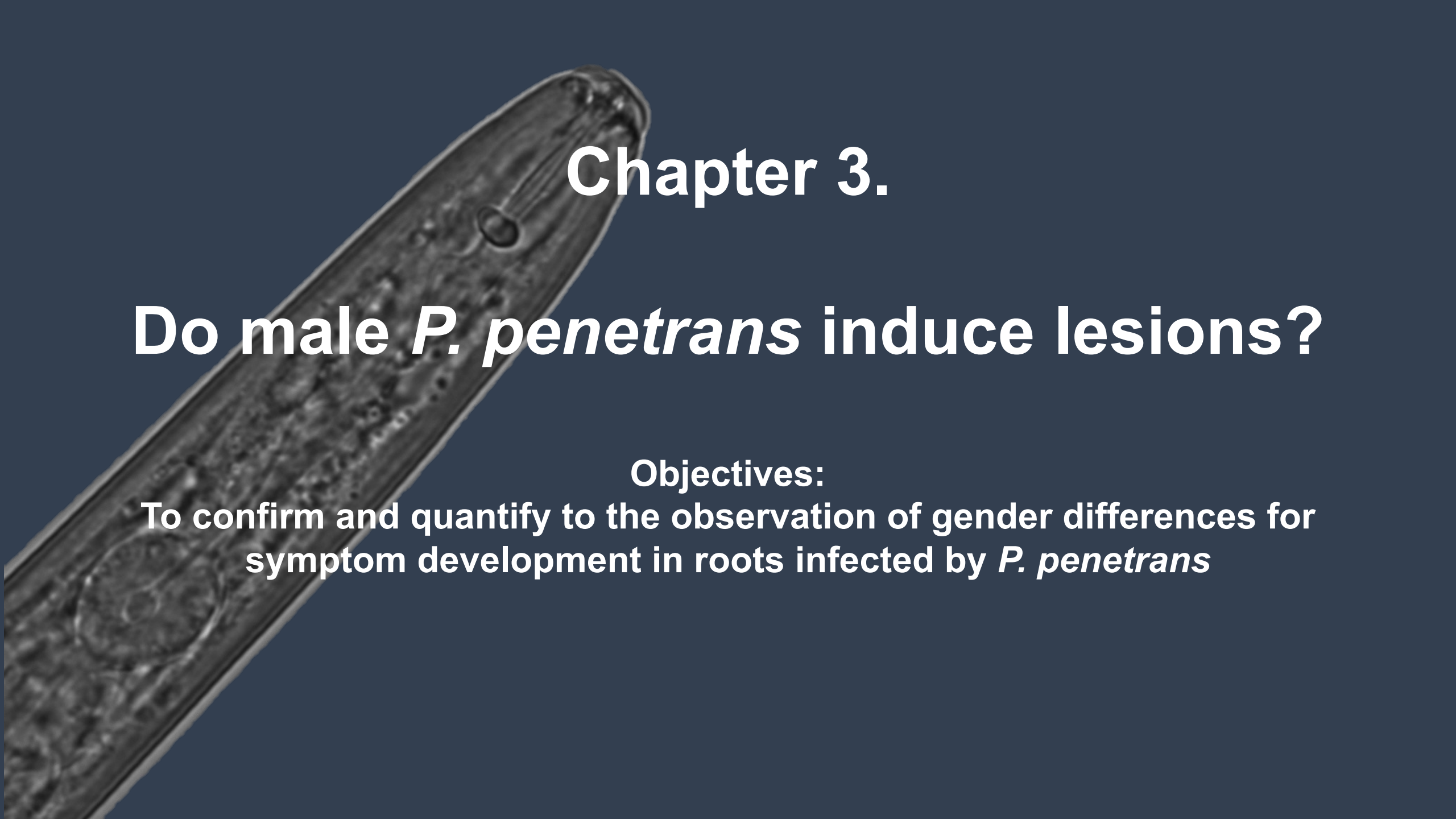
Need further studies on the damage potential of *P. alleni* and *P. fallax.*

Outline

Chapter 1. Soybean response to *P. penetrans* in field and greenhouse environments.

Chapter 2. Gonochoristic species of *Pratylenchus* in soybean cropping systems in Wisconsin.

Chapter 3. Gender difference of *P. penetrans* for symptom development and severity.

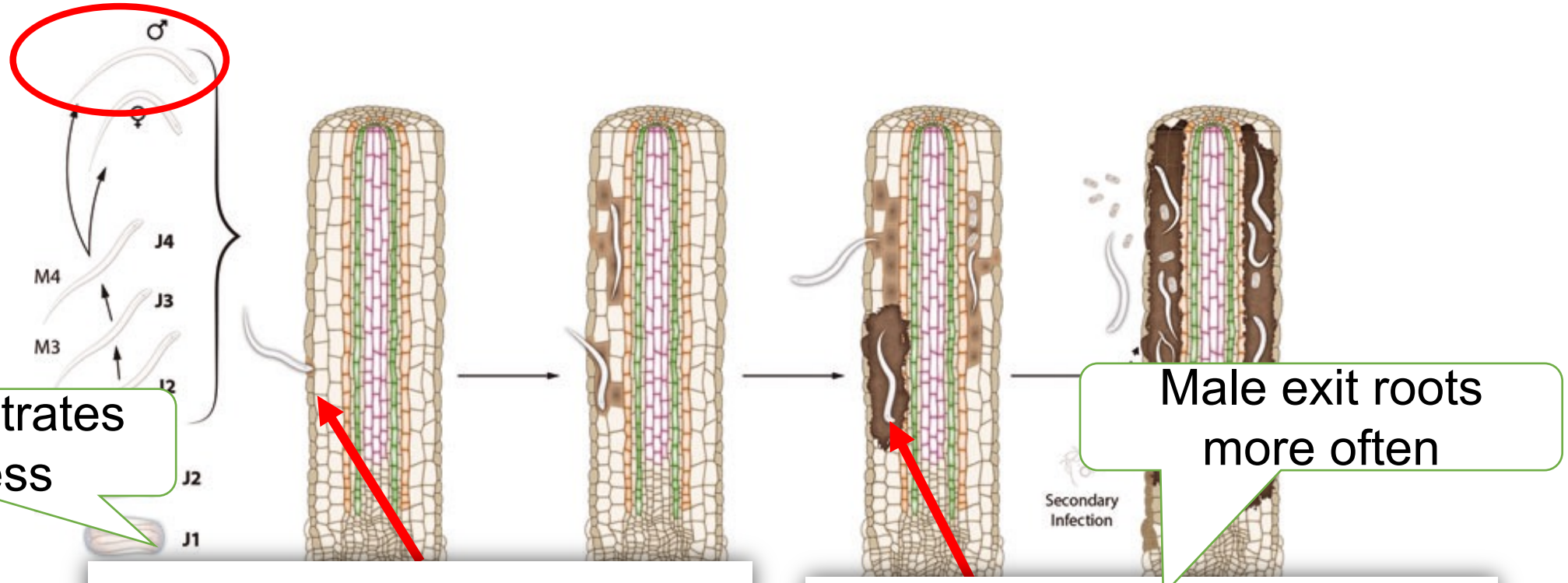


Chapter 3.

Do male *P. penetrans* induce lesions?

Objectives:
To confirm and quantify to the observation of gender differences for symptom development in roots infected by *P. penetrans*

Background



Male penetrates roots less

Male exit roots more often

Infectivity of Pratylenchus penetrans on Alfalfa[1]

J. L. TOWNSHEND[2]

t: The infectivity of *Pratylenchus penetrans* on alfalfa seedlings cv. Du Puits was studied. nse root-hair zone was the preferred zone of penetration by females, males, and third-stage A lesion initially appeared as a water-soaked area at the root surface, becoming yellow liptical as the nematode entered the cortex, with dark-brown cells later appearing in the as the nematode fed. At 20 C, females penetrated roots earlier, faster, and in greater rs than either males or third-stage larvae. Females penetrated roots at temperatures from C, with maximum penetration between 10 and 30 C, while males and third-stage larvae ated roots only between 10 and 30 C with maximum penetration at 20 C. Penetration of y females, males, and third-stage larvae increased after storage of 5 C for 35 days, but ed after storage of 140 days or more. Combinations of the three life stages in pairs neither ed nor inhibited penetration of roots by individual life stages; males were not attracted to s. Increasing inoculum density up to 20 nematodes/seedling did not affect penetration.

Key Words: root-lesion nematode, penetration, lesion, *Medicago sativum*.

Journal of Nematology 22(4):614–617. 1990.
© The Society of Nematologists 1990.

Differences in Egress of Male and Female *Pratylenchus penetrans* from Pea Roots[1]

D. J. WIXTED AND A. E. MACGUIDWIN[2]

Key words: attraction, behavior, egress, infection, migration, *Pratylenchus penetrans*.

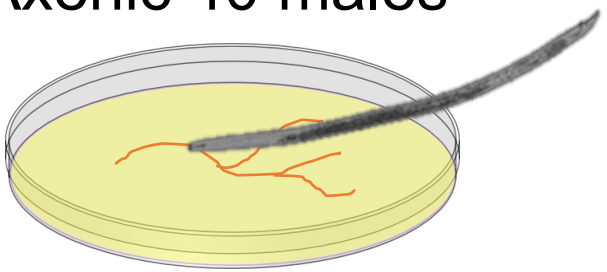
Pratylenchus spp. are migratory endopar- asites of plants. Despite being obligate par-

medium (2) were used. Inoc of 40 males or 40 females w axenically transferred into a containing 0.5 ml sterile wa Pea seeds (*Pisum sativum* L. cv. Early Per-

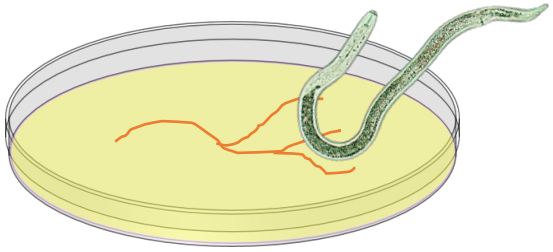
In vitro study design

Nematode introduction

Axenic 40 males



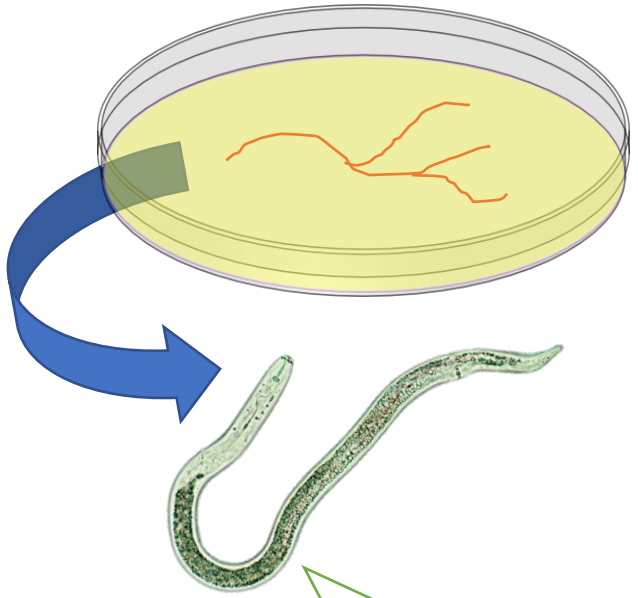
Axenic 40 females



Lesion measurements for 14 days

Record lesion number and length

Harvest at 14 days

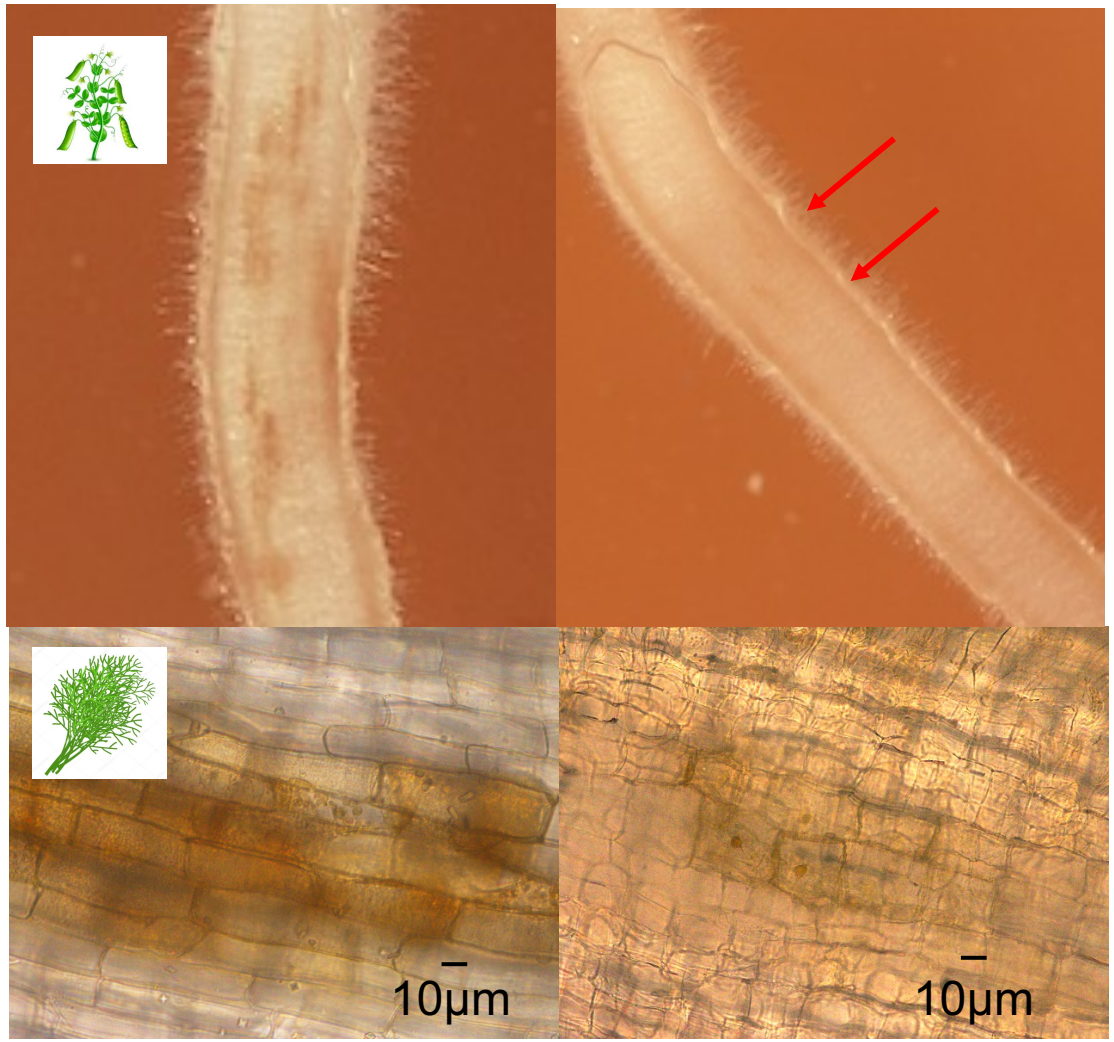


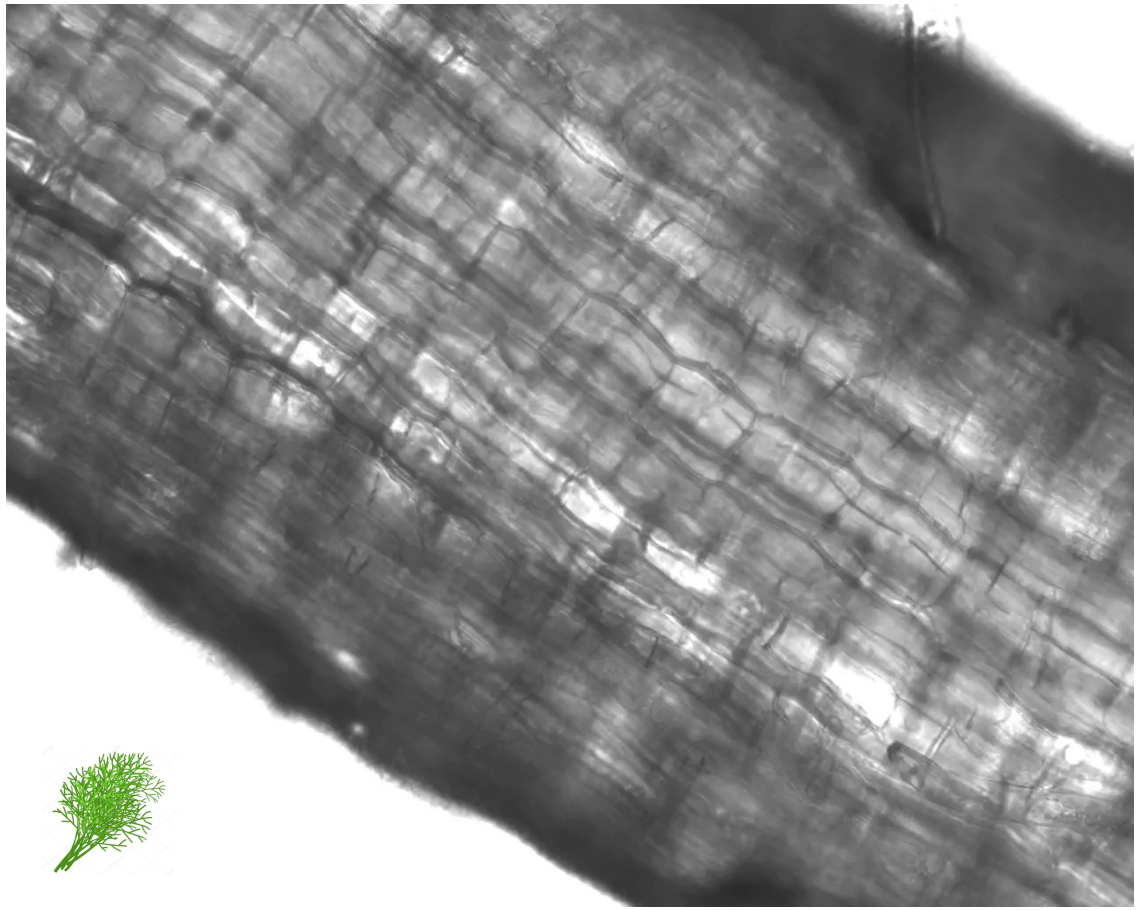
Record nematode number

Lesions by female and male

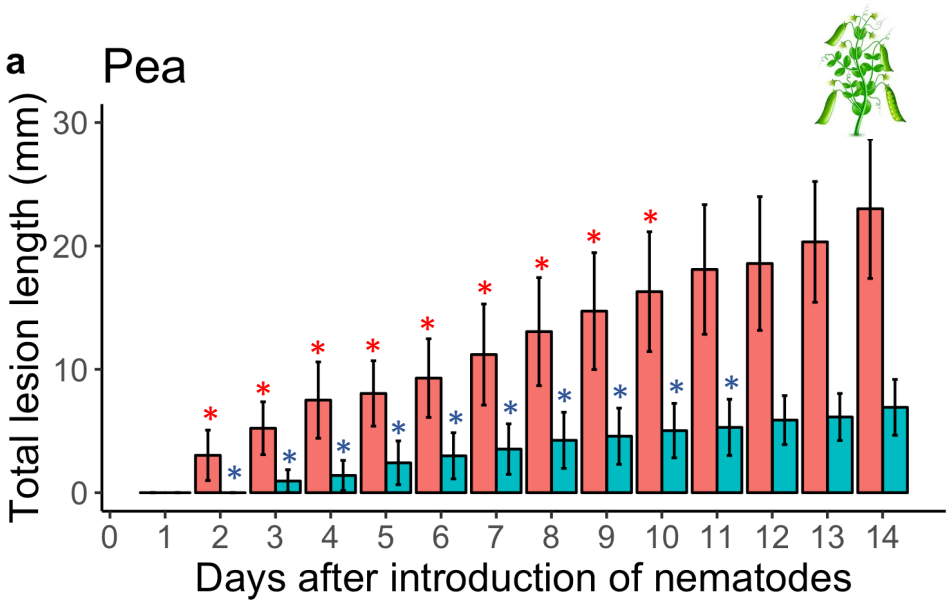
female

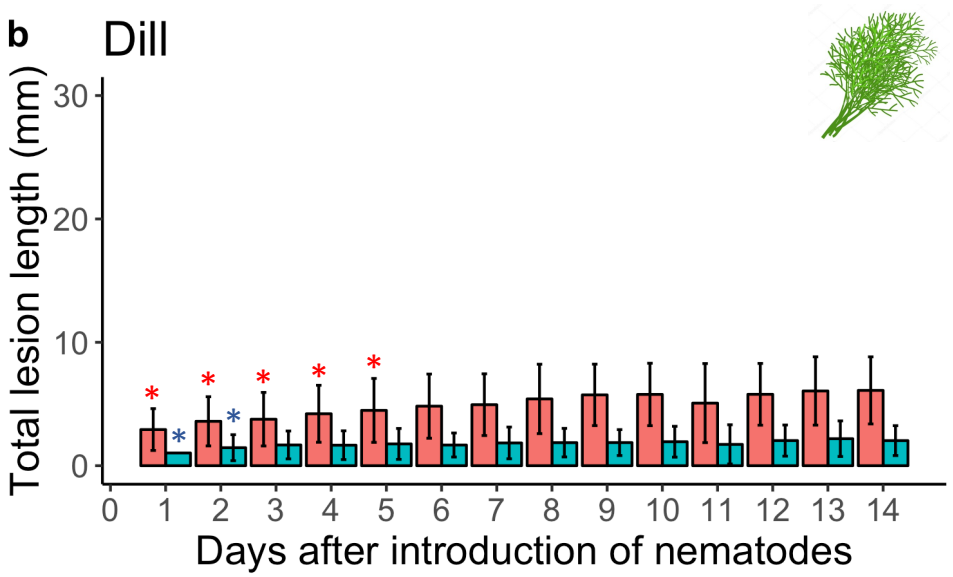
male

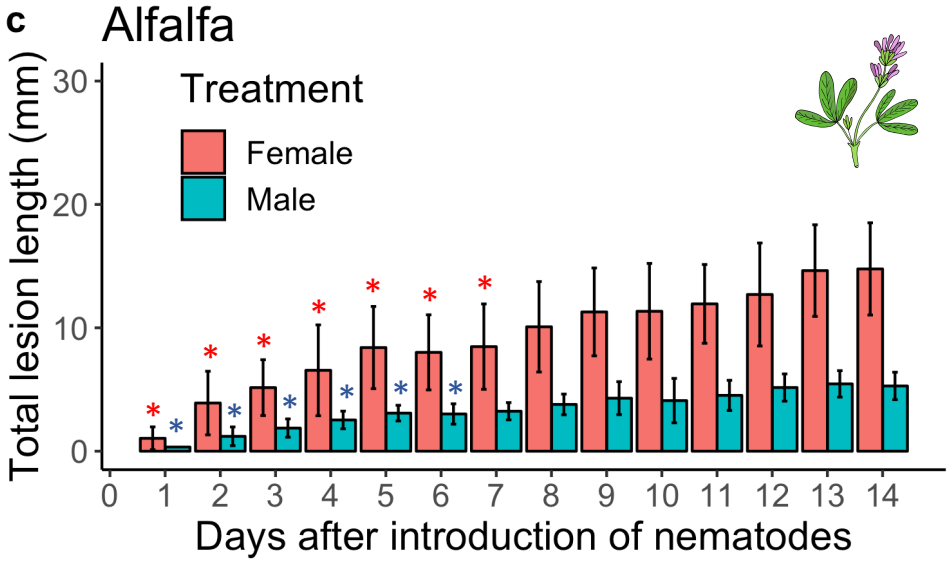




Gender effect on total lesion length



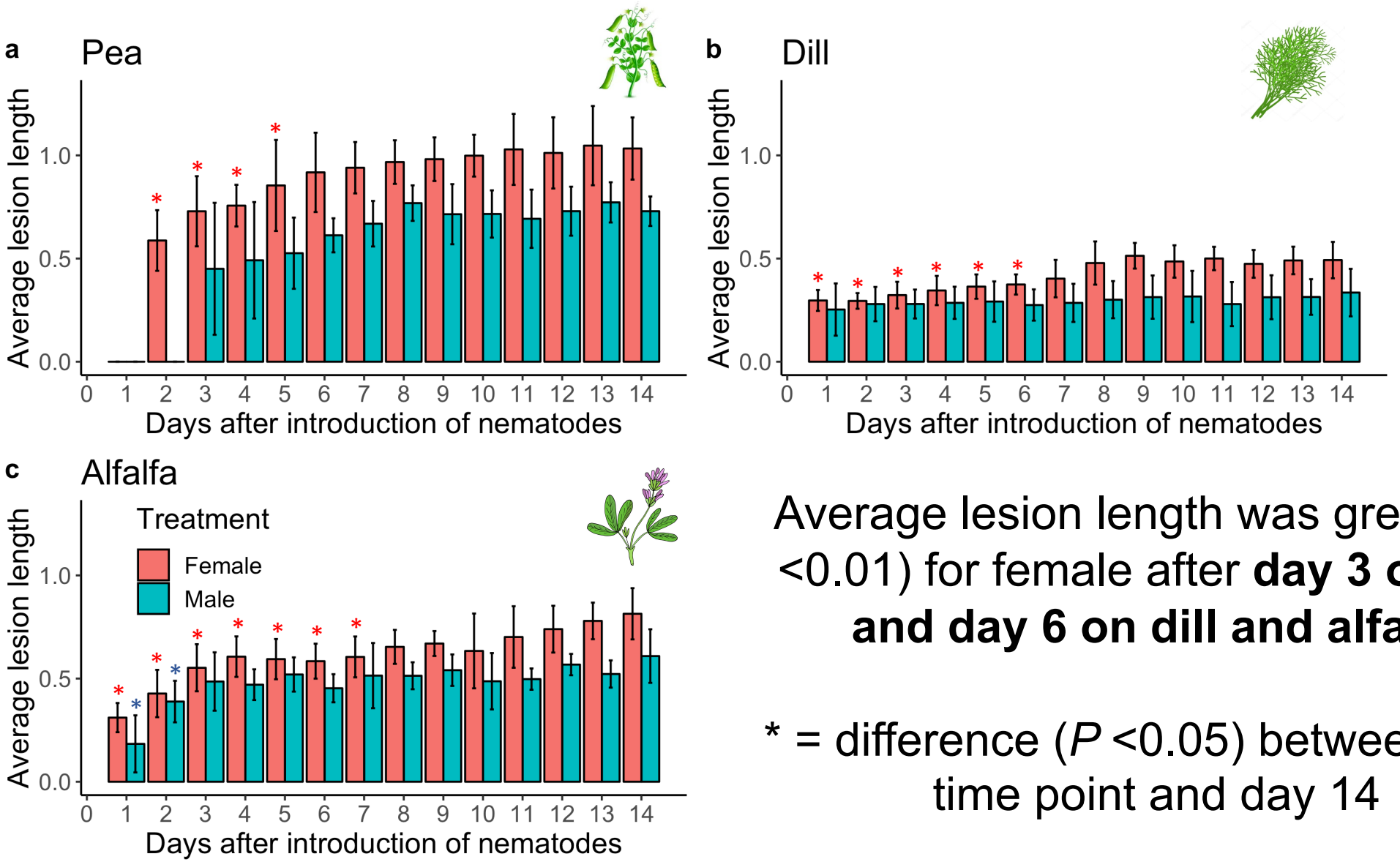




Total lesion length was greater (P <0.01) for females than males at **every time point**.

* = difference (P <0.05) between each time point and day 14

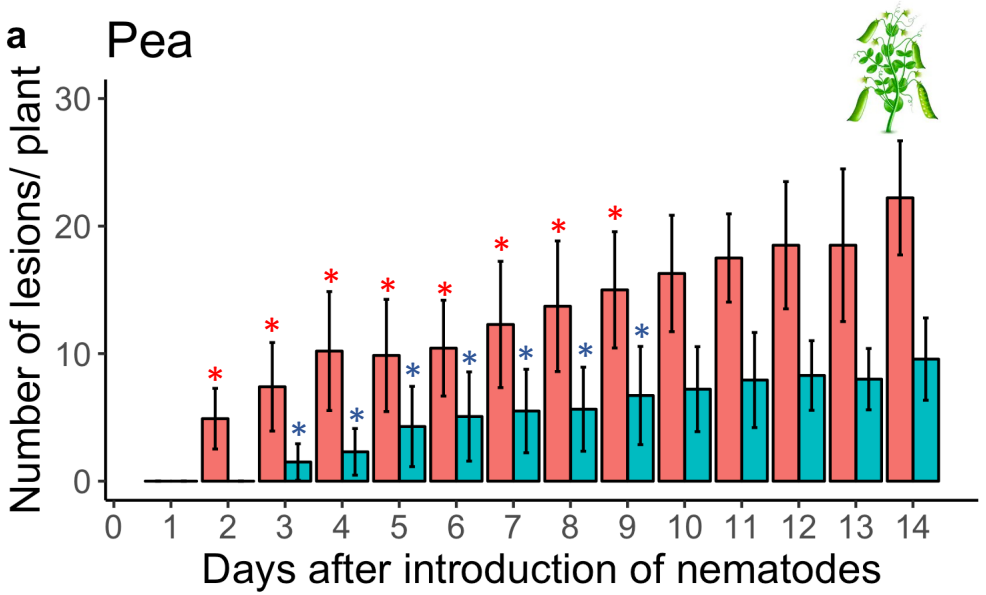
Gender effect on average lesion length

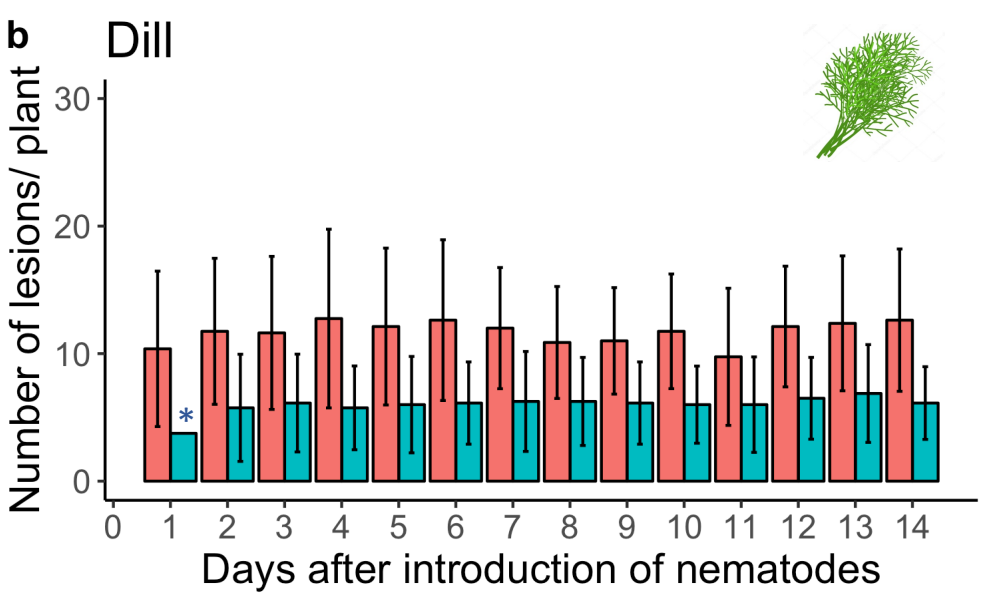


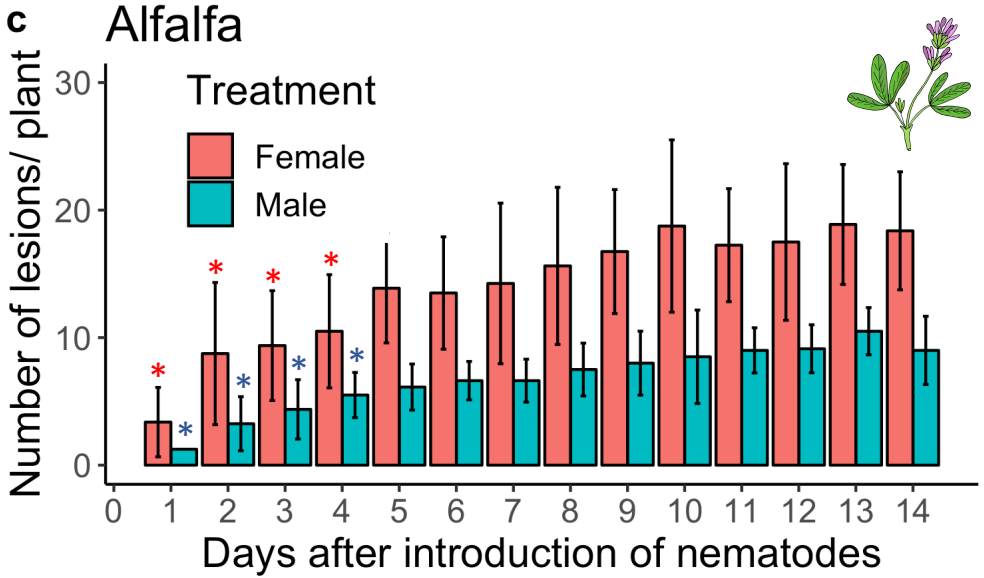
Average lesion length was greater (*P* <0.01) for female after **day 3 on pea and day 6 on dill and alfalfa**

* = difference (*P* <0.05) between each time point and day 14

Gender effect on lesion number



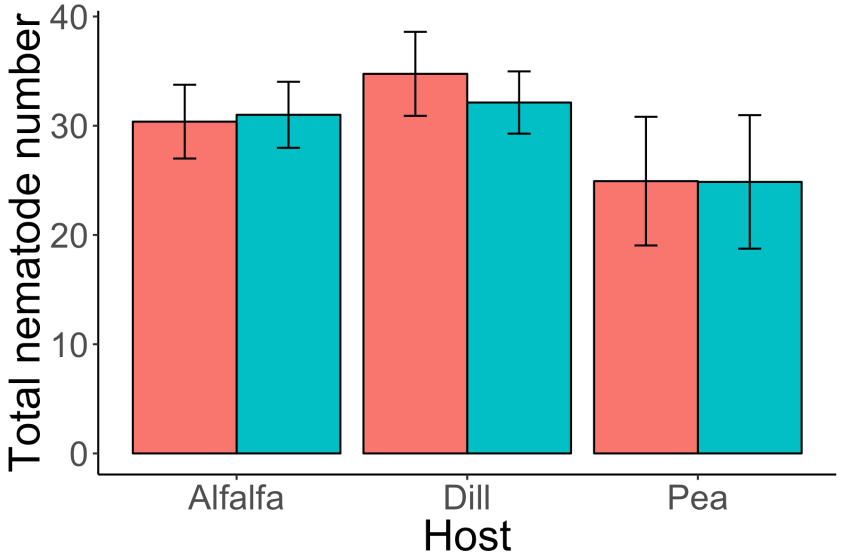


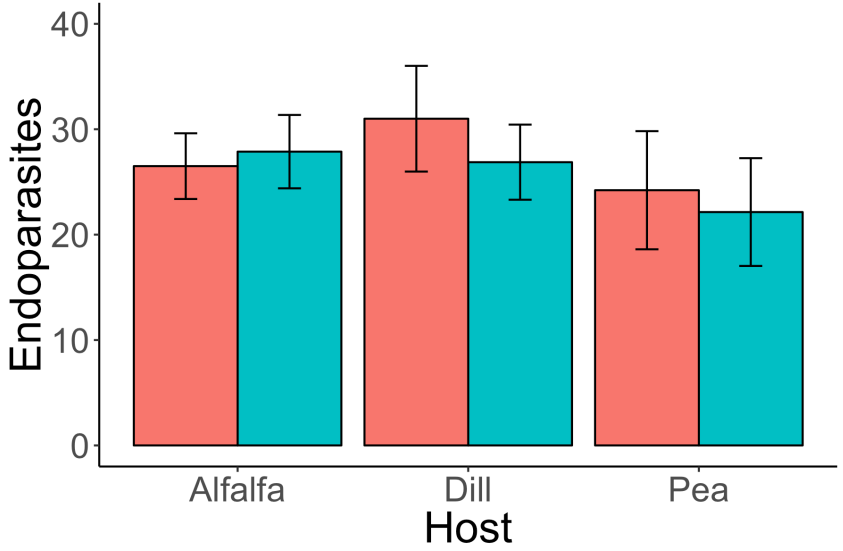


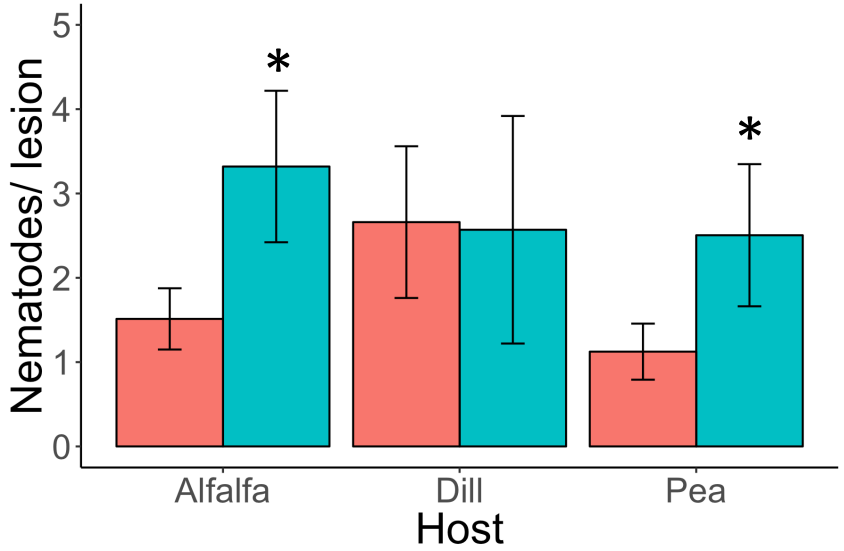
Lesion number was greater (P <0.01) for females than males at **every time point**.

* = difference (P <0.05) between each time point and day 14

Number of nematodes at day 14



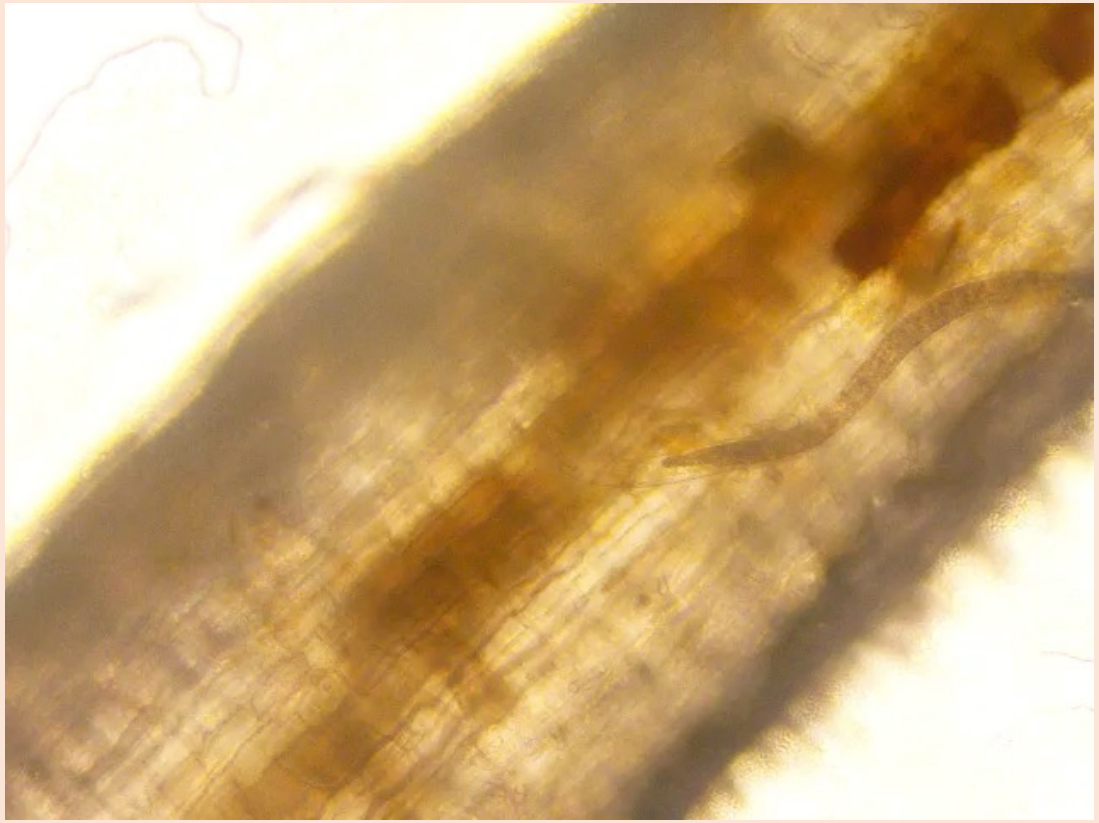




Number of total RLN and endoparasites did not differ by gender.

* = gender difference (P <0.01)

Chapter 3 - Summary



Male *P. penetrans* induced fewer lesions on the three hosts.

Root infection and occupancy was the same for both genders, diminishing the possibility that our findings were biased by gender difference in infection competency.

Greater lesion number and size were constantly associated with female at all time points.

Synthesis

***Pratylenchus penetrans* is an important pathogen on soybean.**

The nematode induces yield loss by reducing pod number and seed mass.

The high incidence of *P. penetrans* demonstrated in chapter 2 in combination with its damage potential based on chapter 1 suggest ***P. penetrans* is a major constraint to the soybean industry.**

Ack wledgement

MacGuidwin lab member:
Gary Pack, phD
Ibrahim Saeed, phD
Lauren Raasch
(David Sundquist)
(Bre Bender)
(Toby Lunt)
(Tomas R
All the

Guidwin (Chair)
Conley
ard Lankau
ug Rouse
Damon Smith
r. Murray Clayton)

H Station:

ISCONSIN
YBEAN
MARKETING BOARD

nt Pathology
University of Wisconsin-Madison

JASSO
Independent Administrative Institution
Japan Student Services Organization

Special thanks:
Maria Kamenetsky (Statistic Consulting)
Dr. Zafar Handoo (USDA-ARS)