Preparation for Crops Diagnostic Workshop

Soils were collected in 35 fields; from Dusty to Colfax to Uniontown

10 sub-samples/sample; ¾ - 1½ acres/sample

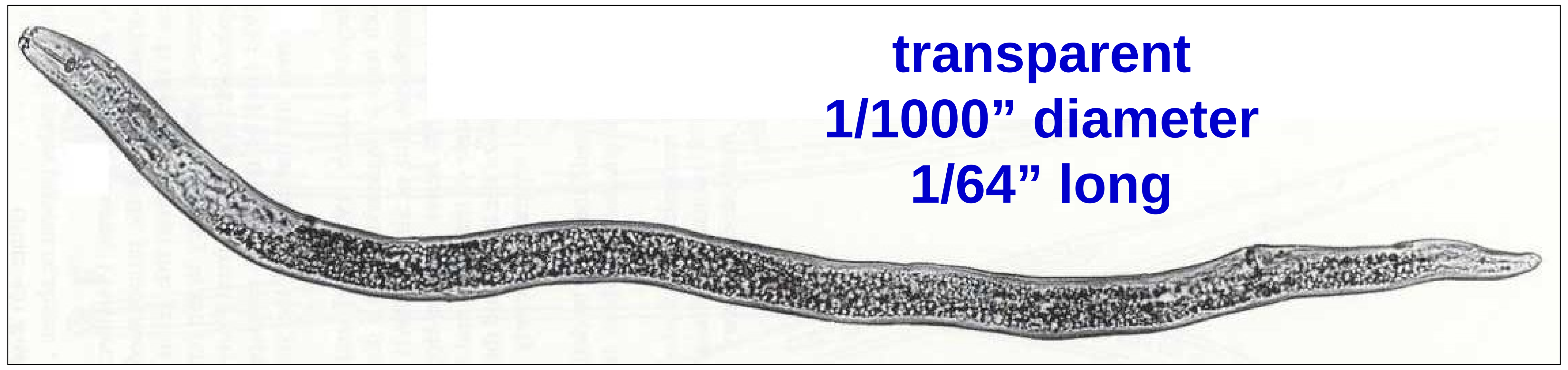
Nematodes detected:	**Root-lesion**	**Cereal cyst**	**Stunt**
Positive detections	33	20	16
% of samples	**94%**	**57%**	**46%**
Present in high numbers	12	11	3
% of samples	**34%**	**31%**	**9%**

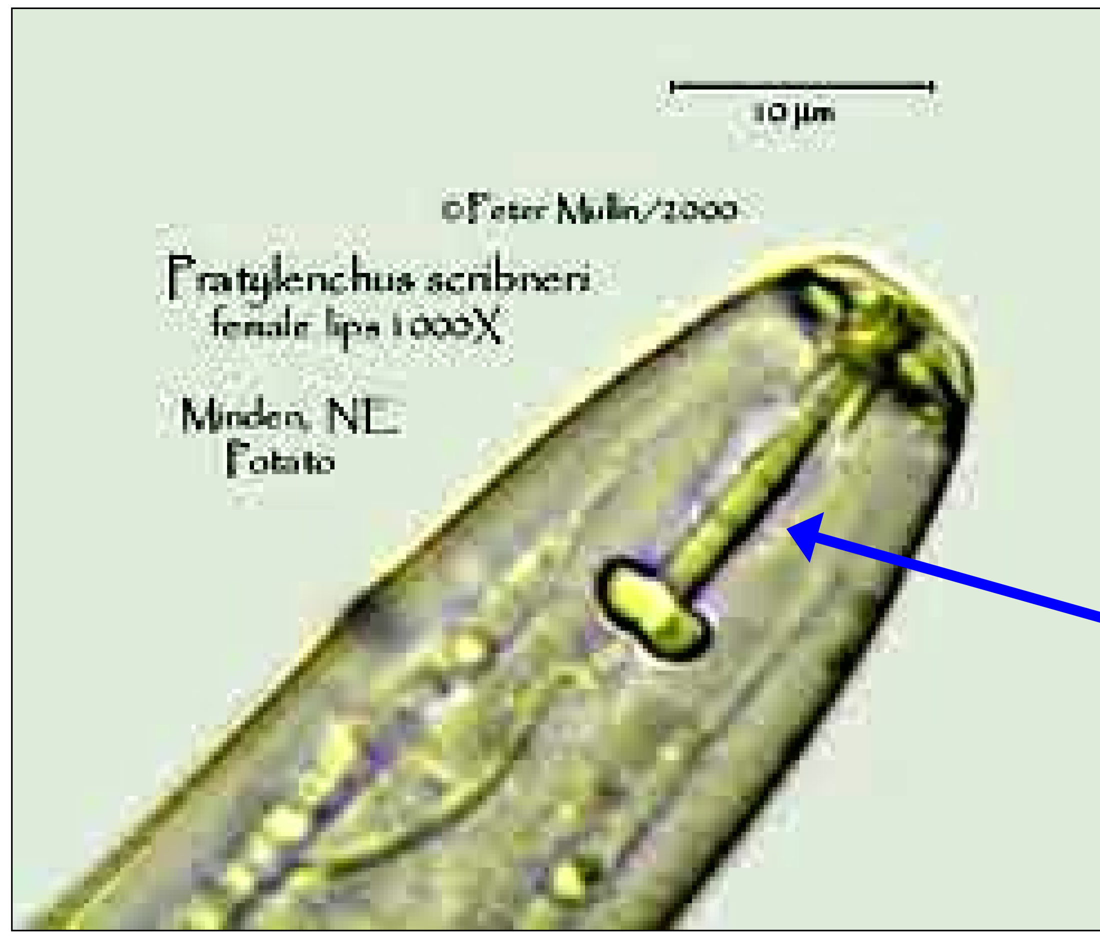
Root-lesion Nematodes (RLN)

Pratylenchus neglectus

and

Pratylenchus thornei

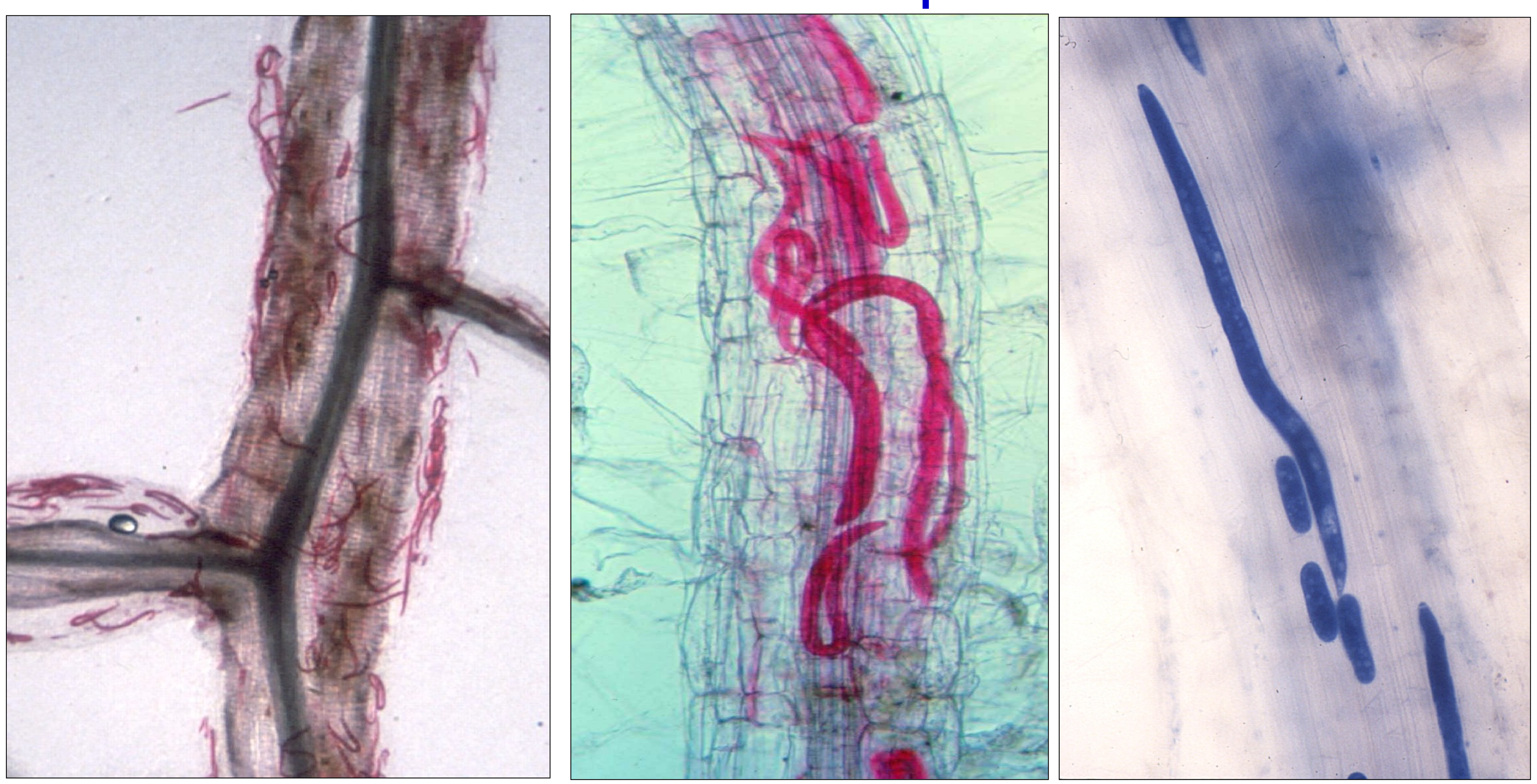




Feeding stylet

Simple life cycle: egg → juvenile → adult female → egg

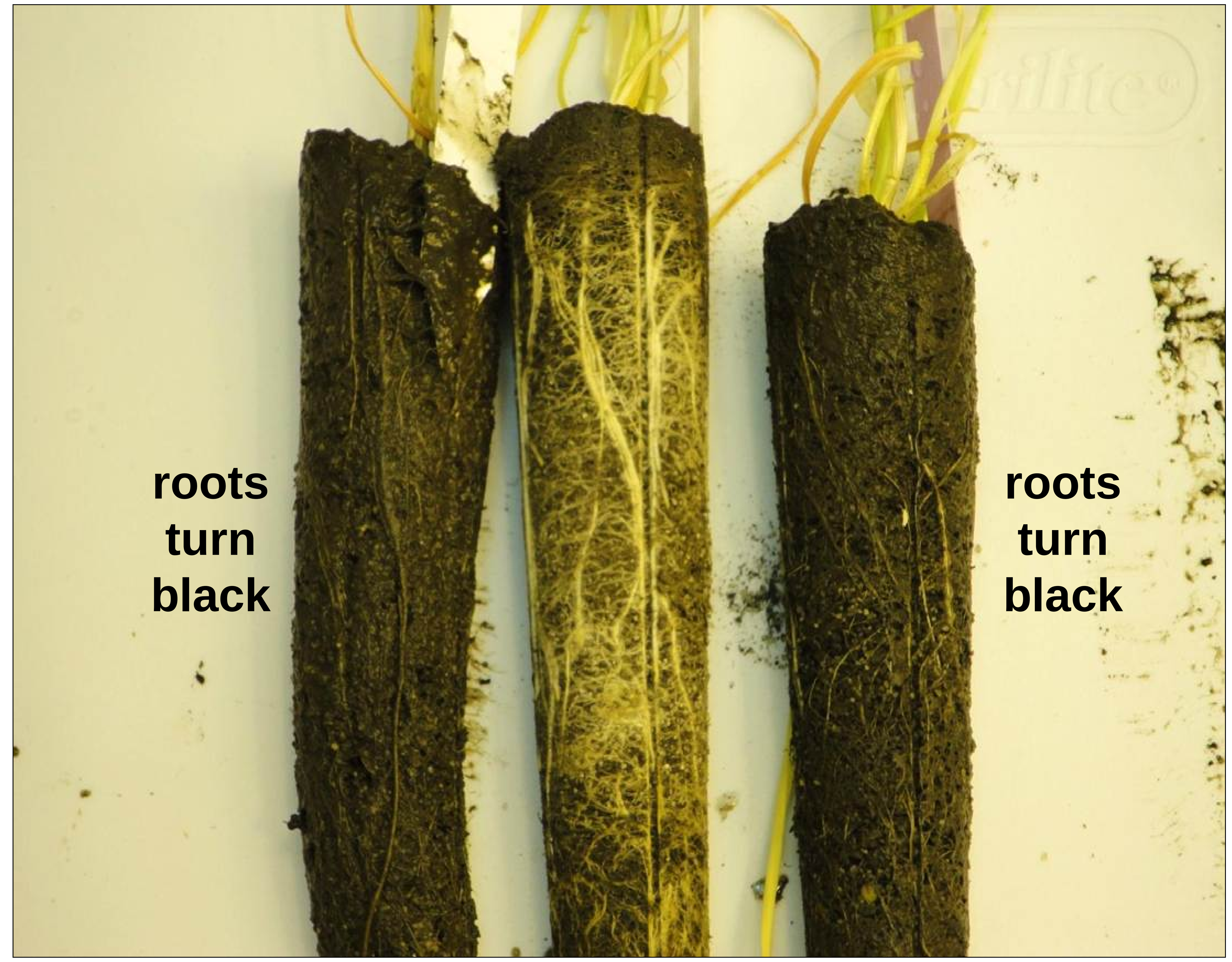
nematodes were stained to reveal presence in root tissue



Effect of Root-lesion Nematodes on Wheat Health

Field test at OSU (+/- nematicide)

Greenhouse test at WSU



Alpowa (susceptible) | **AUS 28451** (resistant) | **Louise** (susceptible)

- **Reduced extraction of soil water & nutrients**
- **Reduced tillering & plant vigor**
- **Reduced grain yield & grain quality (lower test weight)**
- **Reduced economic efficiency in infested fields**

Root-lesion nematodes are widely distributed in PNW

surveys revealed counties (●) with potentially damaging densities

OR & WA: Smiley et al. (2004) *Plant Disease* 36:54-68

ID: Strausbaugh et al. (2004) *Canad. J. Plant Pathol.* 26:167-176

MT: Johnson (2007) MSc thesis, Montana State University

WA: Kandel et al. (2013) Plant Disease 97:1448-1456

Horizontal Variability of Root-lesion Nematodes near Pendleton

(nematodes/ lb of soil in 5 ½ x 20 ft plots)

168	1,936	73	1,755	2,764	532	205	77	1,677	82
2,318	1,564	50	223	18	4,873	132	577	9,418	318
1,232	336	0	41	173	23	5,800	4,882	732	150

sampled to 12" depth

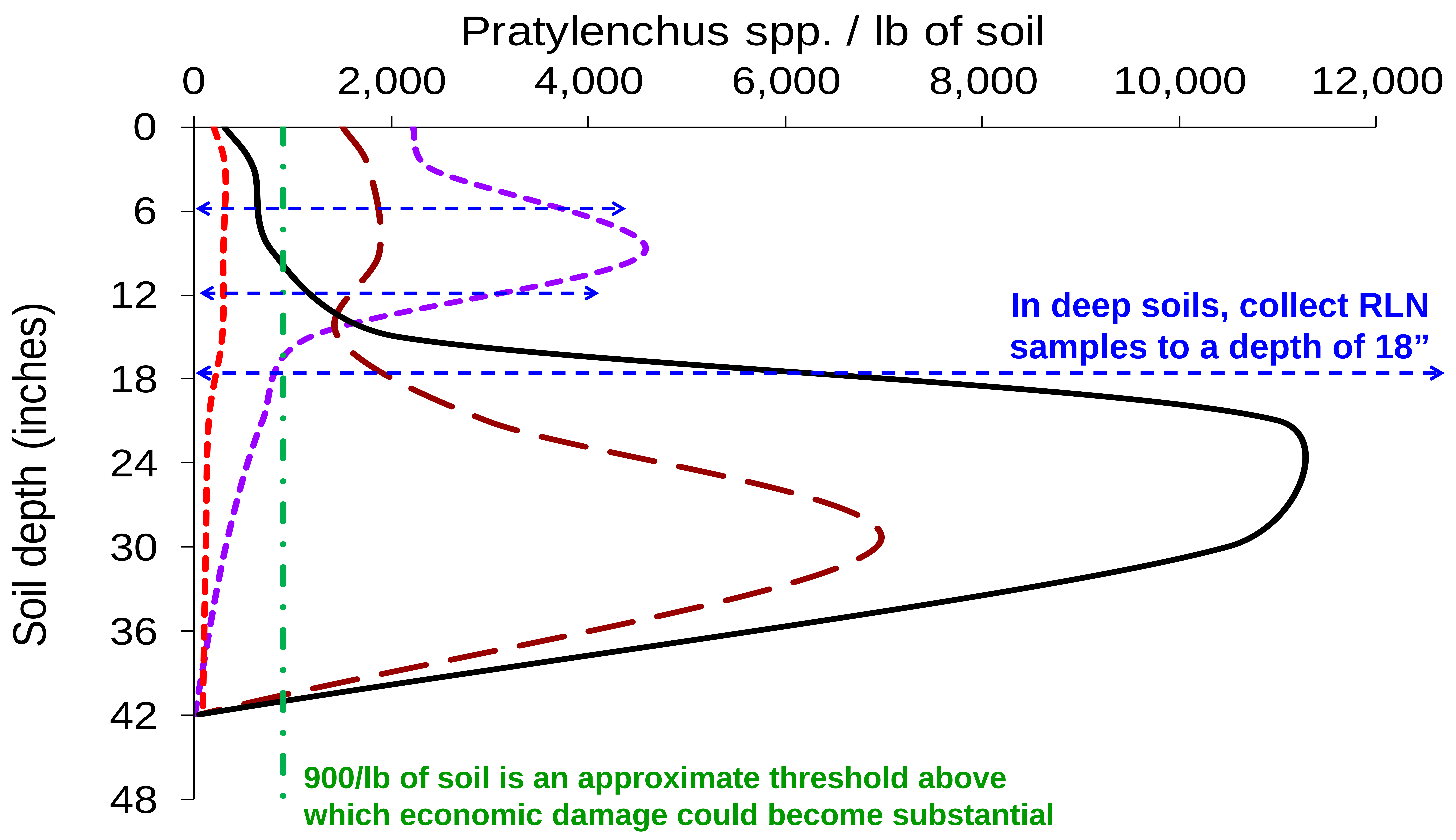
12 cores/ 110 ft^2 plot

total area = 0.1 acre

range = 0 - 9,418 nematodes/ lb of soil

average = 1,404 nematodes/ lb of soil

Vertical Distribution of Root-lesion Nematodes at 6” Depth Intervals



Root-lesion Nematodes vs Yield of SW in Oregon

Concepts of Resistance and Tolerance

Resistance: is the nematode's ability to multiply in roots

After harvest, how many nematodes will be left in soil to attack the next crop?

Tolerance: is the effect of nematode invasion & reproduction on grain yield

How will the yield of the current crop be affected?

Resistance and tolerance are genetically independent !

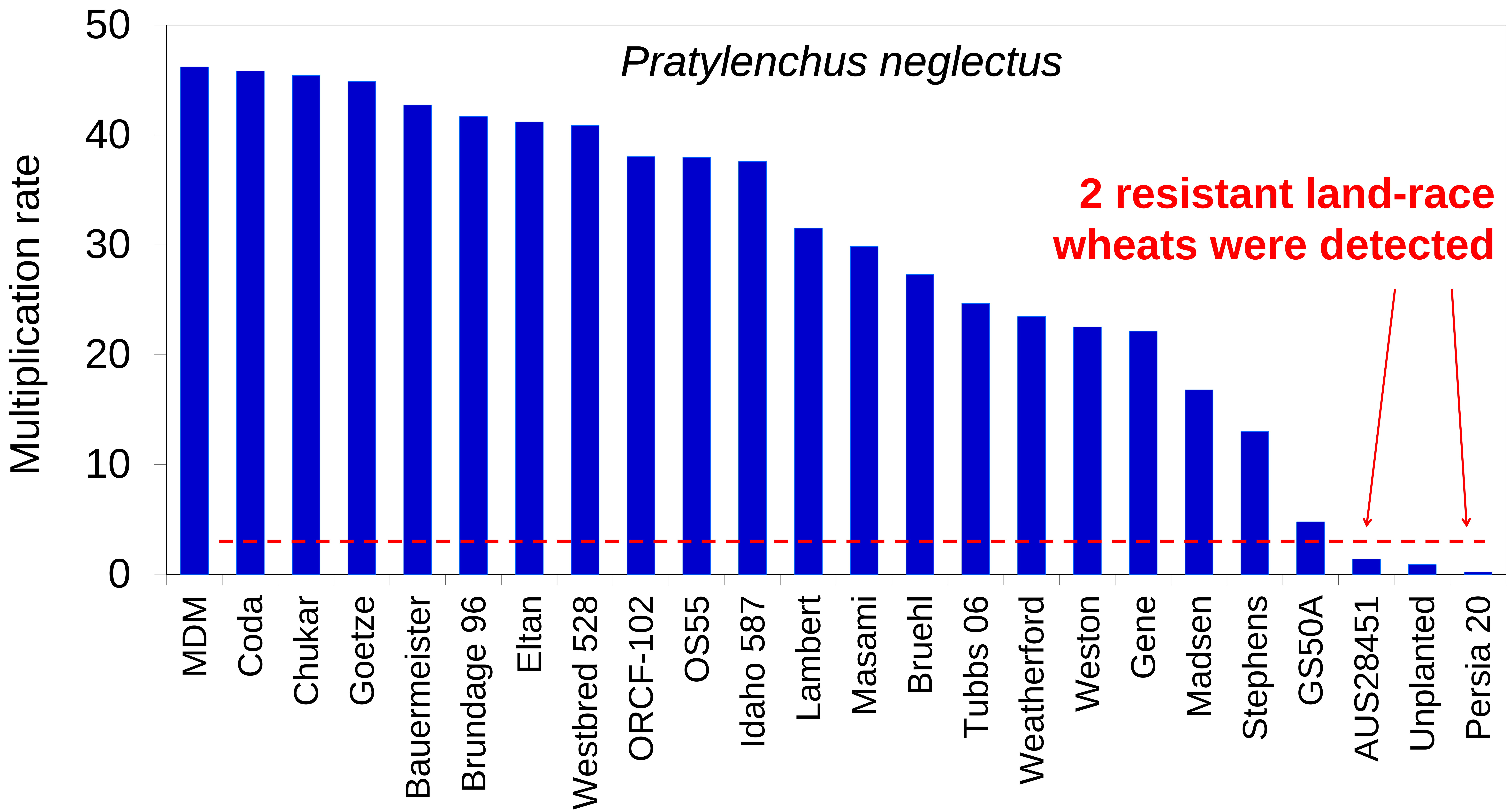
	susceptible	resistant
tolerant	**high reproduction** **minor yield loss**	**low reproduction** **minor yield loss**
intolerant	**high reproduction** **major yield loss**	**low reproduction** **major yield loss**

Spring Wheat Tolerance to *P. neglectus* at Heppner

data were averaged over 3 years; 2006–2008

Multiplication of Root-lesion Nematode in Winter Wheat

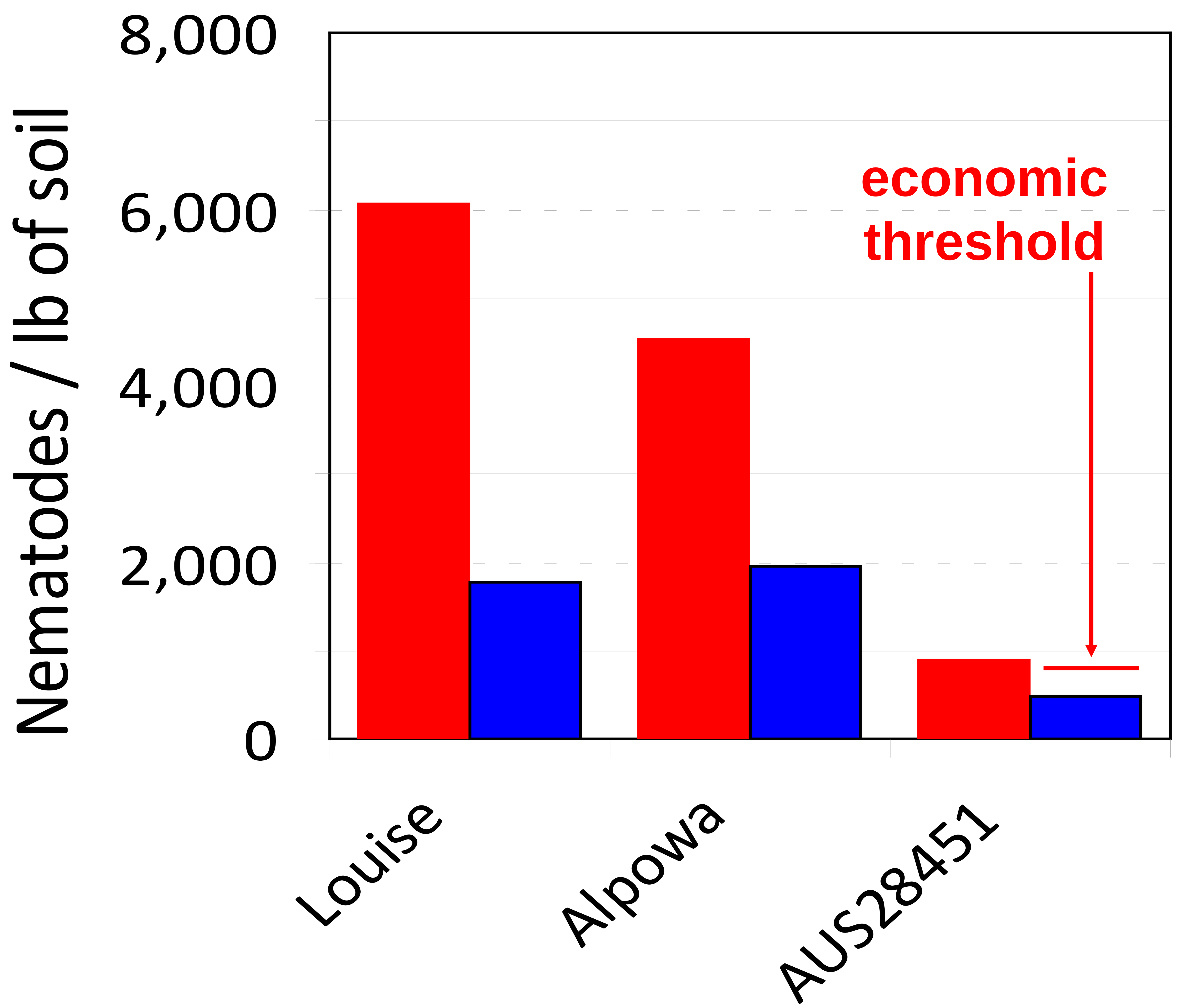
Multiplication rate (MR) = final ÷ initial population over the 16-wk test period
Resistance is defined as <5% of maximum MR in the test (the 'red line')

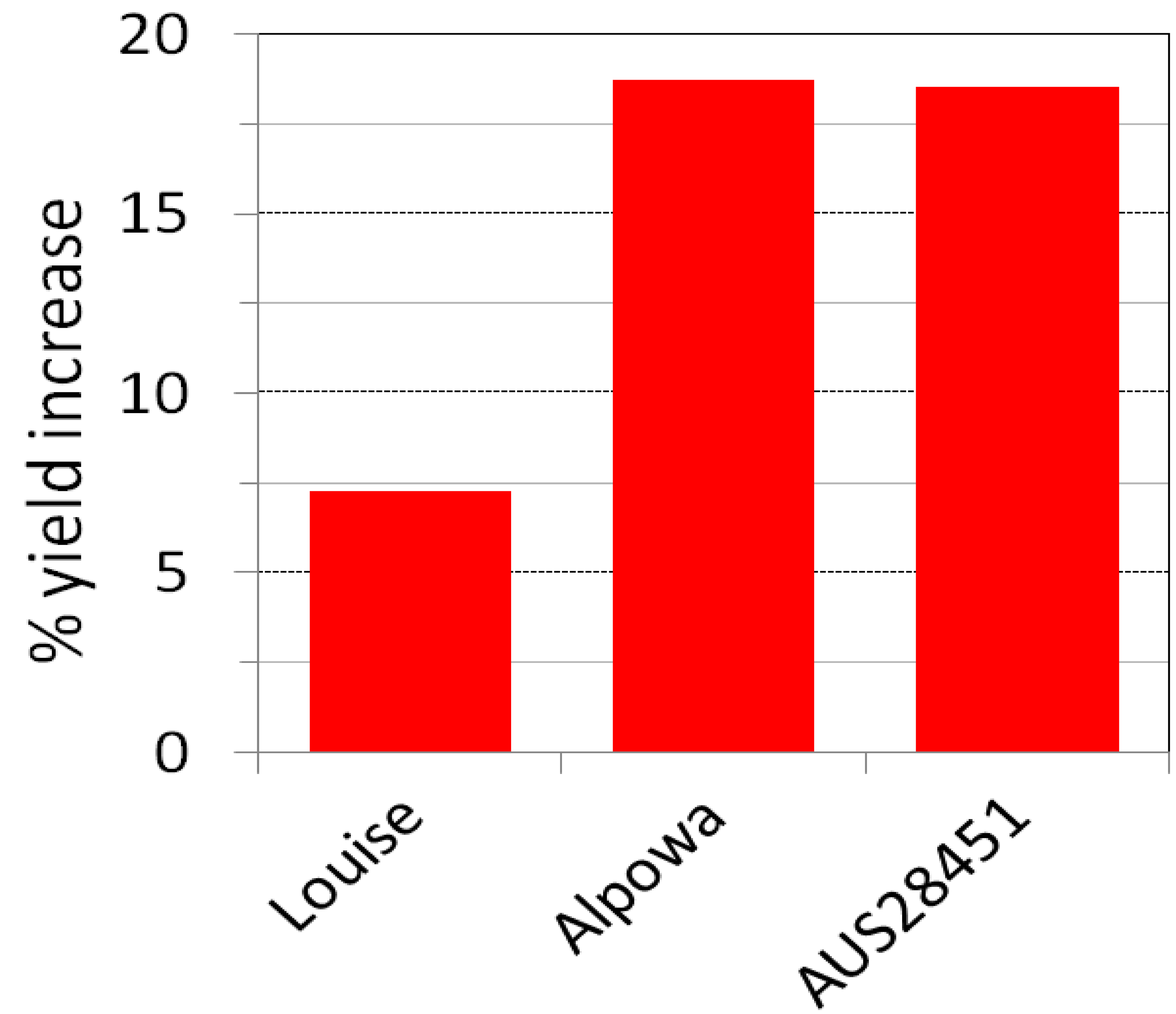


Multiplication of *P. neglectus* in Roots of Spring Wheat and Barley

RLN Density after Harvest & Yield Increase from Nematicide Application

(average of 4 site-yrs; 2 yrs at each of 2 locations; mixtures of *P. neglectus* and *P. thornei*)





red = untreated control: "What the farmer would experience"

blue = application of a non-registered nematicide for this research

**** RLN reduced profitability of wheat by >$8/acre in this experiment ****

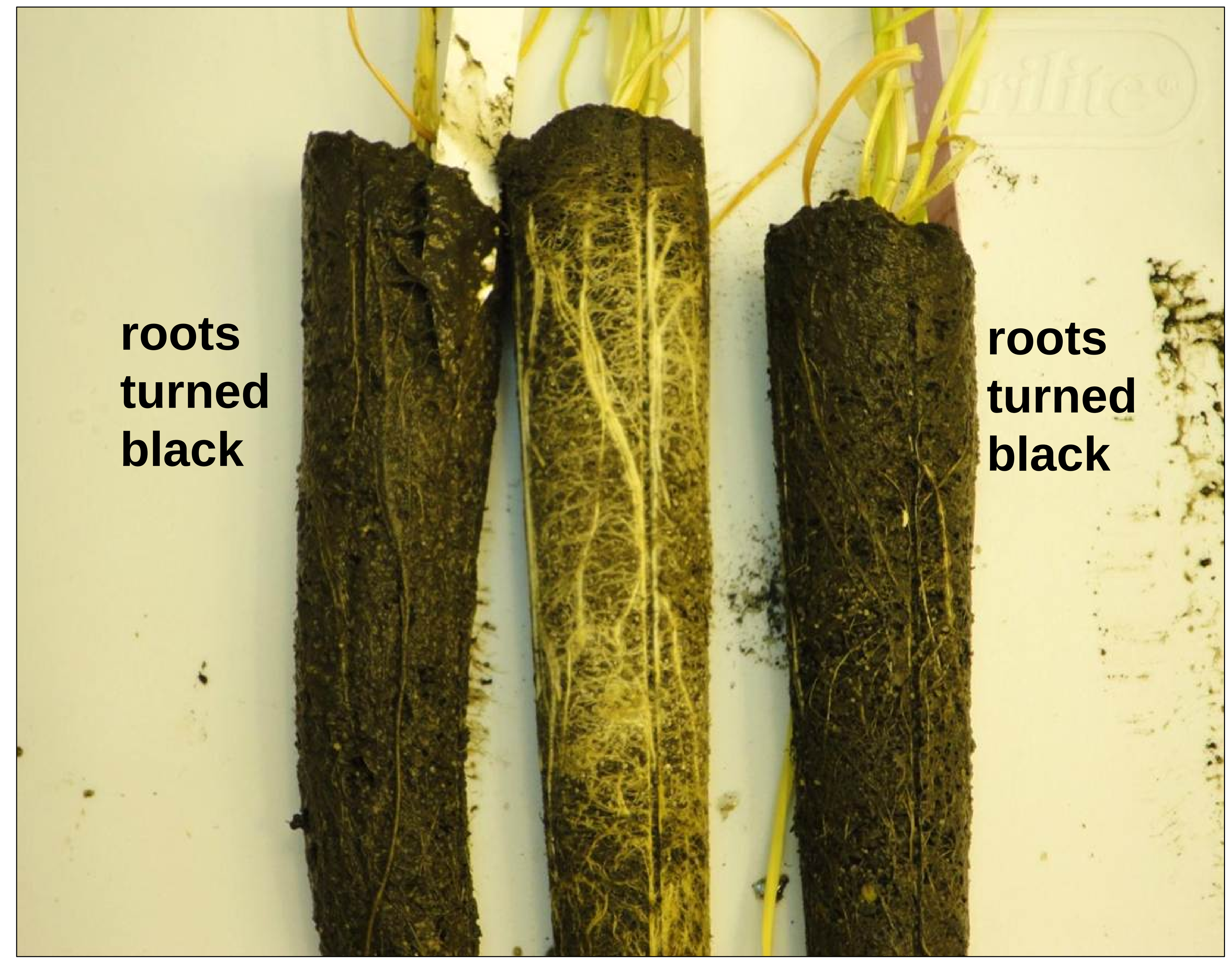
Density of Root-lesion Nematodes after Growing Alpowa and AUS28451 in Field Trials

(5 experiments at 2 locations over 3 years)

RLN/lb of soil following Alpowa & AUS28451				
	Mission		Pendleton	
Year	Alpowa	AUS	Alpowa	AUS
2011	1,754	253	955	nd
2012	16,143	1,397	3,086	542
2013	19,253	2,428	2,887	771

% reduction: AUS28451 vs Alpowa			
Year	Mission	Pendleton	Ave.
2011	-81%	nd	**-81%**
2012	-92%	-82%	**-87%**
2013	-87%	-73%	**-80%**
Ave.	**-87%**	**-78%**	**-83%**

Greenhouse test at WSU



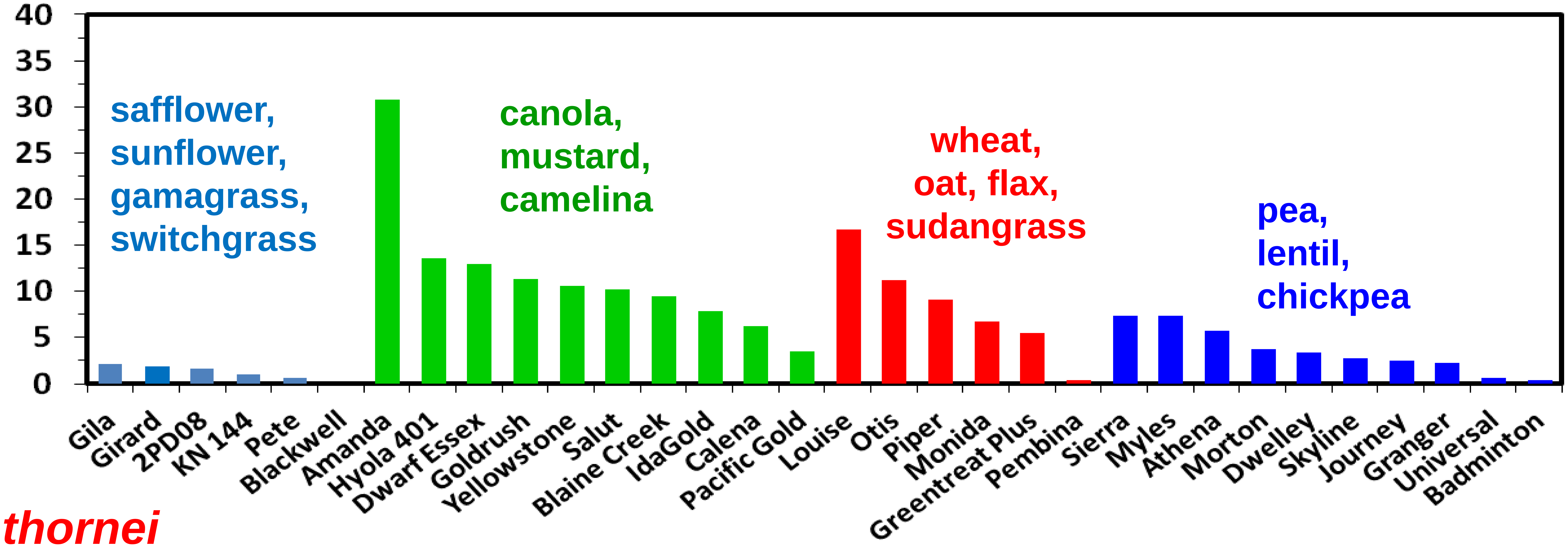
Alpowa **AUS 28451** **Louise**

- Crosses of AUS28451 with PNW-adapted varieties are being developed by WSU/USDA-ARS
- Genetic markers are being developed to allow breeders to identify resistant lines

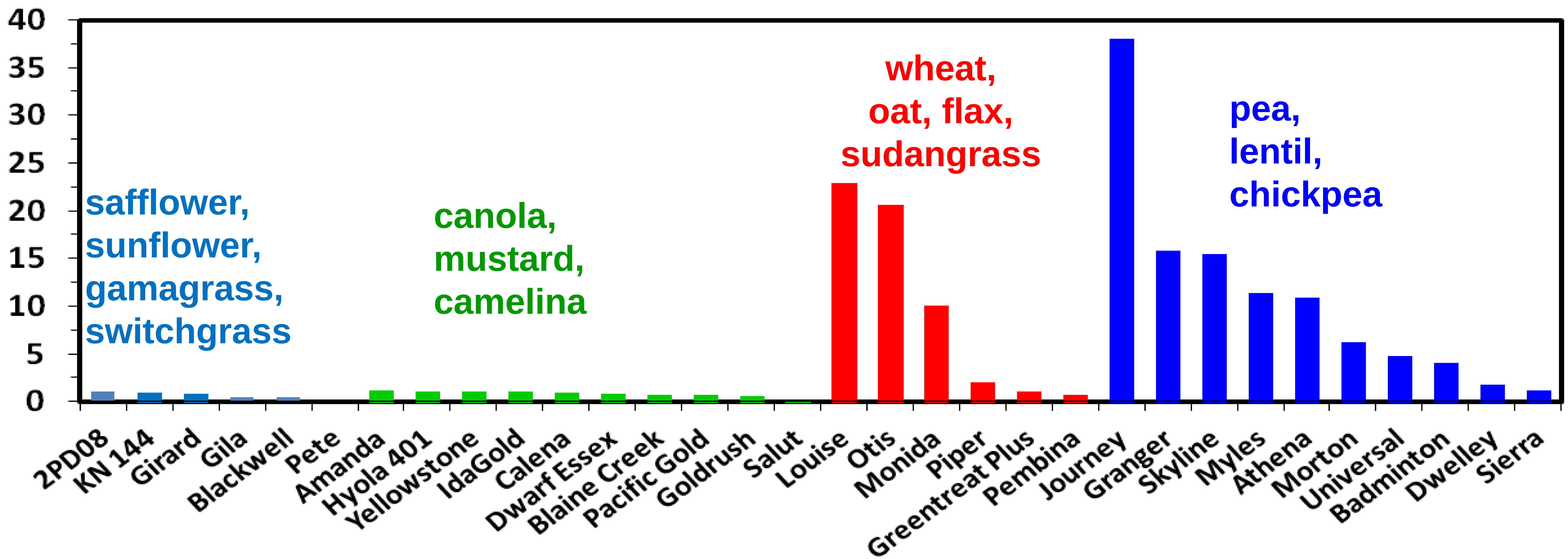
Crops as Hosts for Root-lesion Nematodes (2013)

(relative multiplication rate)

P. neglectus



P. thornei



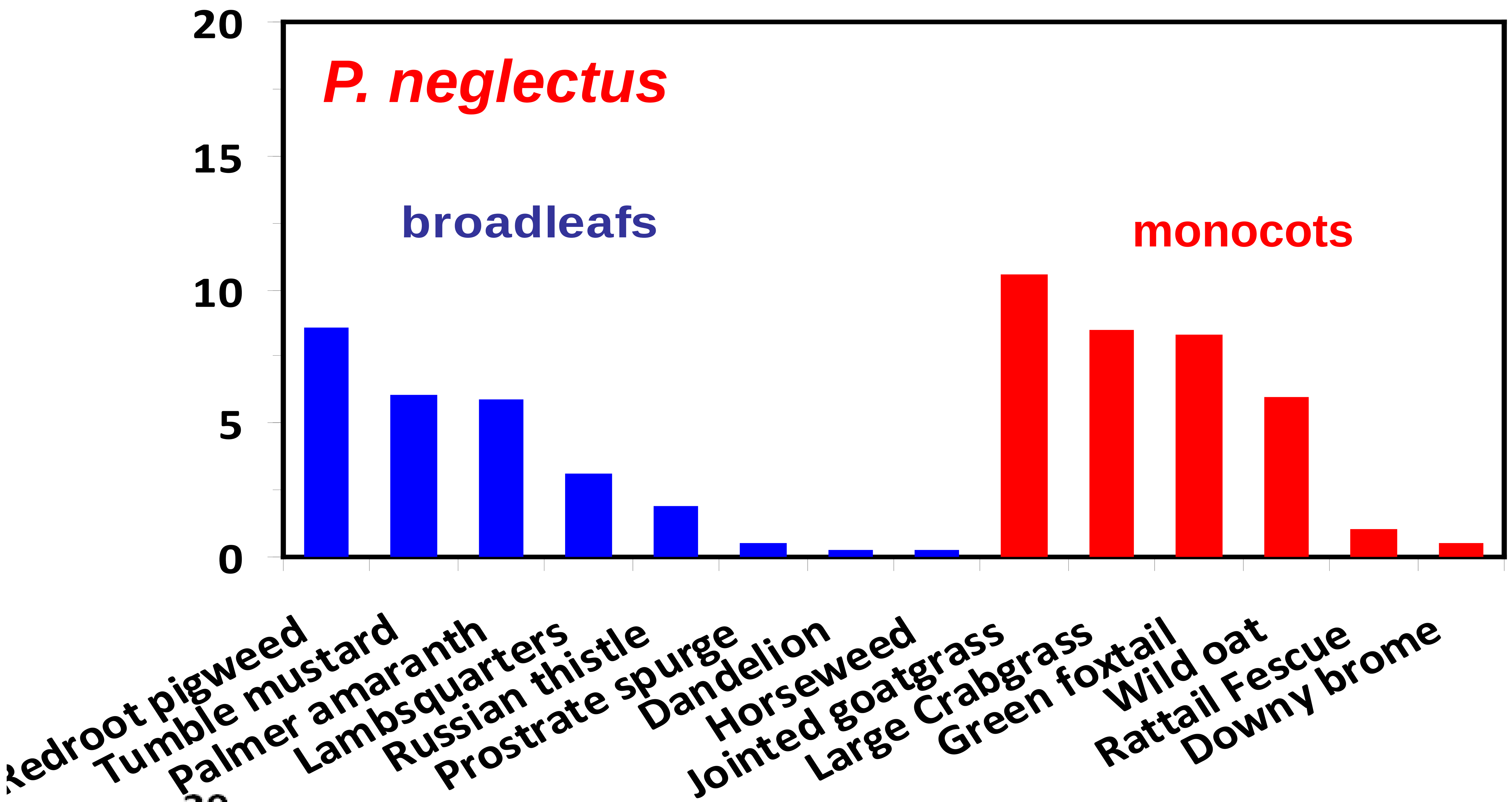
Crops as Hosts for *Pratylenchus* Species

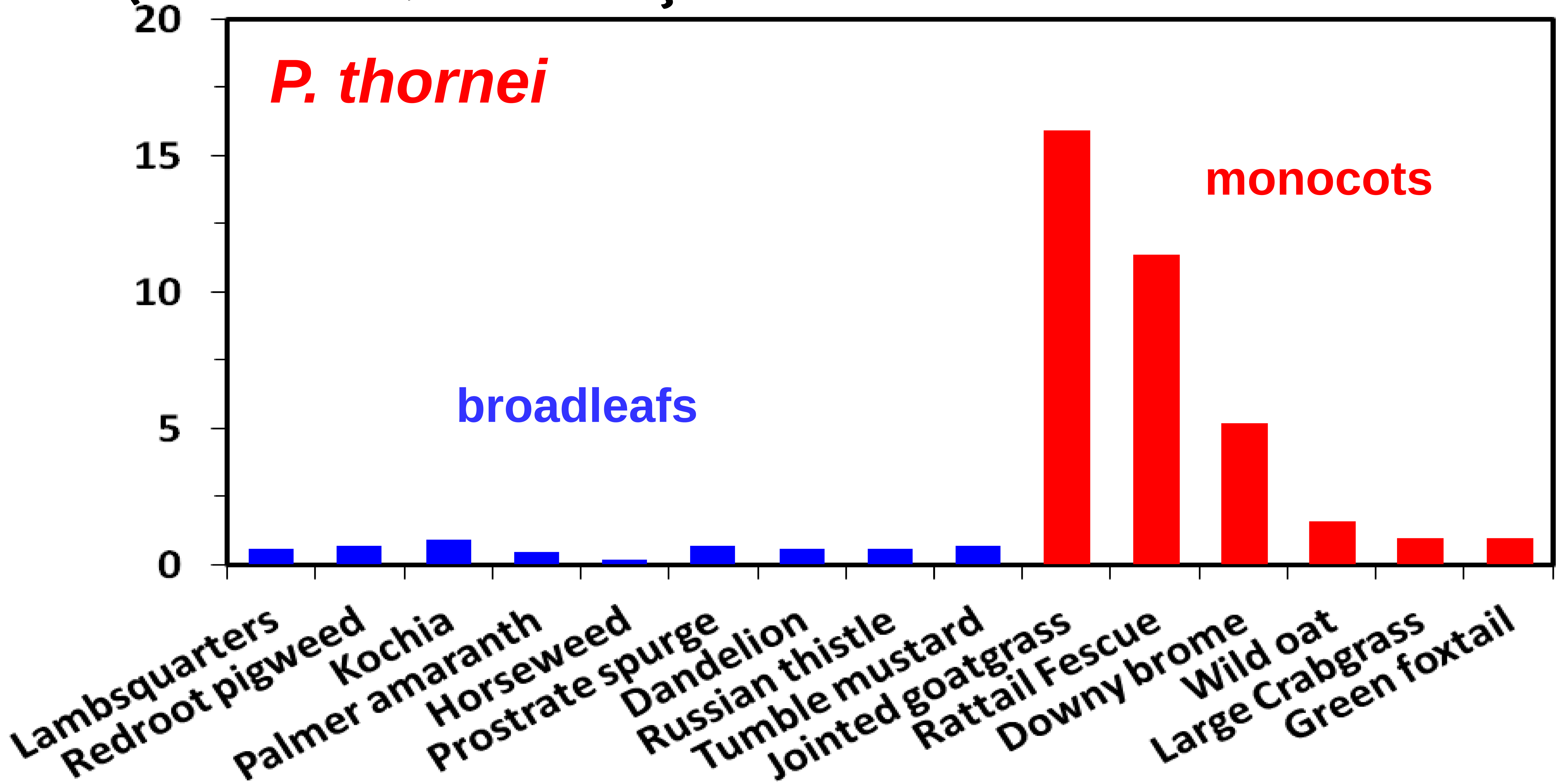
Hosting:	*P. neglectus*	*P. thornei*
Very good & good hosts	wheat, canola, camelina, yellow mustard, chickpea, oats	wheat, field pea, lentil, oats
Minor hosts	barley, brown mustard, lentil, yellow pea, field pea, alfalfa, vetch	barley, chickpea, yellow pea
Poor hosts & non-hosts	safflower, sunflower, switchgrass, flax	canola, camelina, flax, brown mustard, vetch, yellow mustard, alfalfa safflower, sunflower, switchgrass, sudangrass

Nematode species identification is essential to understand the potential impact of rotations and of individual crops and varieties on each species!

Weeds as Hosts for Root-lesion Nematodes (2013)

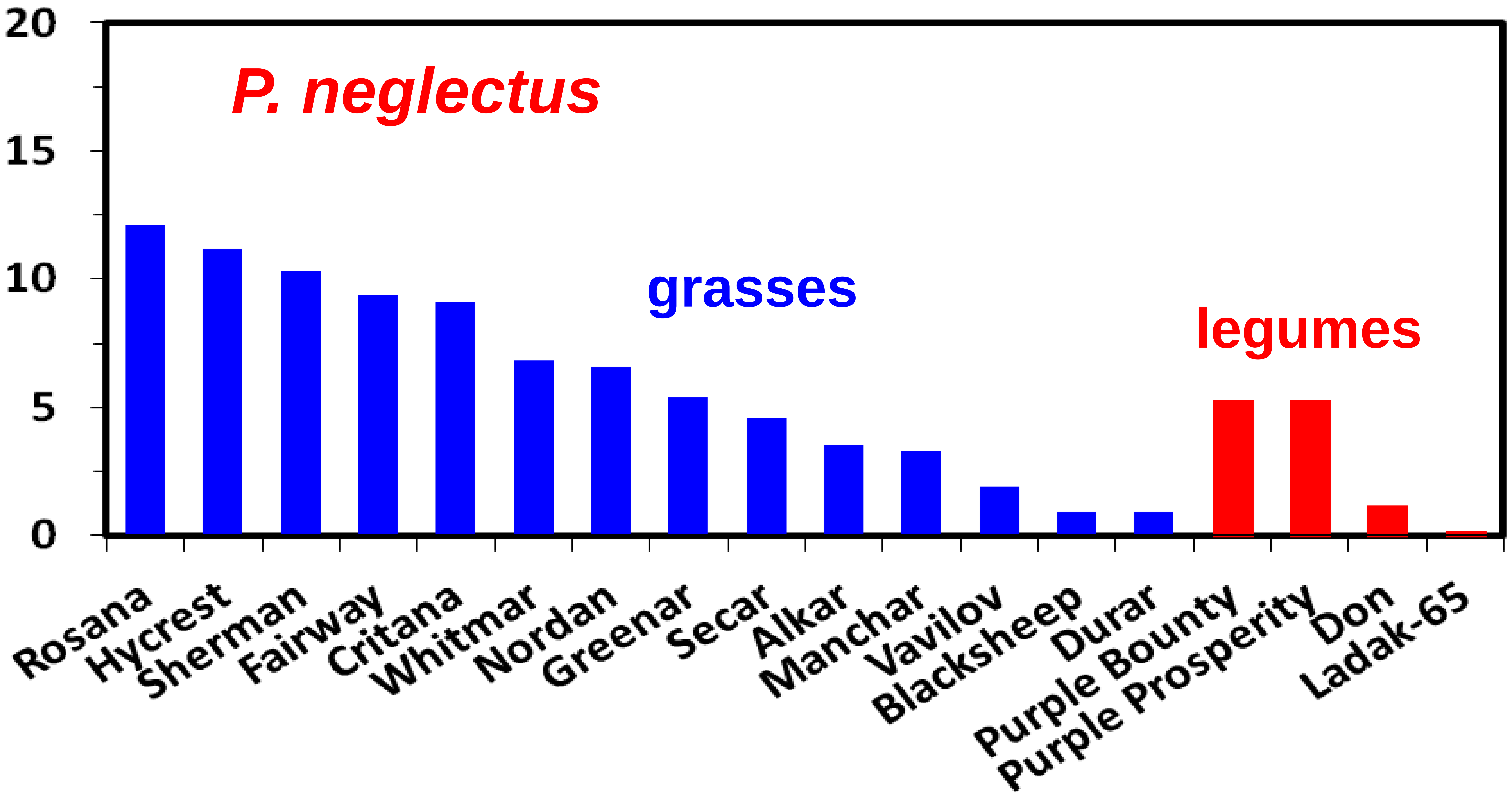
(relative multiplication rate)

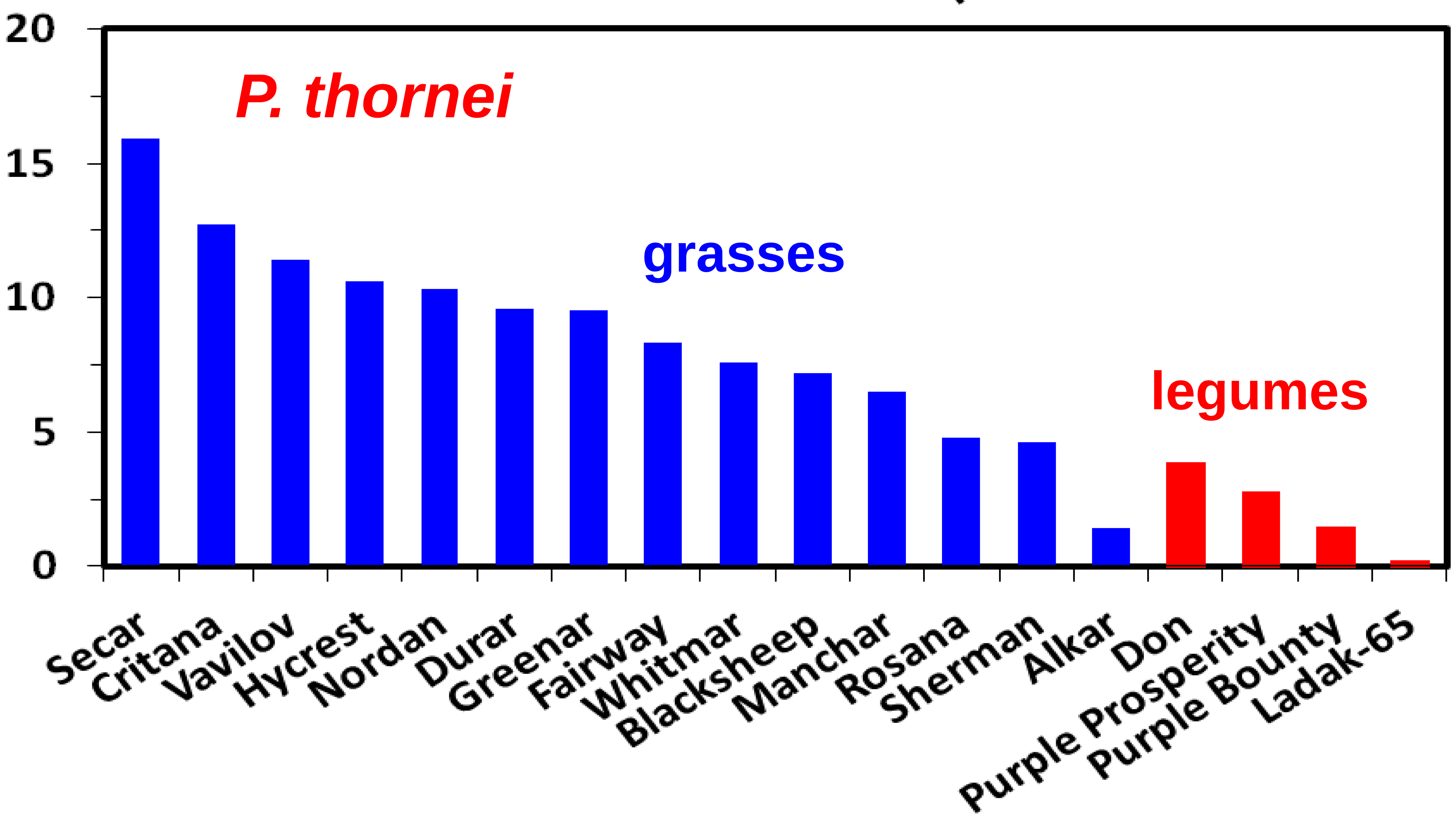




CRP (rangeland) Plants as Hosts for Root-lesion Nematodes (2013)

(relative multiplication rate)





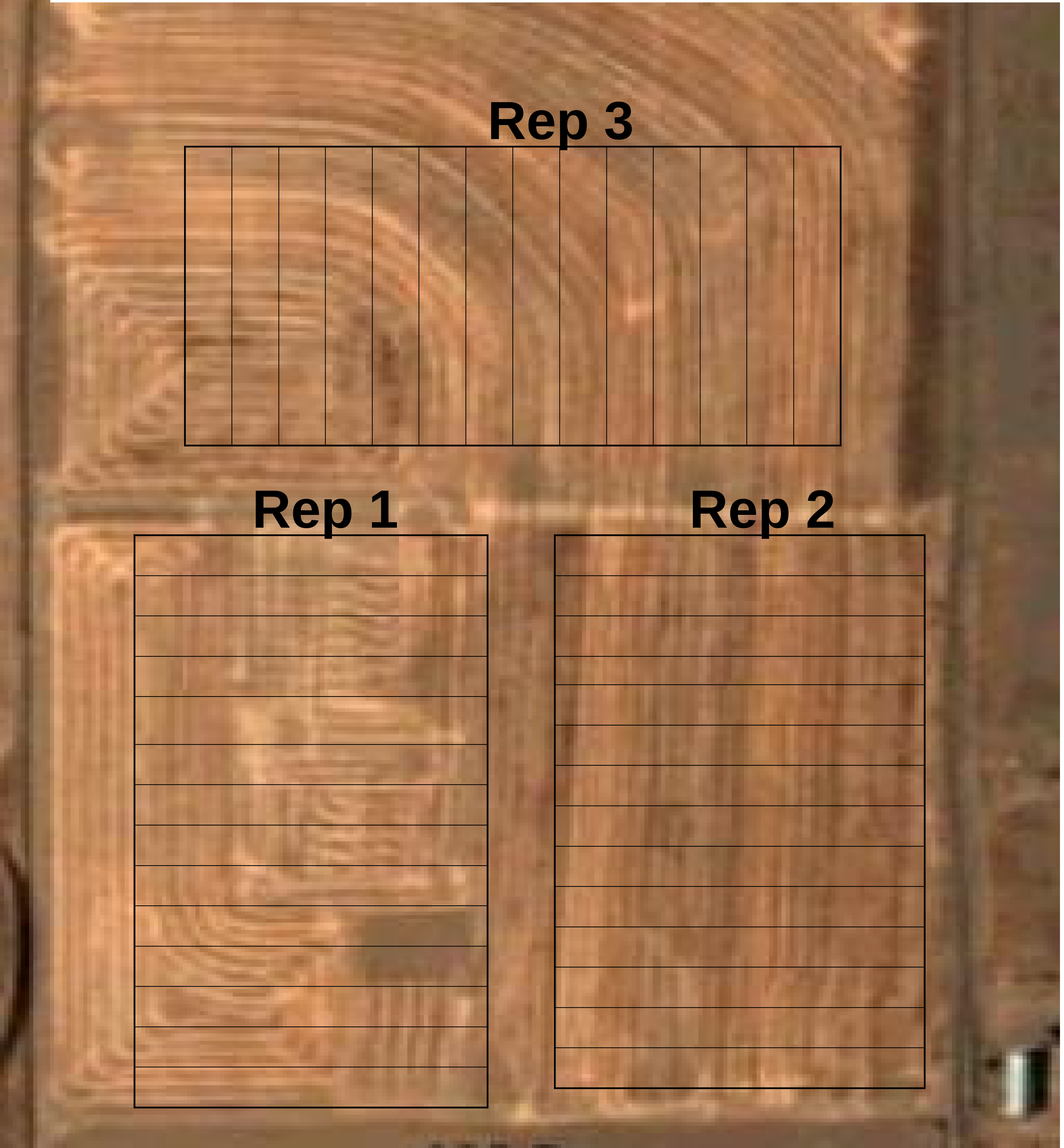
Range Plants & Weeds as Hosts for *Pratylenchus* Species

Hosting:	***P. neglectus***	***P. thornei***
Very good & good hosts	most range grasses, kochia, pigweed, palmer amaranth, jointed goatgrass, crabgrass, foxtail, wild oat	most range grasses, jointed goatgrass, rattail fescue
Minor hosts	alfalfa, hairy vetch, lambsquarters	downy brome
Poor hosts & non-hosts	russian thistle, rattail fescue, prostrate spurge, dandelion, horseweed, downy brome	alfalfa, hairy vetch, kochia, pigweed, russian thistle, dandelion, palmer amaranth, crabgrass, lambsquarters, foxtail, wild oat, prostrate spurge, horseweed

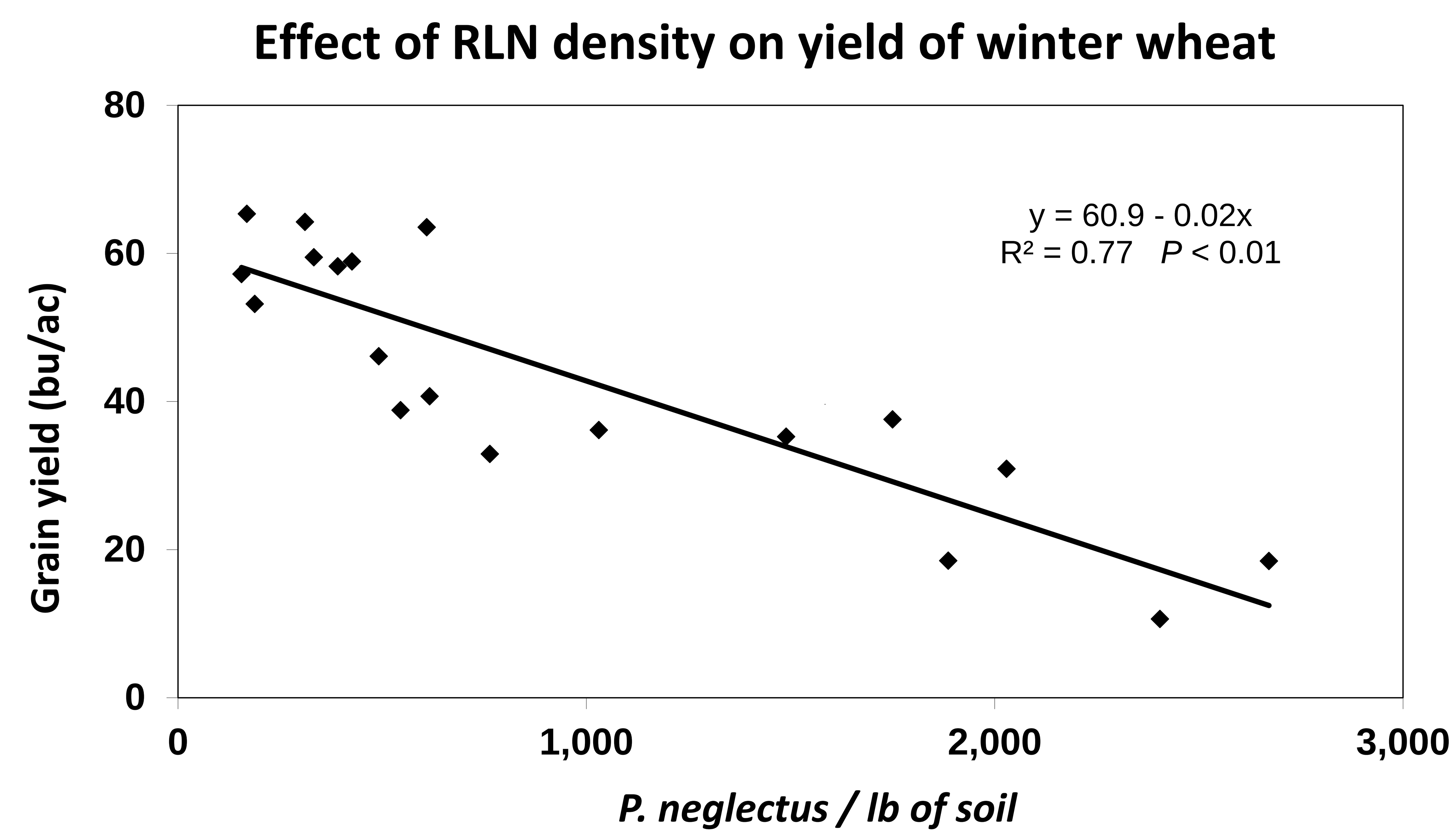
nematode species identification is essential for understanding the potential impact of rotations and of individual varieties on each species!

Long-Term Cropping Systems Experiment at Moro, OR

14 treatments, 3 reps, 4 years, 48 x 350 ft plots



Annual winter wheat	NT
Annual spring wheat	NT
Annual spring barley	NT
WW / cultivated fallow	tilled
WW / chemical fallow	NT
WW / winter pea	NT
WW / SB / chem fallow	NT
Flex-crop sequences	NT



Root-lesion Nematode Density in a Long-term Experiment at Moro

(averaged over 8 years; sampling was after the crop or management shown in bold)

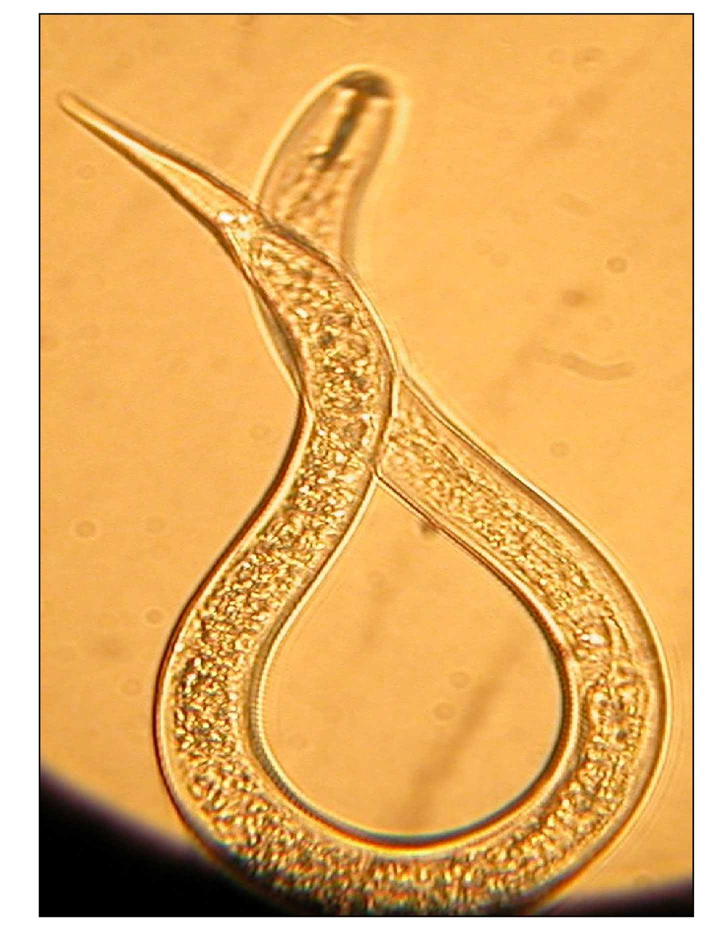
Cropping system	Nematodes/lb of soil
Annual no-till crops:	
winter wheat	1,259
spring wheat	1,146
spring barley	171
Comparison of fallow systems:	
winter wheat/cultivated fallow	2,084
winter wheat/***cultivated fallow***	892
winter wheat/chemical fallow	1,440
winter wheat /***chemical fallow***	702
Winter wheat-winter pea no-till rotation:	
winter wheat/winter pea	893
winter wheat/***winter pea***	1,031
3-year no-till rotation:	
winter wheat/spring barley/chemical fallow	567
winter wheat/***spring barley***/chemical fallow	355
winter wheat/spring barley/***chemical fallow***	30

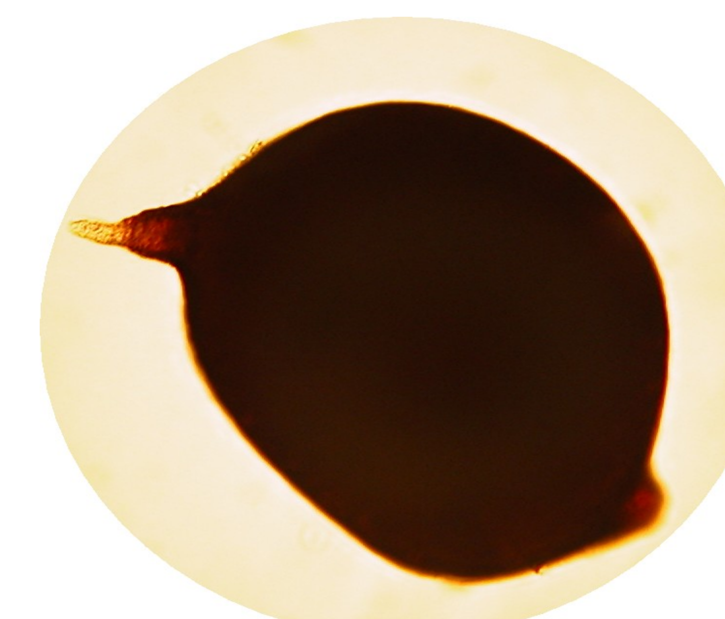
Cereal Cyst Nematodes (CCN)

Heterodera avenae

and

Heterodera filipjevi



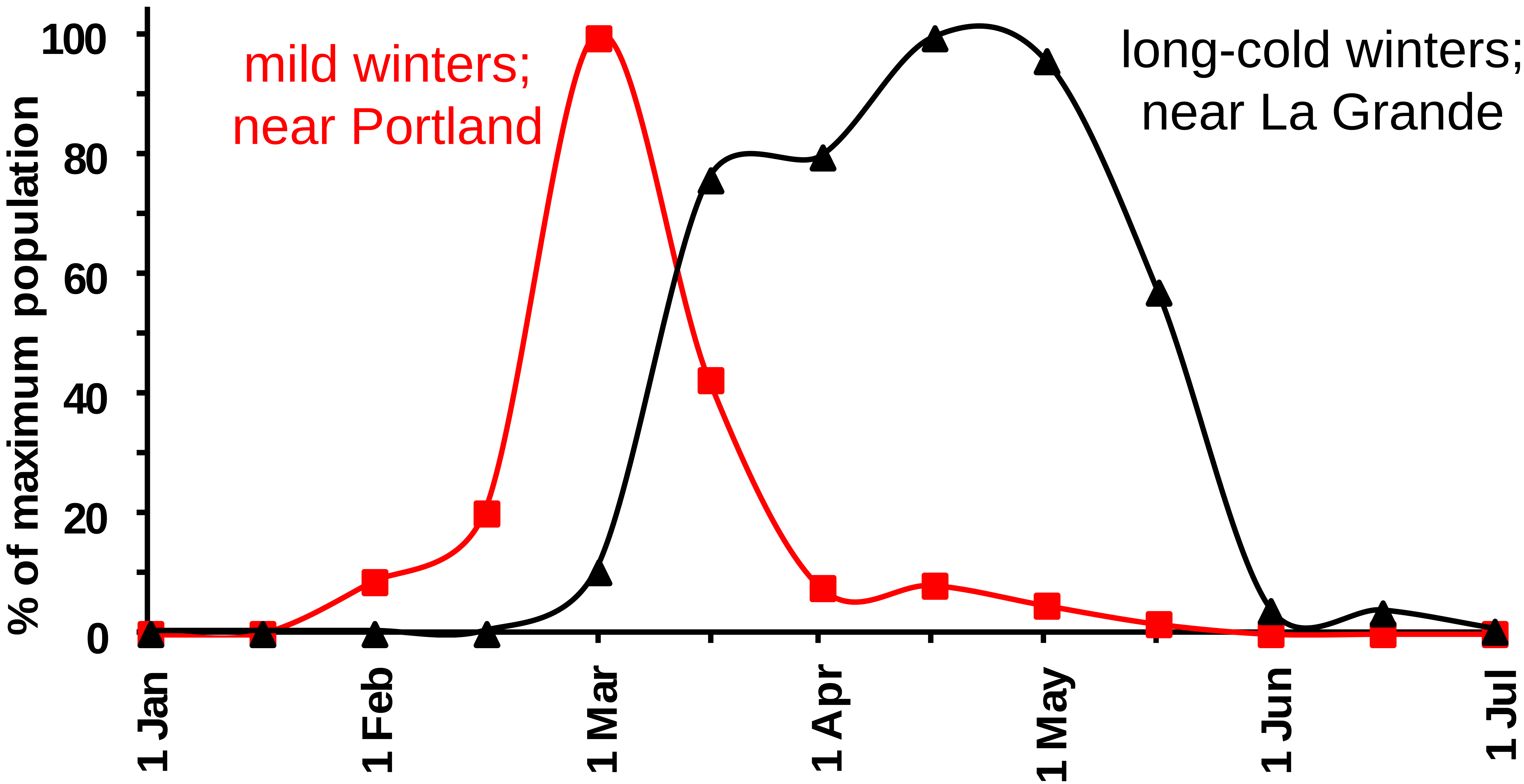


Known distribution of cereal cyst nematode in the western USA

it is almost certain that many other regions are also infested but have not yet been discovered

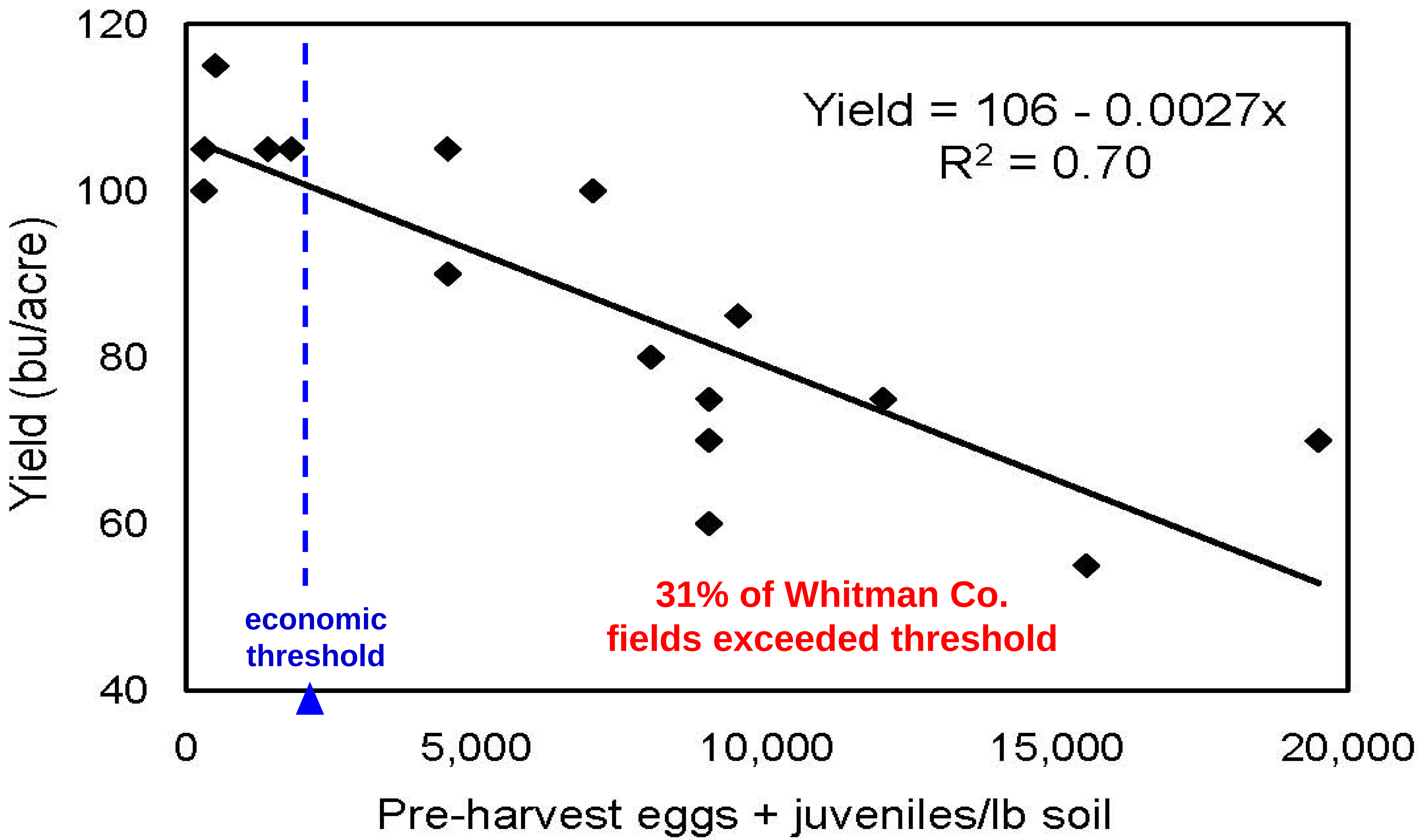

Cereal cyst nematode
Heterodera avenae
(1-year life cycle)
1. In spring, 2nd stage juveniles emerge from brown cysts & migrate through soil; some are released each year, over several years
feeding stylet
2. Stylet thrusts outward; injuring root cells & injecting toxins
3. Inflated 3rd stage female becomes embedded in roots of small seedlings
4. Roots become knotted & shallow, restricting uptake of water & nutrients
5. Swollen 4th stage females embedded in roots
6. Egg-filled swollen white female (≈1/32" diam.) at time of crop anthesis
7. At crop maturity, brown cysts are released into the soil
8. Hundreds of eggs & juveniles are released when a brown cyst is ruptured

Peak populations of *H. avenae* invasive juveniles present in soil at two Oregon locations with diverse climates



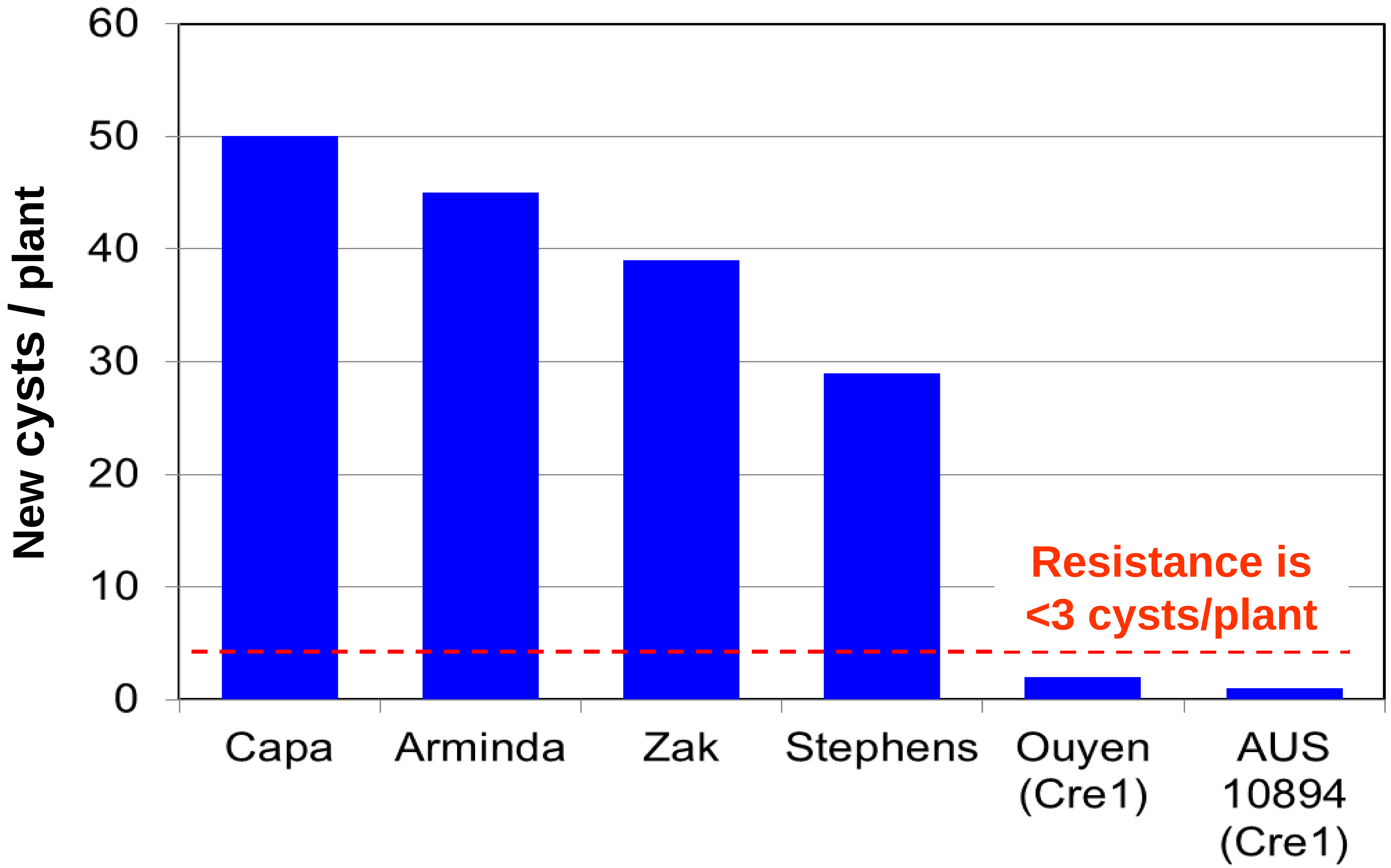
the timing of the peak population of invasive juveniles in soil coincides with the dominant production practice and spring-time temperature in each area

Cereal Cyst Nematode vs Yield of Irrigated WW in Oregon



Resistance of wheat to *Heterodera avenae* in Greenhouse Trials

Smiley et al. (2011) Nematology 13:539-552



- results from testing Idaho, Oregon & Washington soils
- Ouyen is an improved variety in Australia
- AUS10894 is an un-adapted landrace wheat

Resistance and Tolerance to *Heterodera avenae* in Spring Wheat at Cashup - 2012

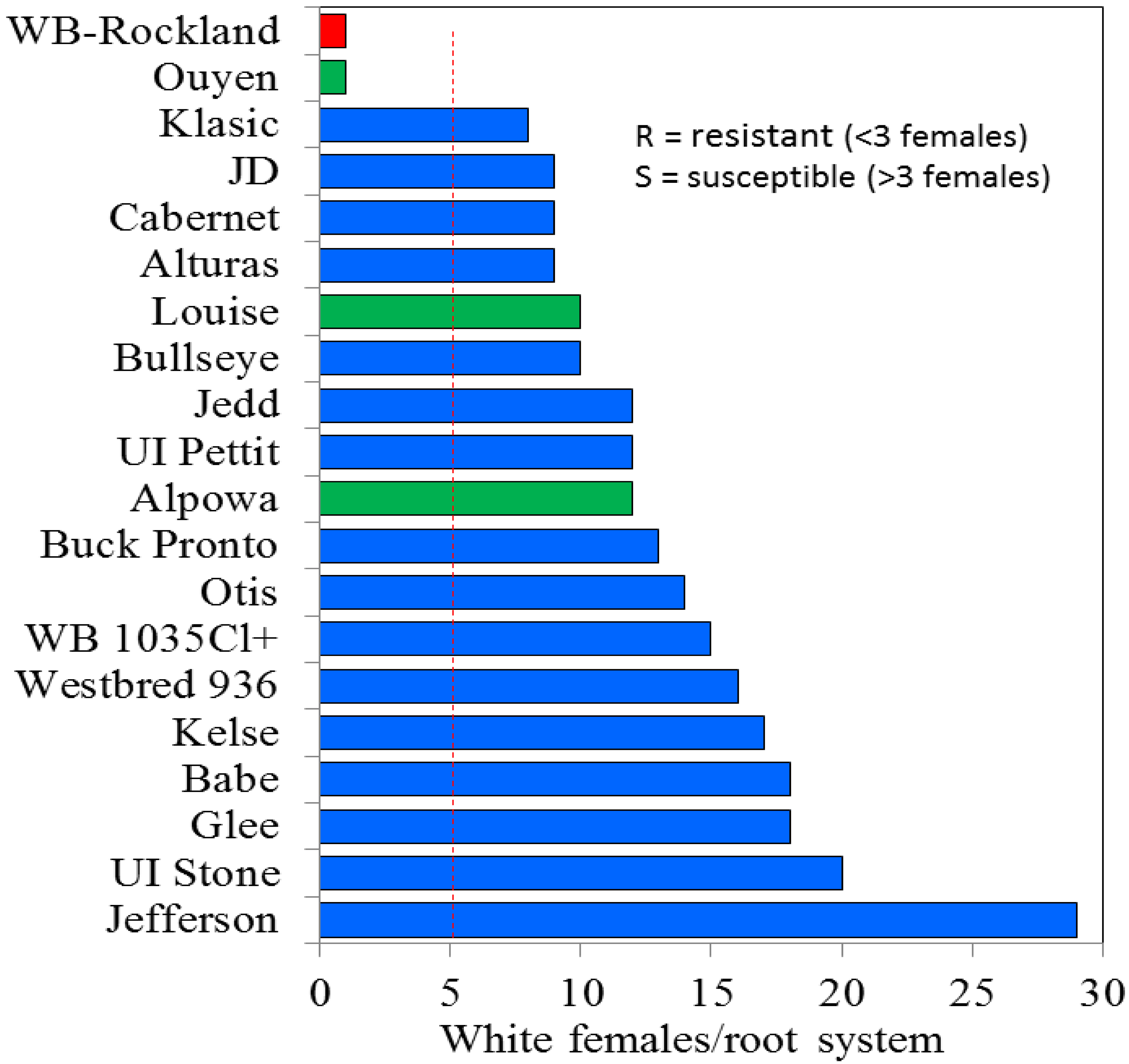
- paired drill passes ± Temik
- change varieties every 30 feet
- count white females on roots (R)
- rate severity of damage to roots (R)
- count eggs/lb of soil after harvest (R)
- compare yield and test weight (T)





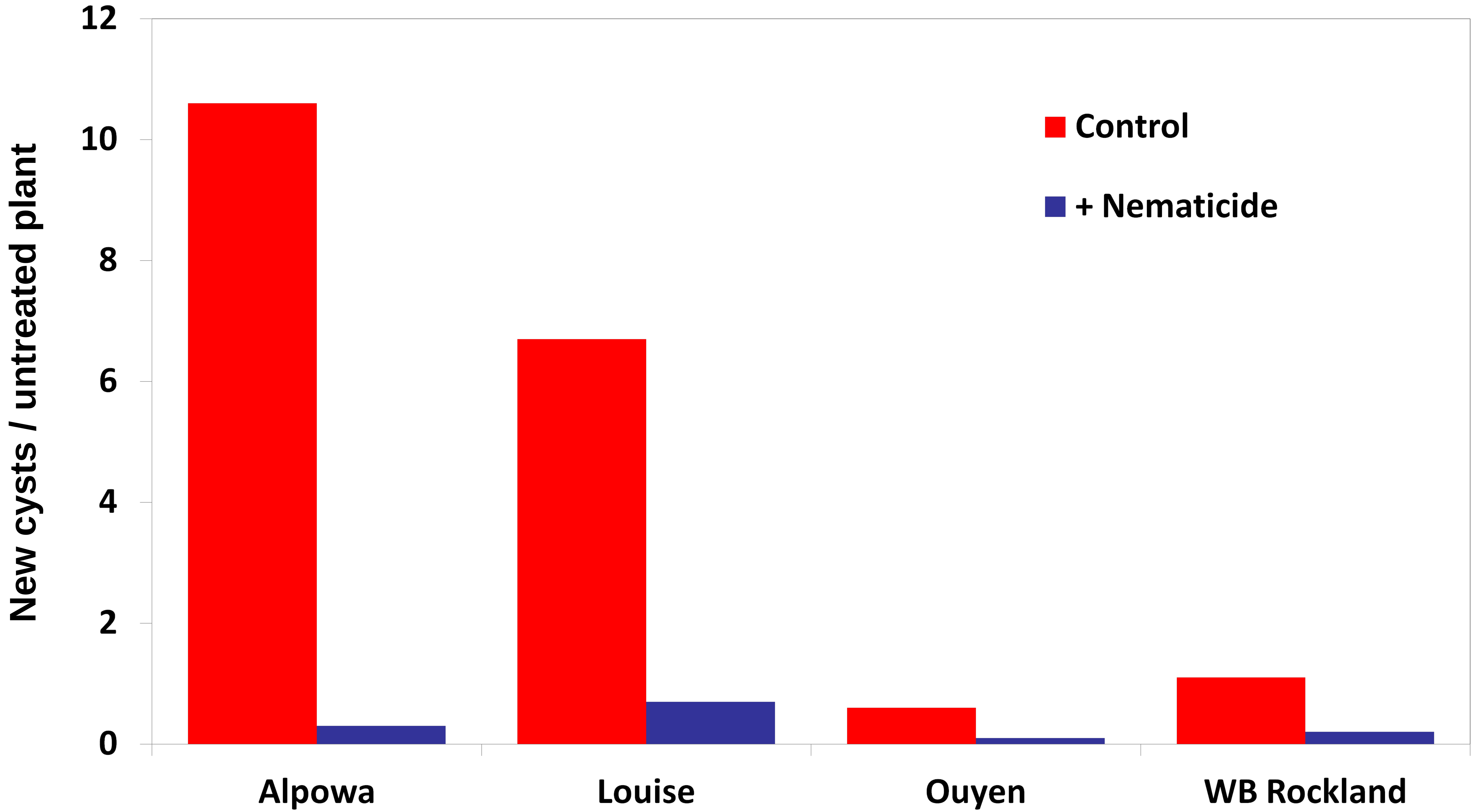
Spring Wheat Resistance to CCN

averaged over 2 locations in 2012: St. Anthony, ID & Cashup, WA



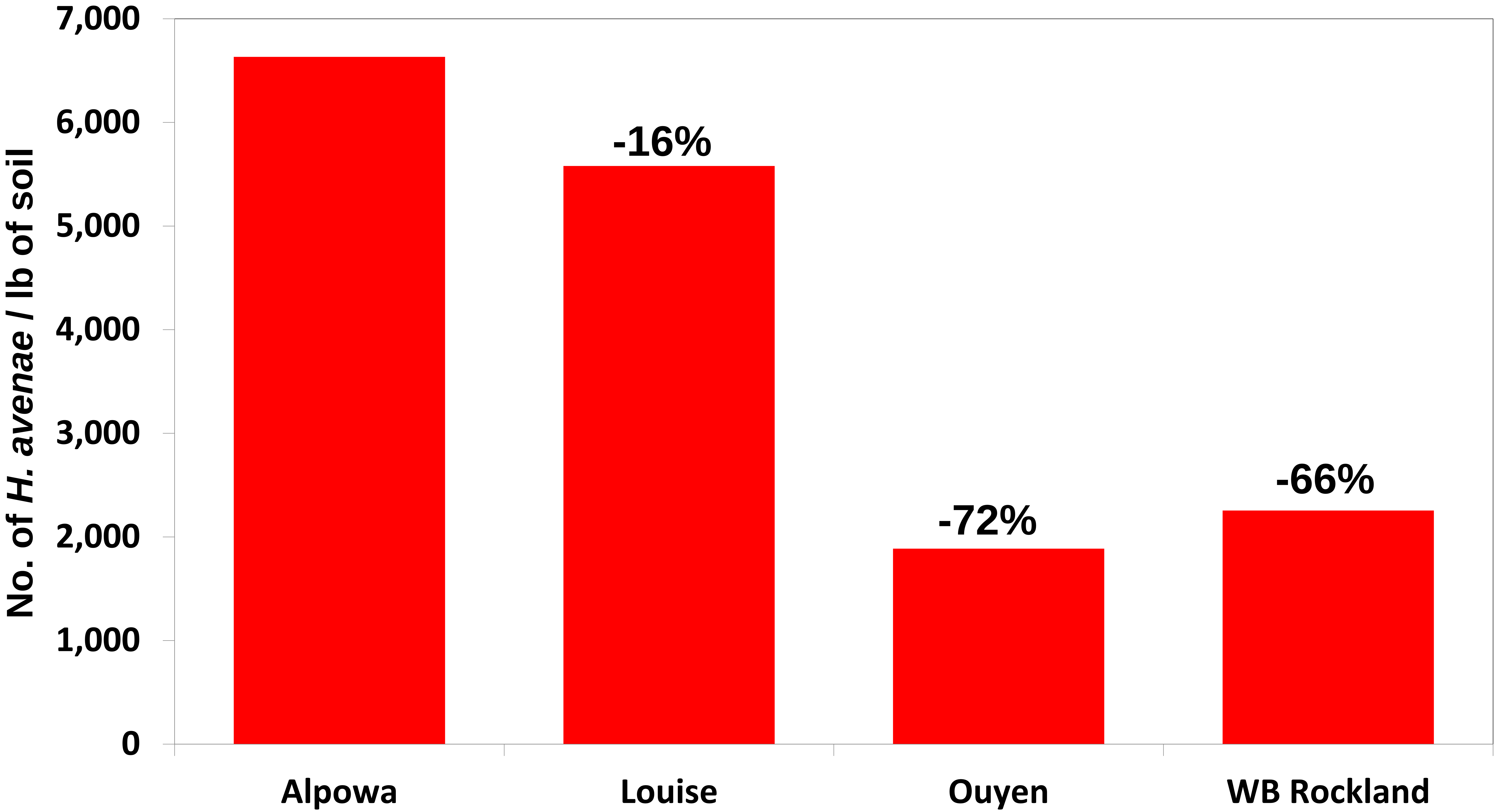
Reproduction of *H. avenae* on Susc. & Res. Wheat in the Field

averaged over 2 sites in 2012: St. Anthony, ID & Cashup, WA

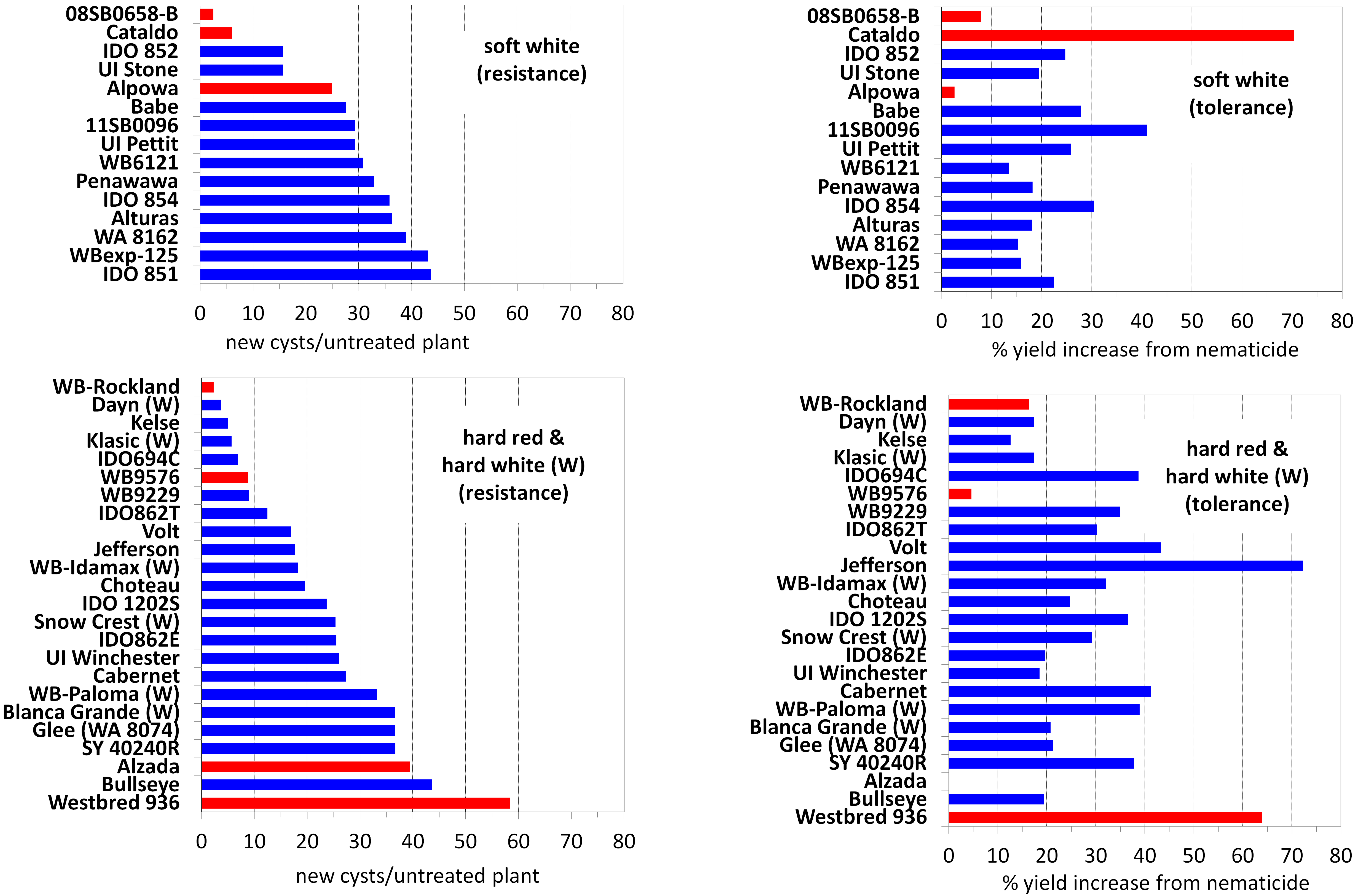


Density of *H. avenae* after Harvesting Susceptible or Resistant Wheat

2012 - St. Anthony, ID



Resistance & Tolerance of 39 Wheats to *H. avenae* at St. Anthony, ID in 2013



Resistance of 46 Malting & Feed Barleys to *H. avenae* at St. Anthony, ID in 2013

(6 = 6-row; all others are 2-row)

Nematode Management

1. Field sanitation

- avoid spreading the nematodes (in soil or on plant roots)
- control weeds & volunteers (don’t let nematodes keep multiplying)

2. Crop rotation

- fallow reduces nematode density (tillage intensity isn’t important)
- 2-yr rotation is not adequate if wheat is planted in alternate years

- **Root-lesion nematode:**
  - broad host range (good rotation crops are barley, flax, safflower, triticale or spring pea)
  - 3-yr rotations greatly reduce nematode density (WW-SB-fallow)
- **Cereal cyst nematode:**
  - only multiplies on wheat, barley & oat (good rotation crops include any broadleaf species)
  - controlled by 3-yr rotations if host crop occurs only once

Nematode Management

3. Crop nutrition

- in addition to the normal fertilizer application, place a starter fertilizer below or near the seed to enhance seedling vigor

4. Water supply

- if available, apply supplemental irrigation to reduce plant stress

5. Genetic resistance

- resistance has been identified and is available in some instances

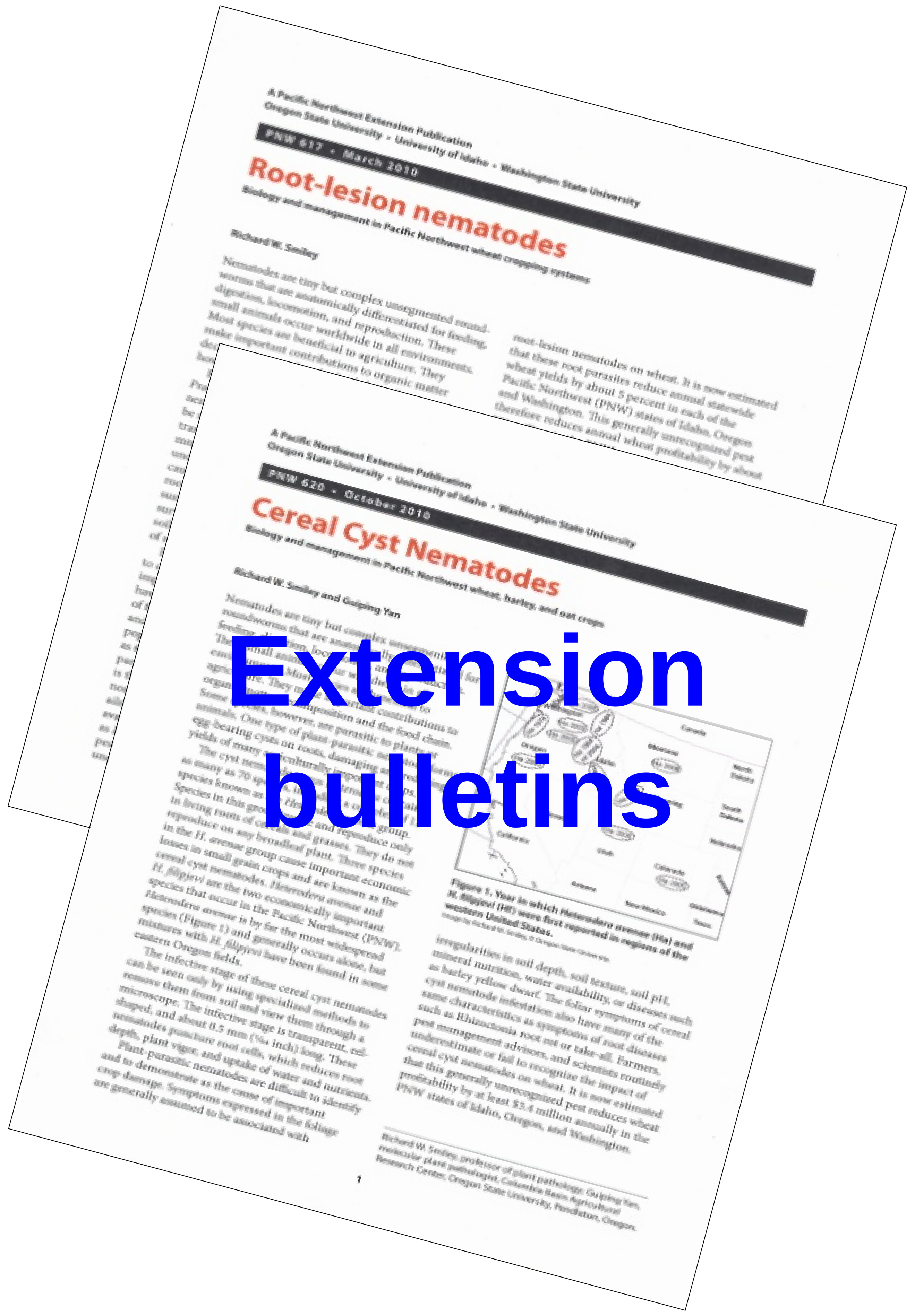
6. Genetic tolerance

- Root-lesion nematode: variety guidelines are available
- Cereal cyst nematode: guidelines are being determined

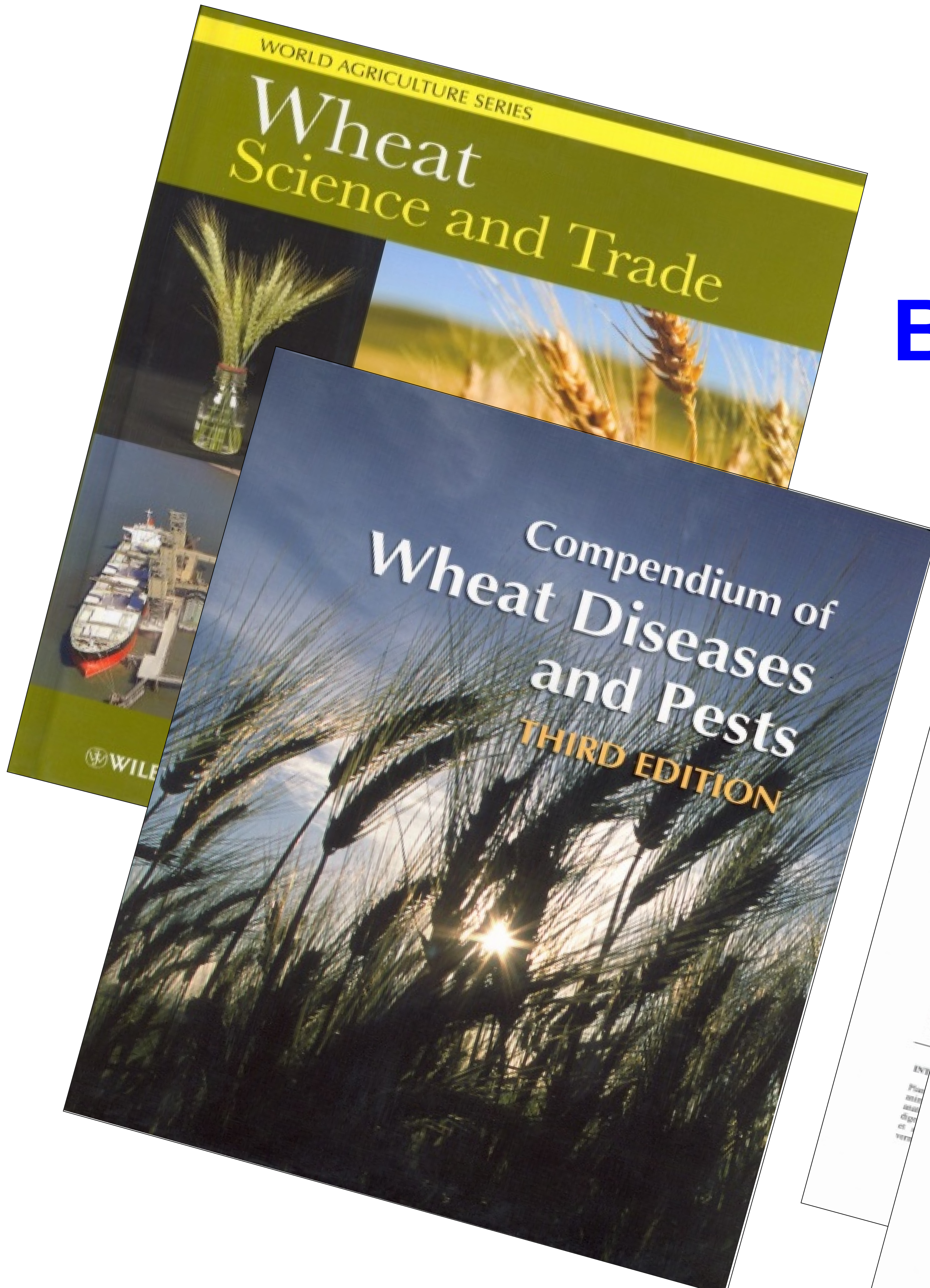
7. Chemical & biological control

- none have been shown to be effective in dryland situations
- fumigant nematicides and bio-fumigant crops are effective when applied before planting high-value irrigated crops

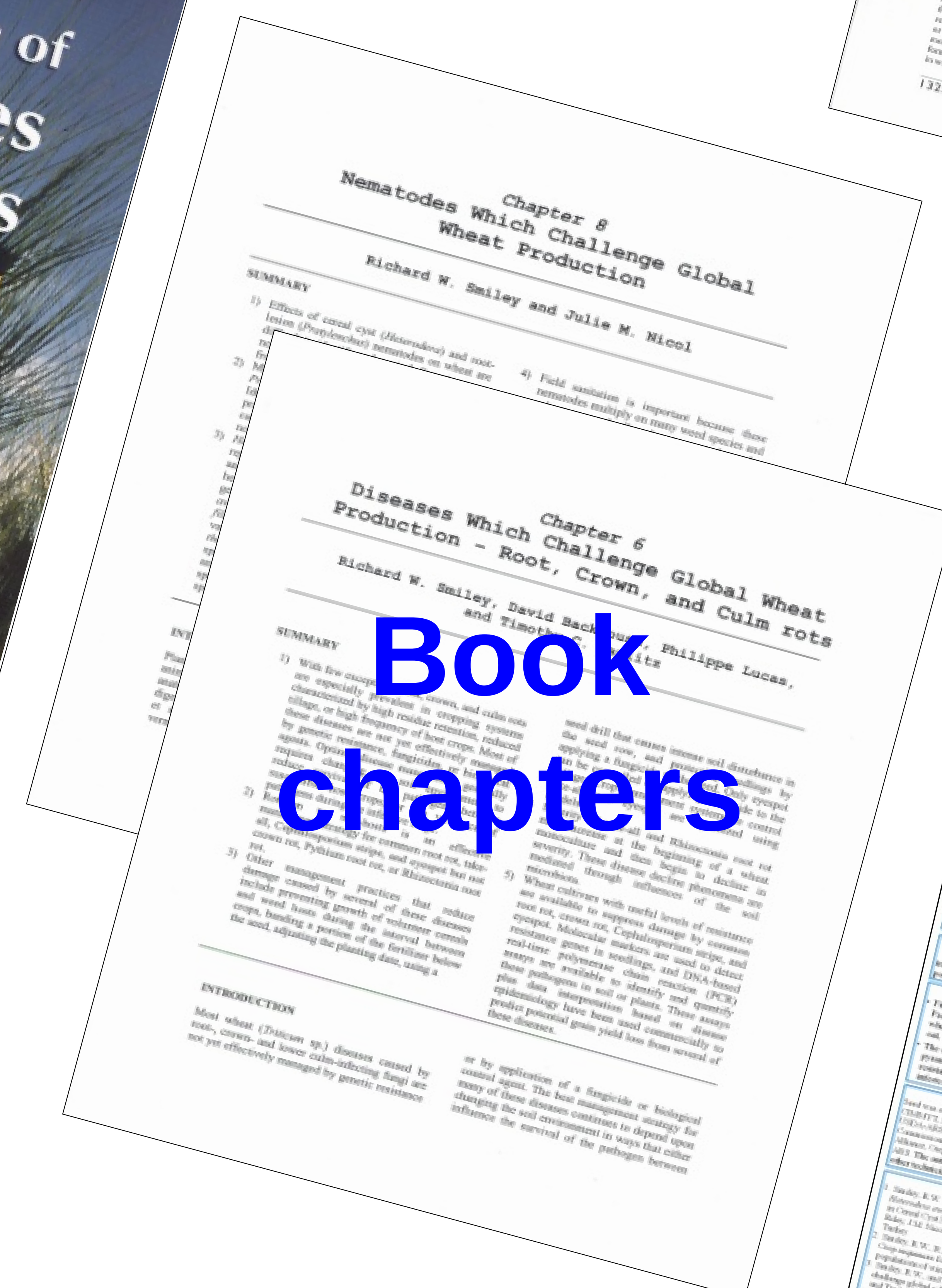
Would You Like More Information?



Extension bulletins



Books



Book chapters

Research papers

Conference posters

<u>Contact me</u>:

richard.smiley@oregonstate.edu

http://cbarc.aes.oregonstate.edu/plant-pathology

Thanks to Collaborators in this Research

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- Syngenta Crop Protection

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- Australian Winter Cereals Collection
- CIMMYT Soilborne Pathogen Program
- Mid-Columbia Producers (Wasco, OR)
- USDA-ARS Nat'l. Small Grains Collection
- Western Laboratories
- Whitgro (St. John, WA)
- Nordic Gene Bank

University & USDA-ARS Staff:

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- Dr. Carl Strausbaugh (ID)
- Dr. Guiping Yan (OR)
- Dr. Dan Ball (OR)
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