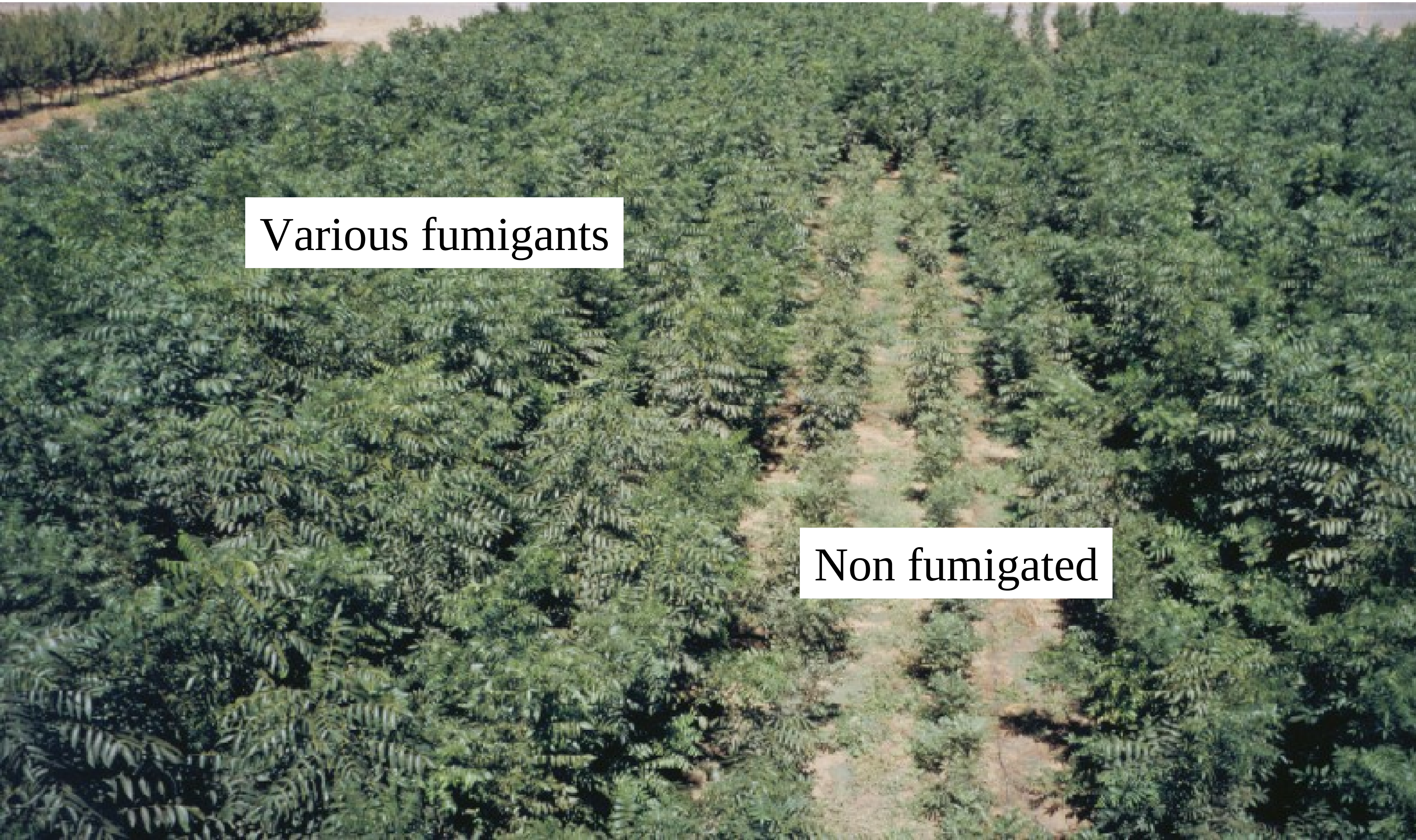
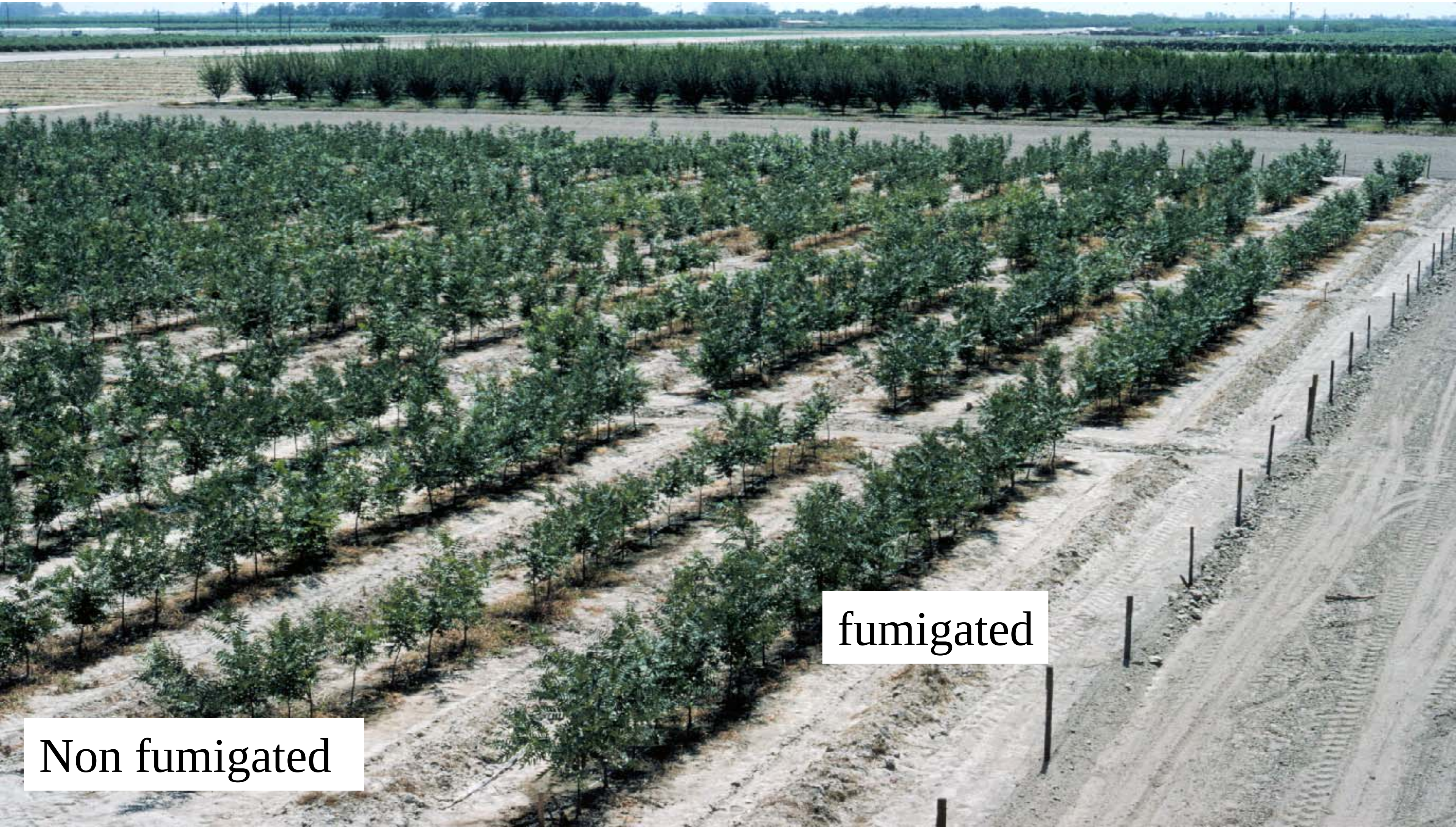
Considerations when Replanting Walnuts

Jan 30, 2009

Wait 2 years, rip to five feet, walnuts after walnuts in clay loam soil, replant with seeds



Wait 2 years, rip four feet deep, walnuts to walnuts in sandy loam soil, replant 1 yr olds



Both sites were impacted by one or more components of the walnut replant problem

1/ The rejection component (old soil ecosystem)

2/ Soil pest and disease component (commonly root lesion nematode)

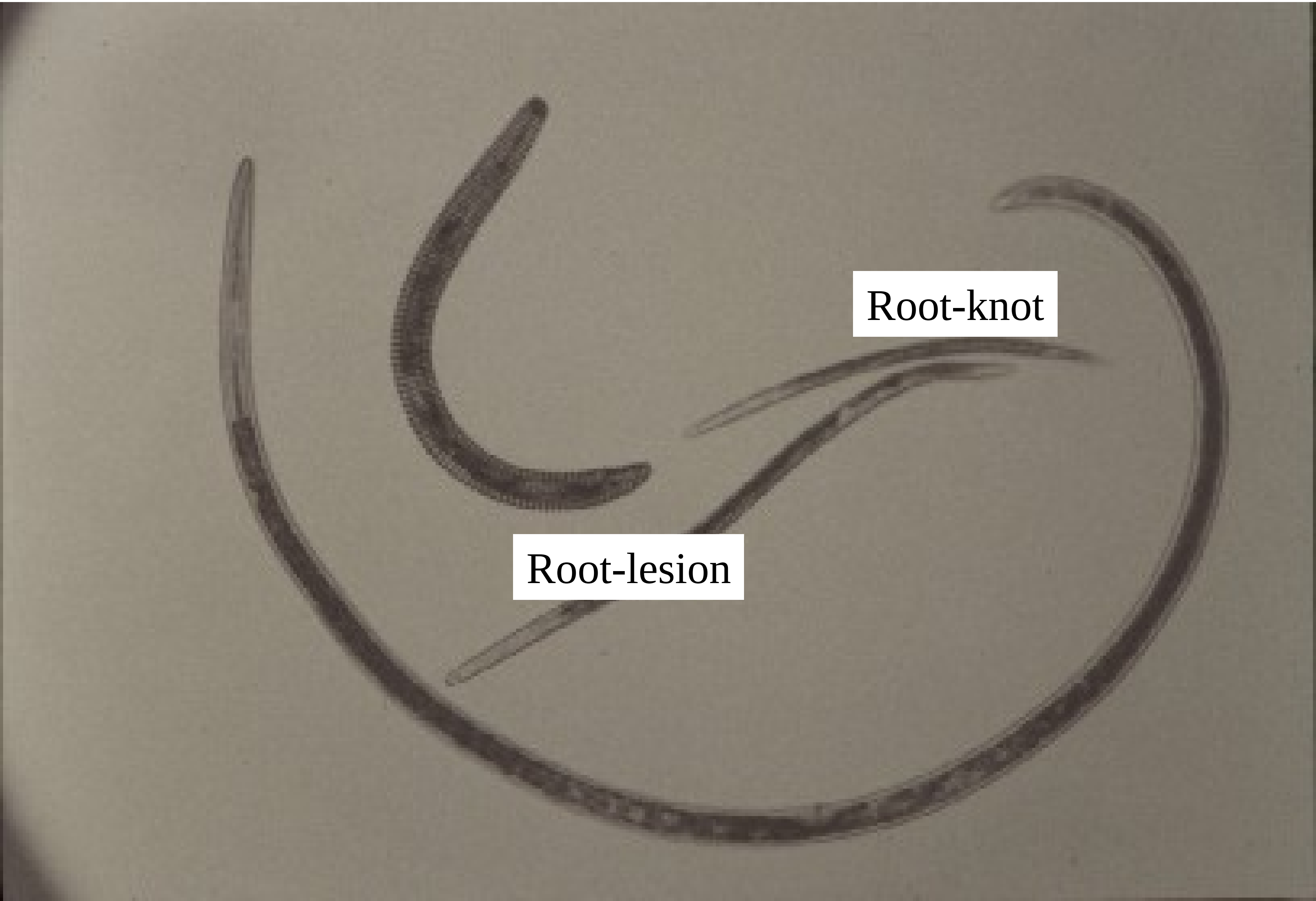
3/ Soil physical and chemical factors (plow pans & chemical residues usually resolved with ripping)

4/ Small amounts of macro and micro nutrients at the time of planting.

The rejection component appears as poor growth, unevenly distributed across the field but only for the first 1 to 1 ½ yrs after replanting.

But, if root lesion nematode is also present, the new trees may never grow well.

Nematodes are a major soil pest of walnuts



Soil fumigation

MB, tarped to deep-dried soil can kill all old roots to 6 feet deep + 99.99% of nematodes within.

Telone II at 33.7 gpa can kill all old roots to 4.5 feet and 99.99% if soil is less than 12% soil moisture content.

Telone C35 at 49gpa can accomplish what Telone II does but also provide: 1) a visible plant growth response + 2) protection from the rejection component of the replant problem.

More on fumigants later:

If soil fumigants are not available or soil is not adequately prepared or can't be dried out: What then???

This is our research question!

The answer will be to know more about the biology of the problem and the plant.

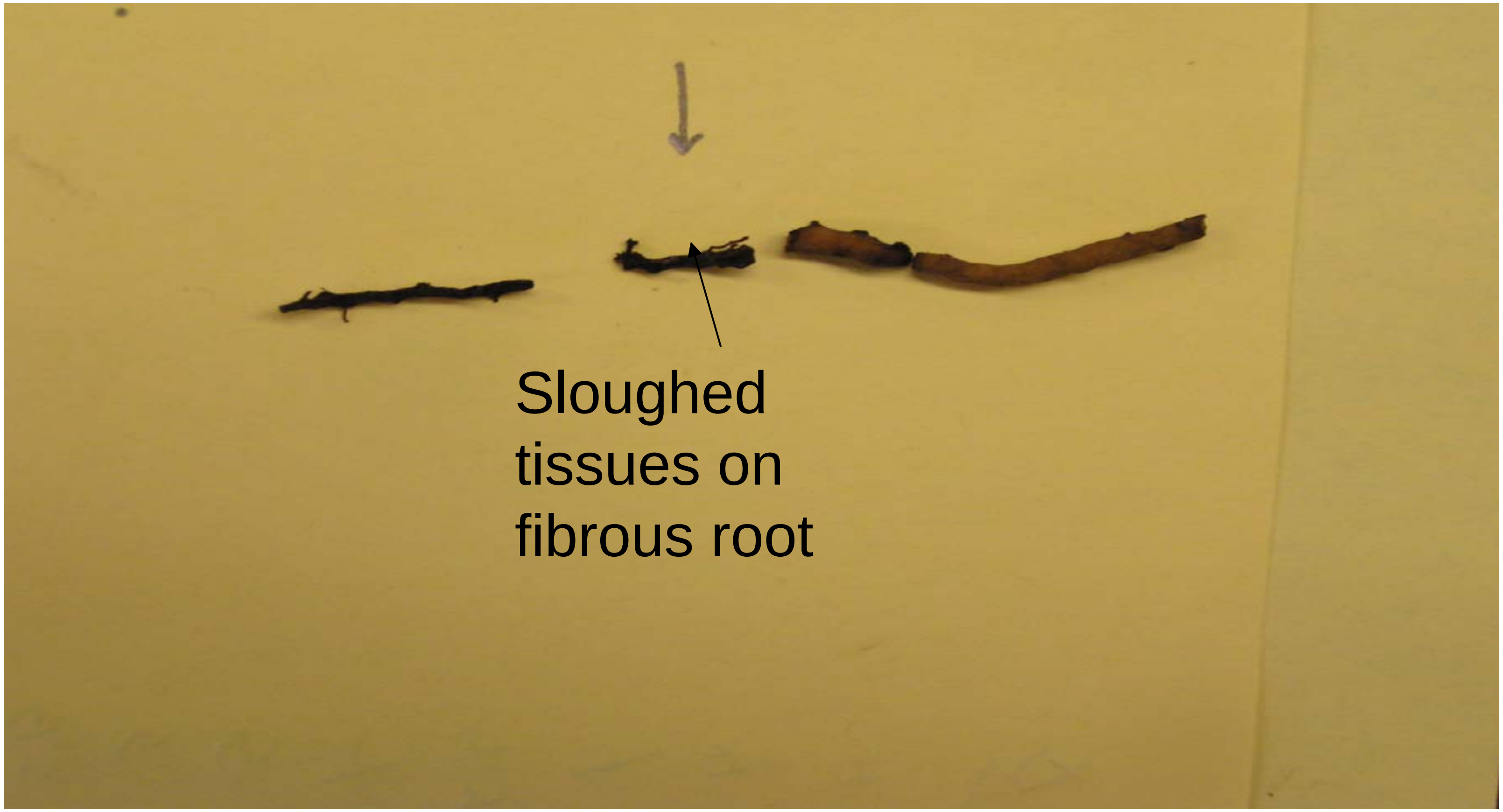
First-year root structure of Serr vs. NCB

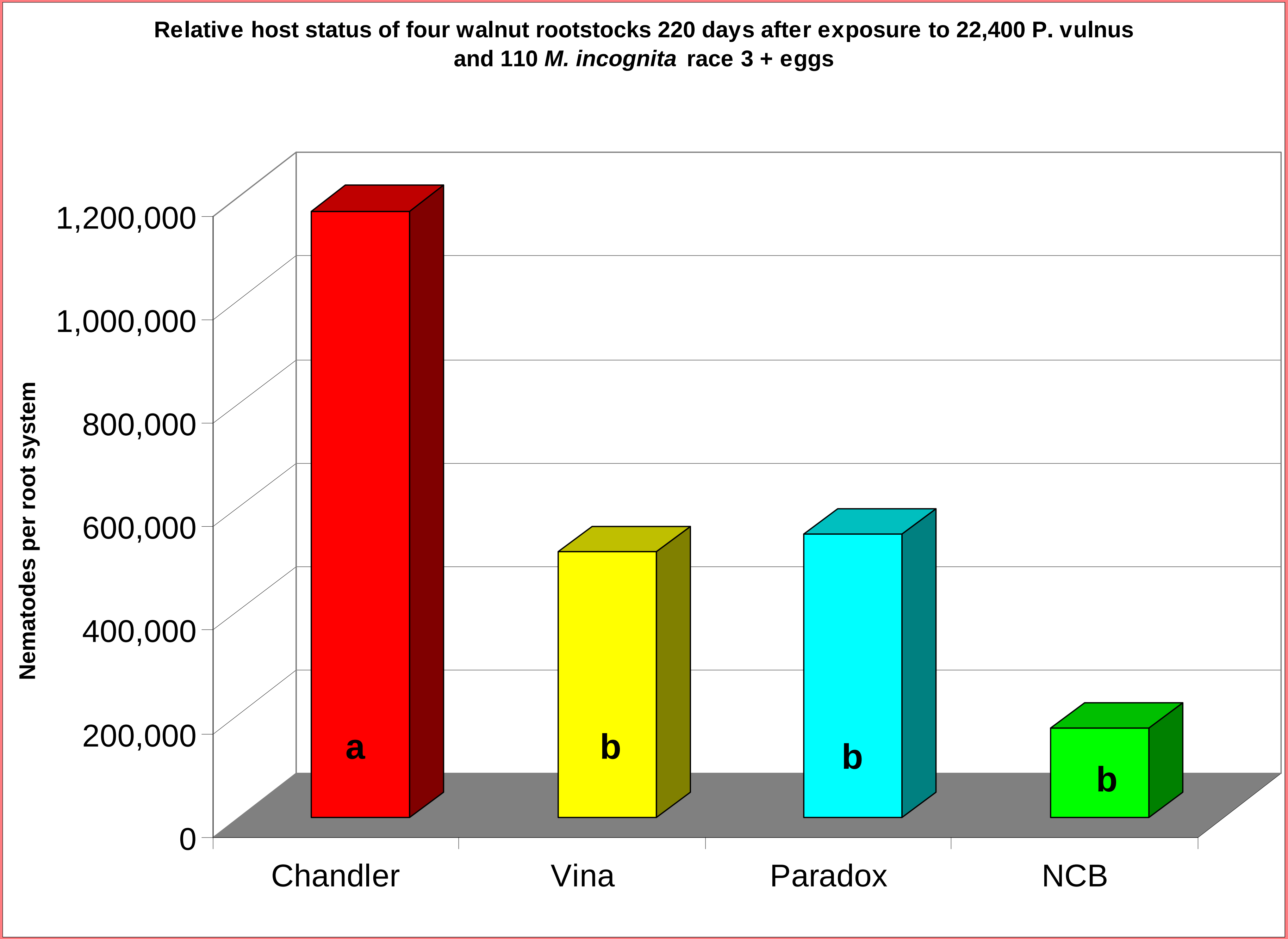
NCB fleshy roots range from 3cm to 15cm in length

Serr root tips range from 1cm to 5cm

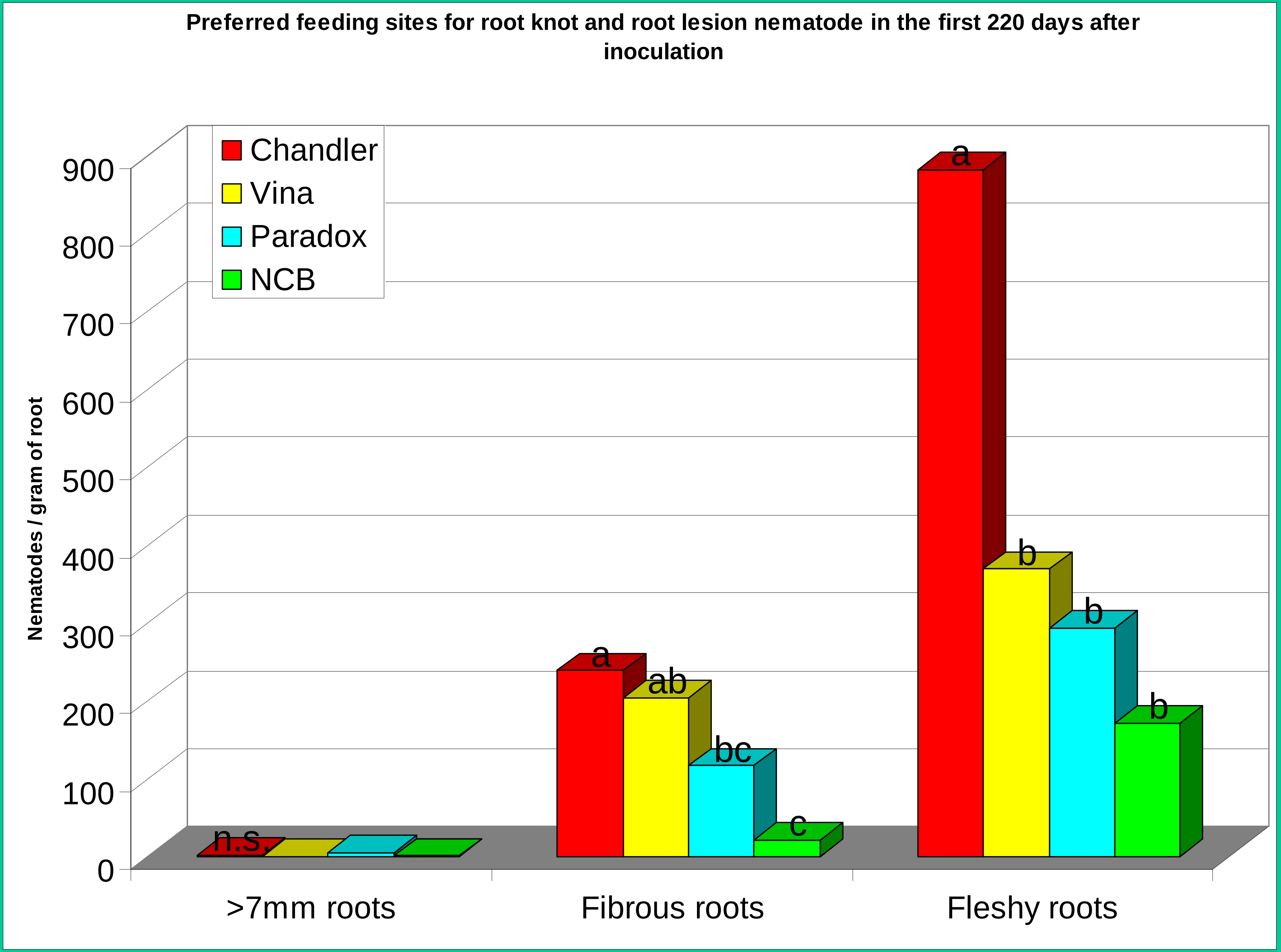
English stocks have multiple tips more often than NCB

Fleshy root tip, fibrous root covered with sloughed tissues and further back the fibrous portion of the root





Relative host status of four walnut rootstocks 220 days after exposure to 22,400 P. vulnus and 110 *M. incognita* race 3 + eggs
Nematodes per root system
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
a
b
b
b
Chandler
Vina
Paradox
NCB


Preferred feeding sites for root knot and root lesion nematode in the first 220 days after inoculation
Chandler
Vina
Paradox
NCB
Nematodes / gram of root
900
800
700
600
500
400
300
200
100
0
n.s.
a
ab
bc
c
a
b
b
b
>7mm roots
Fibrous roots
Fleshy roots

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walnuts on California black walnut—*J. hindsii*—rootstocks. However, trees on Paradox rootstock frequently fail where root-lesion nematode populations are very high. Paradox clones which have shown the best growth in nematode infested soils are being propagated vegetatively by trench layering for test purposes. Progress is being made on development of techniques for propagation by cuttings.

Rootstock selection may limit the amount and kind of nematode damage, but none of the tested rootstocks are resistant to all kinds of nematodes which may be present in any field. Where plants are comparable as to age, size, and so forth, nematode damage is proportional to the number of nematodes parasitizing them. These two facts suggest the desirability of reducing nematode populations by soil fumigation before setting out trees. A good treatment will protect the grower against the drastic effects of high nematode populations on young trees with small root systems. Many more nematodes are necessary for serious injury to a large tree than are necessary for injury to a small one. Preplanting soil fumigation is not very effective in clay, peat, or muck, but is quite effective in other soils if the fumigant is applied when the soil is worked to seedbed consistency to a depth of 10″, is free of debris, moist, and at a temperature between 50°F and 80°F. Longer lasting results will be obtained with over-all treatments than with spot fumigation of planting sites only. If the new orchard follows an old one, best results will be obtained where the area is planted to annual crops for several years before fumigation and replanting of trees. This will allow time for decay of the woody roots which protect nematodes from fumigants. Dichloropropene mixture is as good a material as any available for preplanting control of the nematode parasites of trees. For a sandy loam soil, dosage rates should be 3–4 times those suggested for vegetables by the manufacturer. This rate may be lowered for sand but must be raised for clay loam. Treatments are best made in the fall, allowing two or three months for the phytotoxic fumigant to escape before planting trees.

When nematodes survive preplanting fumigation and return to high population levels, more or less injury will occur and the life of the trees will be shortened. For this reason it would be desirable to reduce nematode populations around established trees. One nematocide—dibromochloropropane—will kill nematodes in the soil around the roots of living trees without marked injury to trees, if the proper dosage—about 2.5 gallons—per acre is used as a periodically repeated supplement to preplanting soil fumigation. This treatment will not kill nematodes inside the roots, and single applications have only occasionally improved the growth of nematode infected trees which had been planted without preplanting fumigation.

Discovery of a systemic nematocide to reduce nematode populations inside roots without injuring trees represents one ultimate aim of basic research.

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Lovell peach seedlings grown in soil infested with a logarithmic series of numbers of larvae of the root-knot nematode, *Meloidogyne incognita acrita*.

Lesion on walnut root resulting from the activity of root-lesion nematodes.

Reaction of Deciduous Fruit and Nut Trees to the Root-knot and Root-lesion Nematodes Common in California

Crop or rootstock	Root-knot nematodes		Root-lesion nematodes	
	Meloidogyne incognita acrita	*Meloidogyne javanica javanica*	*Pratylenchus vulnus*	*Pratylenchus penetrans*
Almond	S[1]	S	S	..
Apple	R[2]	..	R	S
Apricot	most I[3] some S	most I some S	R	..
Cherry (Mahaleb)	R	..	R	R
Cherry (Mazzard)	I	..	S	..
Cherry (Morello)	I	..	S	..
Fig	S	..	S	..
Peach (Bokhara)	some I some S	S	R	..
Peach (Fort Valley 234–1)	some I some S	R	..	..
Peach (Lovell)	S	S	S	H[4]
Peach (Okinawa)	I	R	..	..
Peach (Rancho Resistant)	I	S	..	..
Peach (S-37)	I	S	S	..
Peach (Shalil)	I	S	some R some S	R
Peach (Yunnan)	I	S	some R some S	..
Pear	R	..	R	..
Plum (Marianna 2623 and 2624)	I	I	S	..
Plum (Myrobalan 29, 29C, 29D, and 29G)	I	I	S[5]	..
Walnut (California black)	R	R	S	..
Walnut (Paradox hybrids)	R	R	some R some S	..
Chinese wingnut (walnut rootstocks)	..	..	I	..

[1] S = susceptible.
[2] R = resistant.
[3] I = immune.
[4] H = crop known to be a host; but disease not known to be important in California.
[5]—29D and 29G tested.

Lets re-think old notions about how nematodes damage walnut

- Root-lesion and root-knot damage is to roots that are 50 days old or less.
- 99% of an established walnut root system is relatively resistant to nematode feeding
- Start the tree out nematode-free because 5% of nematode off-spring can live five years without food as they await the next new root tip to emerge in their vicinity.

3500 plants screened

Several mechanisms of potential nematode relief were found

- High vigor in the presence of nematode feeding and reproduction in Paradox VX211
- Pre-infection resistance in Paradox NX and UZ seedlings
- Apparently some resistance to *P. vulnus* in Black walnut selection AW269
- Apparently some resistance in *Juglans microcarpa* selection RX032

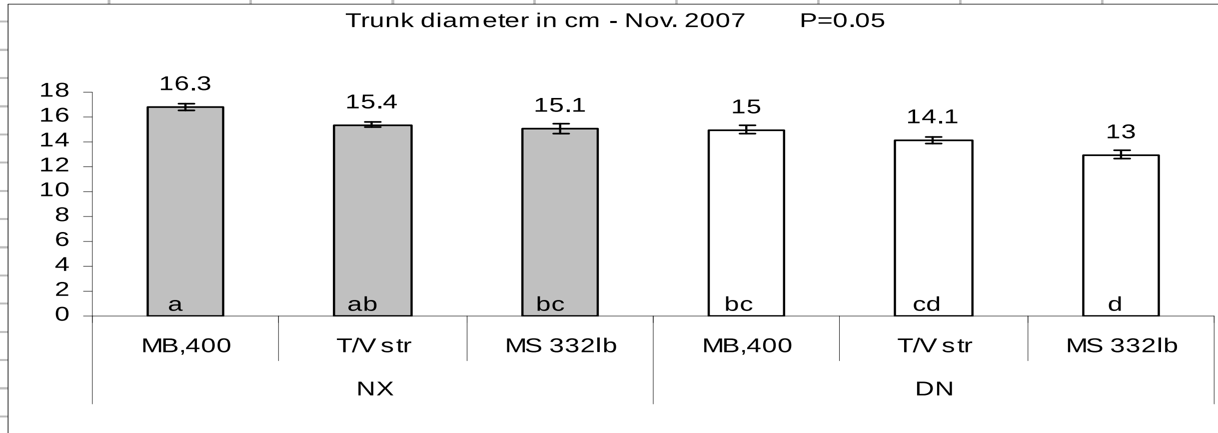
What is the potential of pre-infection resistance noted in NX and UZ seedlings of paradox?

Relative tree sizes in 2005, four years after various fumigations

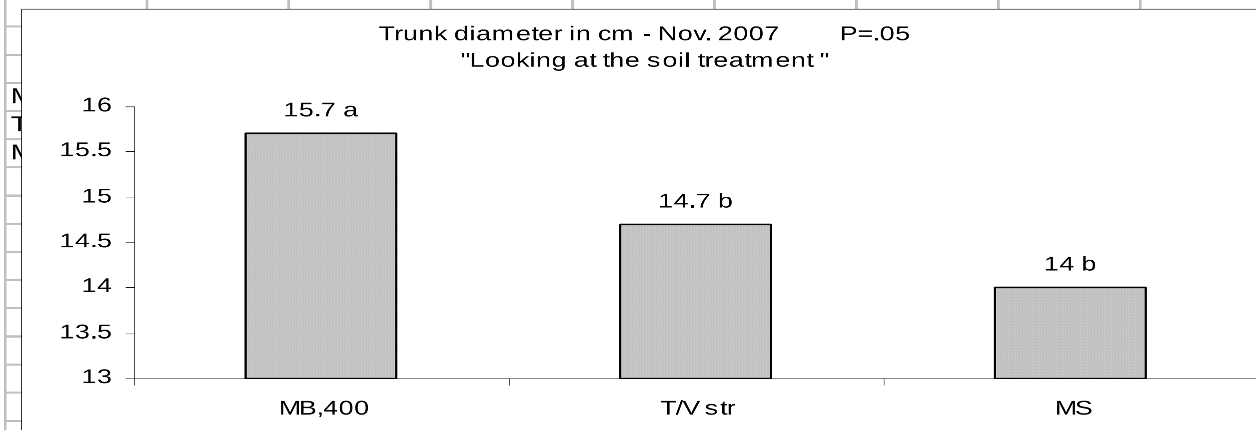
Broadcast MB MS **Strip** T/V

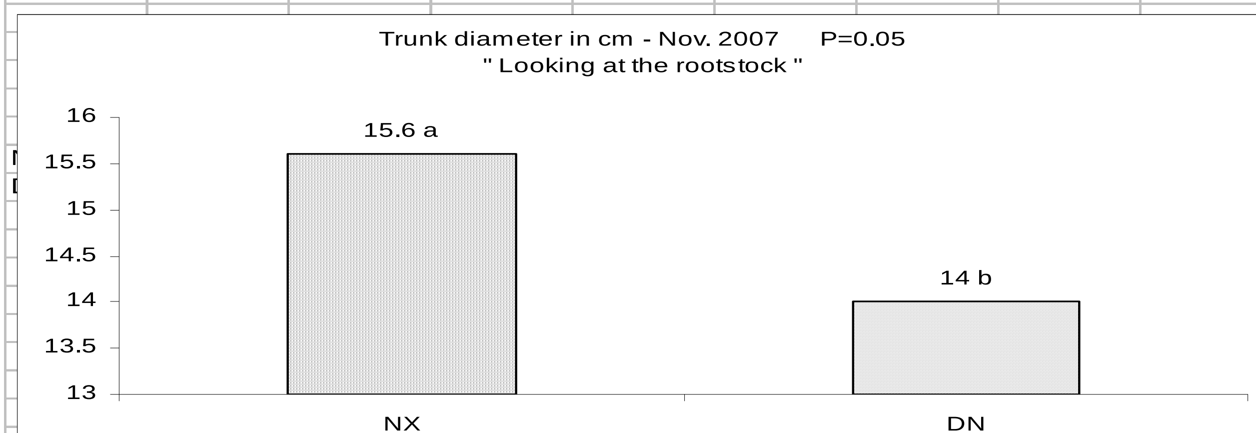
Sixth-leaf differences, 2007

One Way Analysis



Two Way Analysis





NX vs DN Paradox seedlings in fall 2006

Incidence of *P. vulnus* 6 years after various soil treatments at Rio Oso

Soil Treatment	Volume of soil fumigated/ac	Mean counts/250cc soil when replanted to NX Paradox	Mean counts/250 cc soil when replanted to DN Paradox
400lb/ac MB (tarp) broadcast	99.99% control in 24M lbs soil	2 a	123 ab
500lb/ac rate Telone stripped + 110lb MS	99.99% control in 9M lbs soil	301 bc	145 abc
325 lb/ac MS broadcast in 6” water	99.90% control in 16 M lbs soil	432 c	332 c

Sample each foot to 5 feet deep

Samples from top 2 feet at canopy edge

Trunk circumference (inches) at Rio Oso in fall 2008

Fumigant	NX rootstock	DN rootstock
MB @400lb/ac' broadcast	22.6	21.6 ns
Telone II 50gpa strip applied	21.8 a	19.6 b
Vapam drench to 4', broadcast	21.3 a	18.2 b

Read values across, DMRT at *P*=0.05

7th-leaf trunk size (fall 2008)

	NX rootstock	DN rootstock	circumference difference *
99.99% control to 6’	100% a (22.6 in.)	100% a (21.6 in.)	1 inch
99.99% control to 4.5’ by 11’ strip	96% ab	90% c	2.2 inches
99.9% control to 4’	94% b	84% d	3.1 inches

* compared to MB treated

DMRT, $P = 0.05$

Pratylenchus vulnus / 250 cc from each foot to 13 ft depth at 2.5 yr after Garlon

Depth [ft]	Garlon + MB	No Garlon + metam sodium
1	0	0
2	0	0
3	0	0
4	0	9
5	0	43
6	0	1
7	2	14
8	3	2
9	5	1
10	0	3
11	3	7
12	0	1
13	5	0
Mean	1.4	6.7
DMRT (.05)	n.s.	

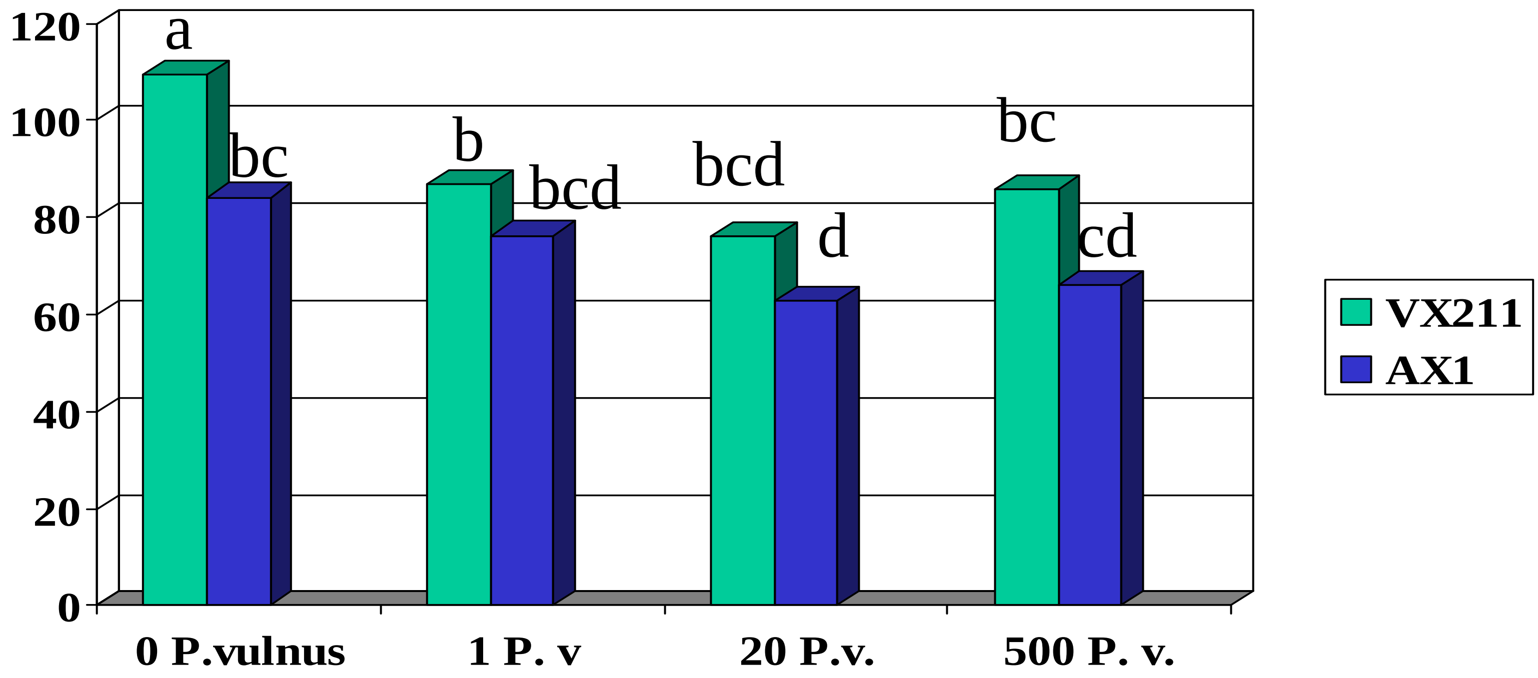
What about Paradox VX211?

Is the vigor due to nematode tolerance or extreme hybrid vigor?

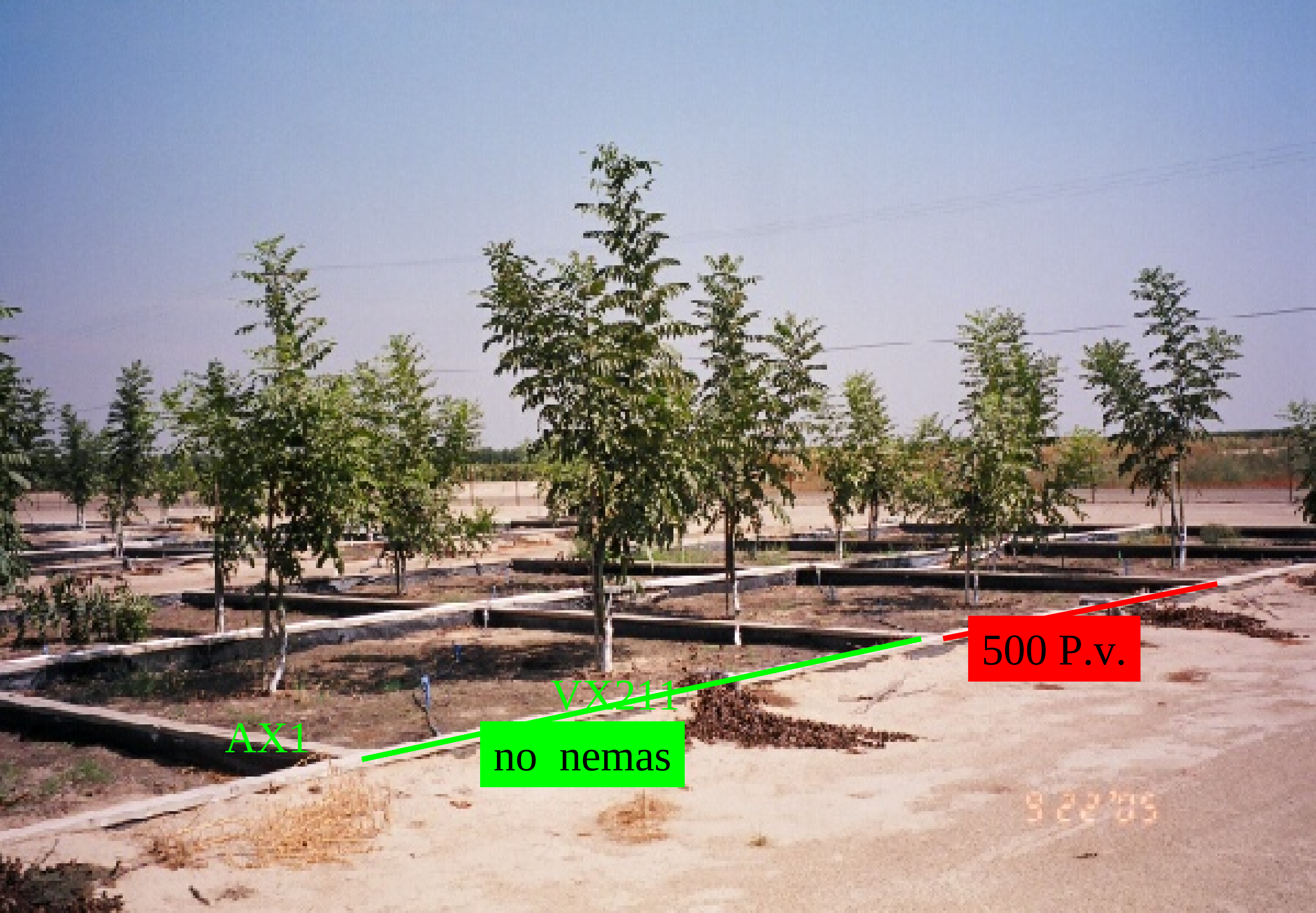
Clones of VX211 compared to AX1 Paradox in first-leaf

1. Each plot is 1/100th acre
2. Plots contain either 0, 1, 20, or 500P. vulnus/250 cc soil

First-year heights of VX211 and AX1 planted to various *P. vulnus* population levels/250cc soil



Second Year



Third-year (October) growth of VX211 vs AX1

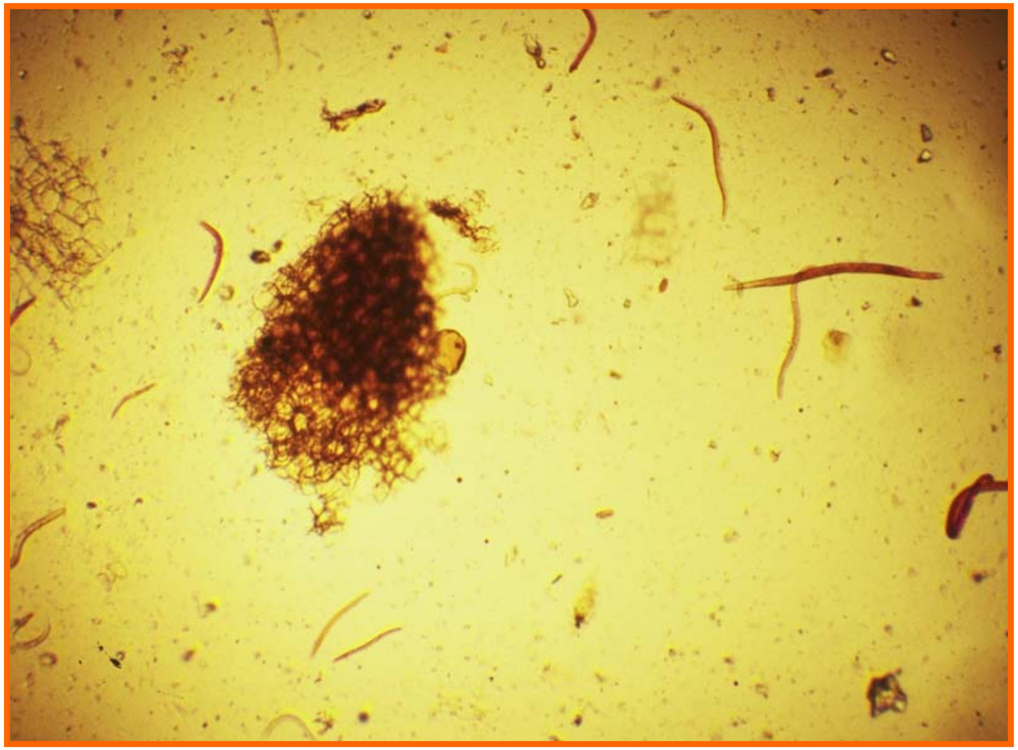
Root system of VX211 in the non-inoculated check

Roots of third-leaf VX211 without nematodes

Roots of third-leaf VX211 inoculated with 500 *P. vulnus/250 cc soil*

Root systems of VX211 and AX1, in 500 *P. vulnus*/250 cc soil

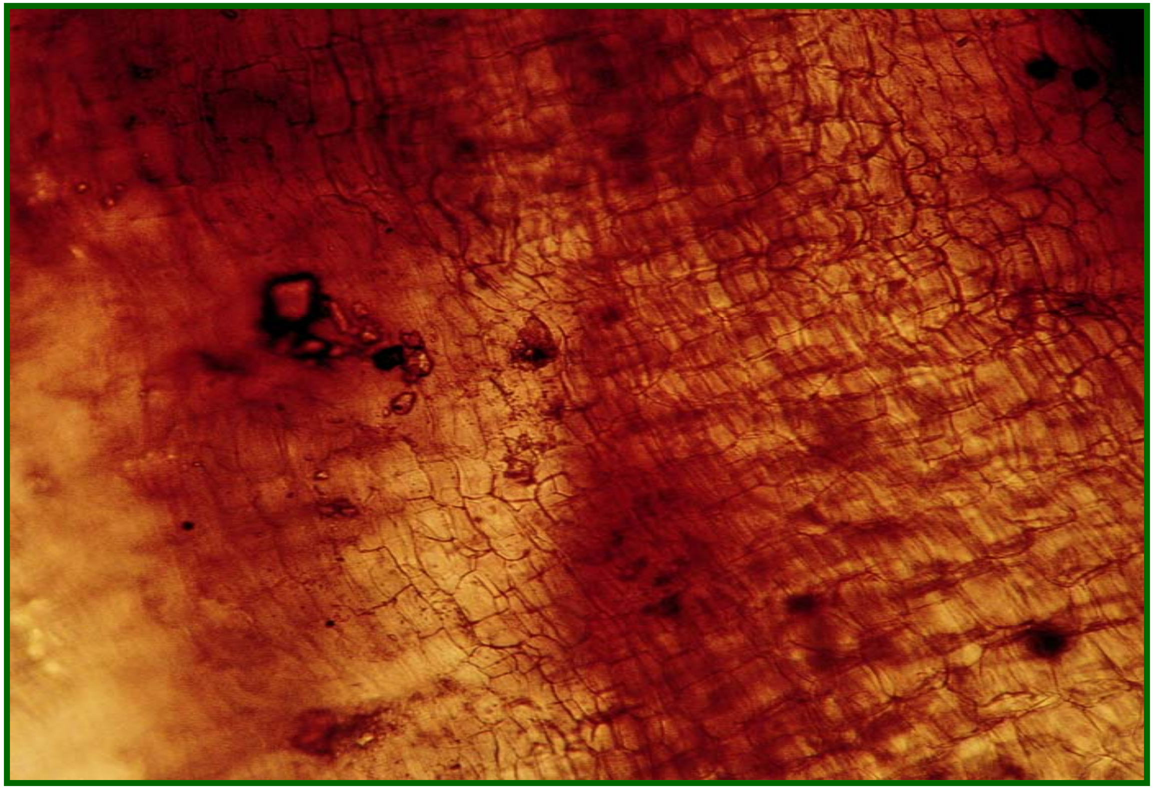
Root-lesion in AX1 Paradox, within the first inch of root tip



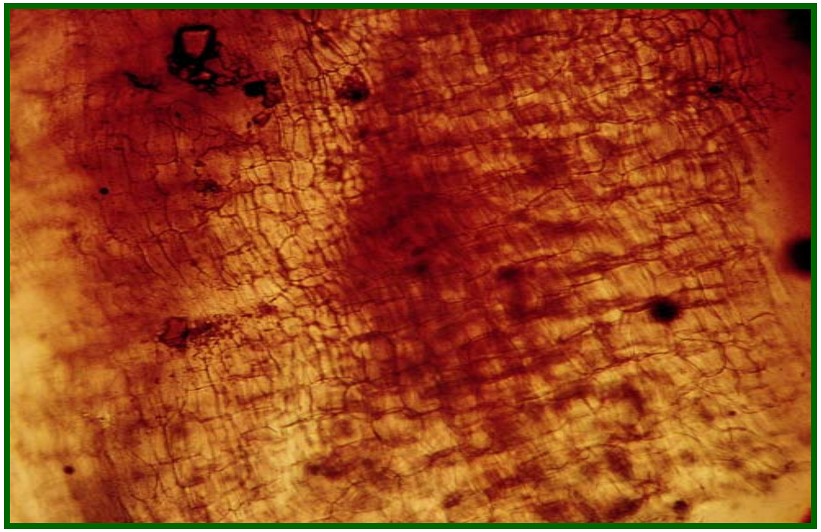
Root-lesion in AX1 Paradox at 1 to 4 inches back from the root tip.

Root-lesion in AX1 Paradox at 4 to 12 inches back from the root tip.

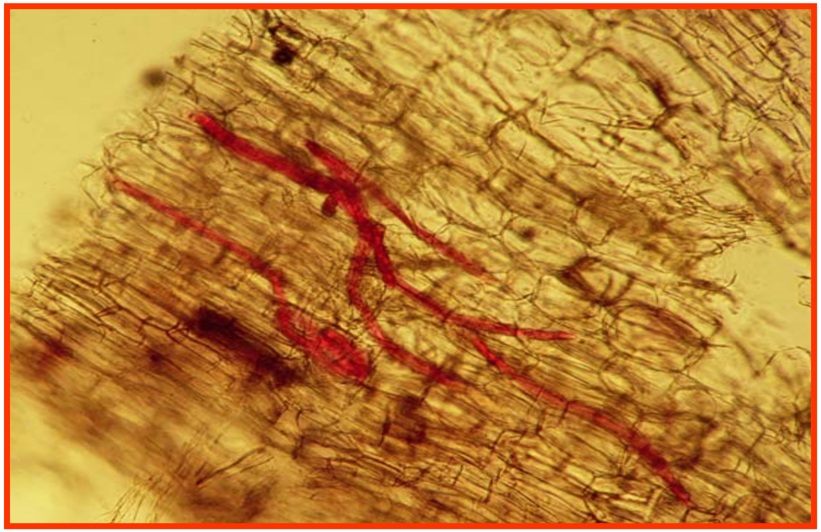
Very few root-lesion found in VX211 root cortex. This photo is at 3 to 9 cm back from the root tip



Root-lesion Nematode in roots of two Paradox walnut clones



VX211-Few nematodes in cortex at 0 to >9 cm from root tip



AX1-nematode in cortex throughout new roots including samples >9 cm back from the root tip

Actual nematodes extracted from within root sections and from soil

Rootstock	0 to 3cm	3.1 to 9 cm	>9cm	per 250 cm^3 soil
VX211	5.9 a	7.9 a	4.0 a	881.
AX1	272. b	345. b	104. b	541.
			P=0.05	ns.

Fifth-leaf Chandler on VX211 vs AX1

Fifth-leaf Chandler on VX211 and AX1 rootstocks

Fifth-leaf VX211 and AX1 trunk circumference (inches)

Nematode Pi	VX211	AX1
0	22.4	15.8
1/250cc soil	19.5	13.7
20/250cc	17.6	11.5
500/250cc	20.1	13.3

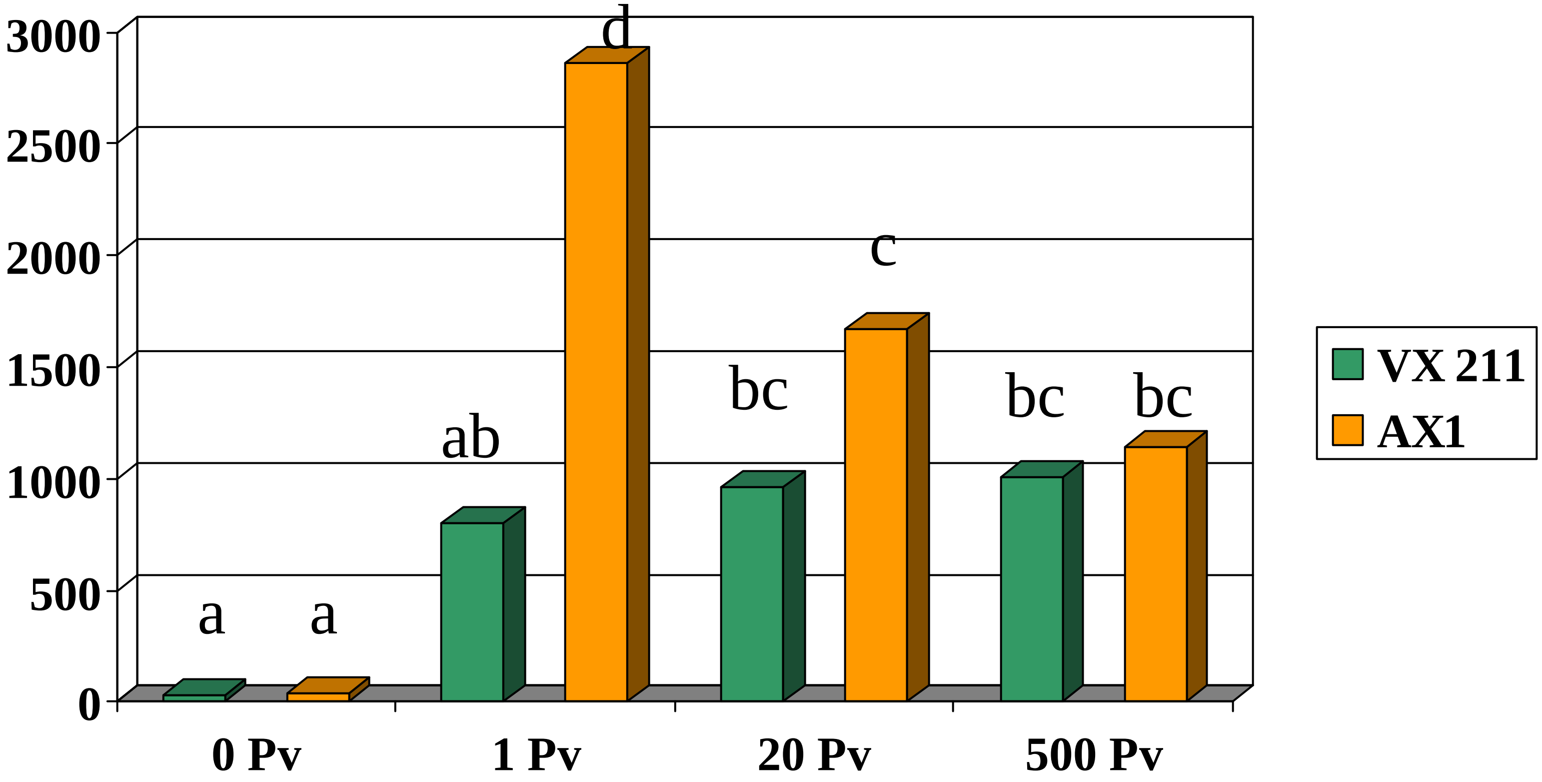
-30%

-30%

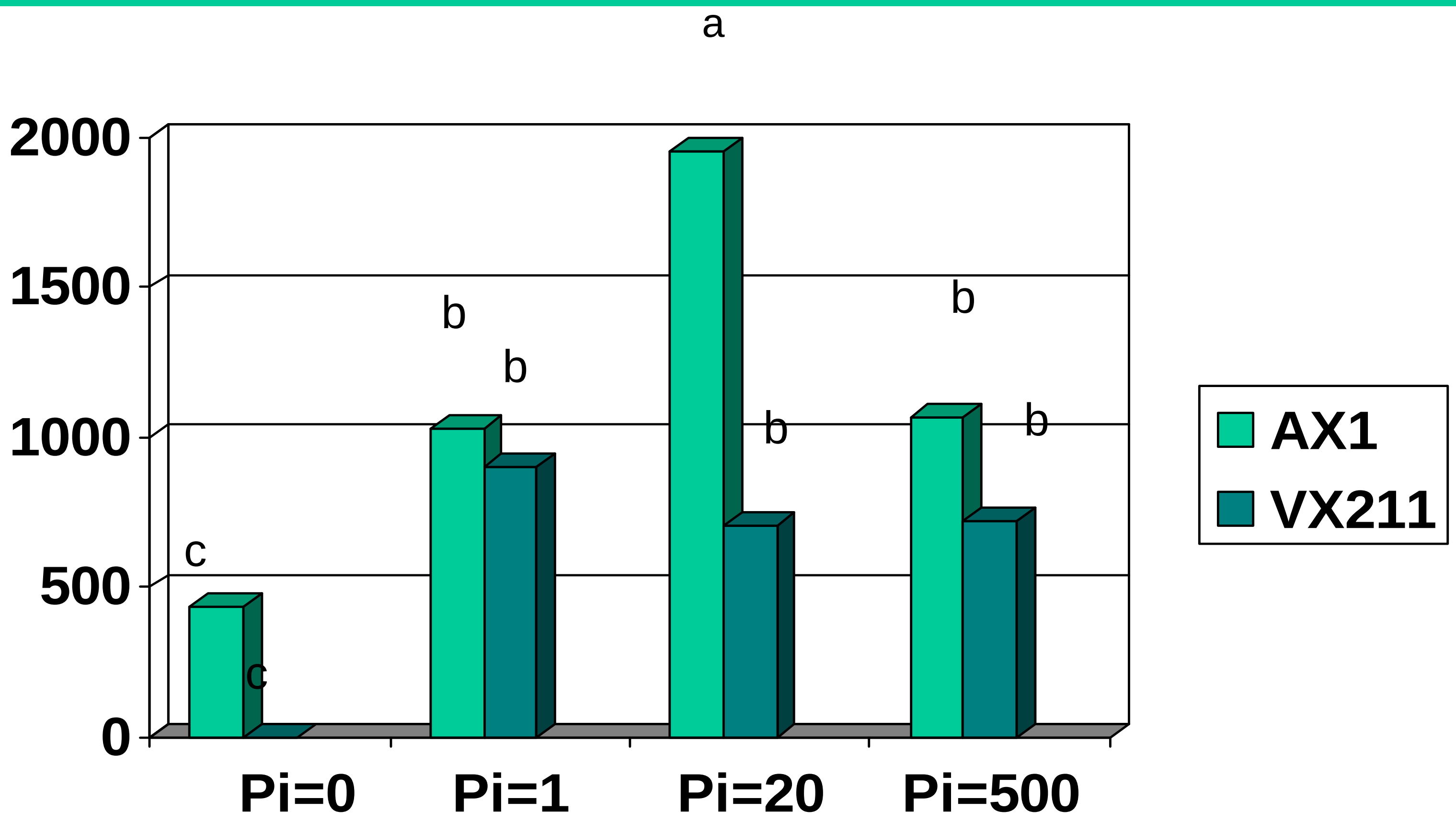
-35%

-34%

P. vulnus / 250 cc soil in third-leaf



Root lesion/250 cc soil at 5th-leaf, Nov. 2008



VX211

High vigor Paradox rootstock a degree of tolerance to nematodes, perhaps due to a resistance mechanism within youngest roots.

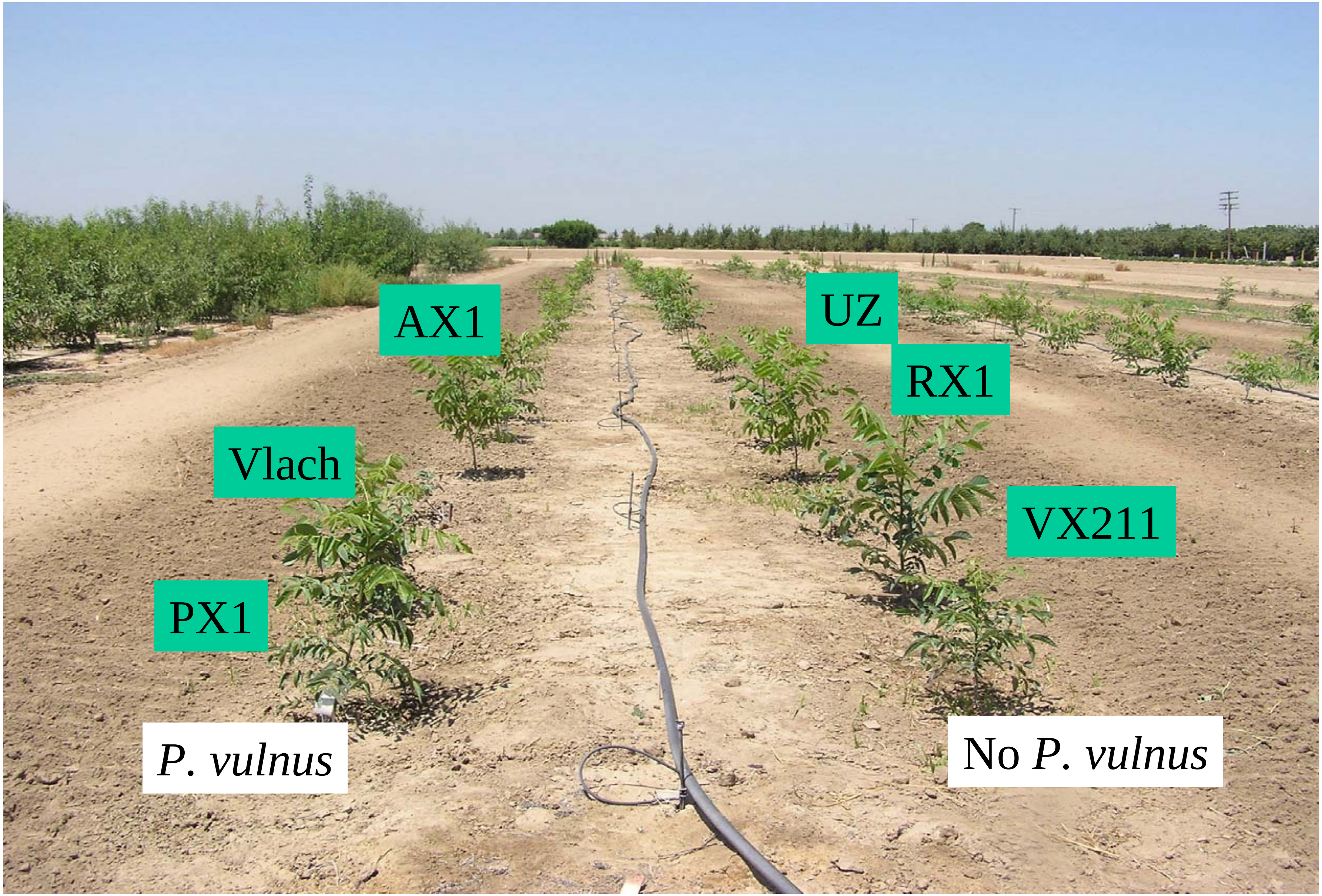
Nematode evaluations of Paradox rootstocks collected by colleagues for their resistance to Phytophthora or Crown Gall

One-year lath house evaluation of *P. vulnus* host status /gram of root tips on several Paradox clones

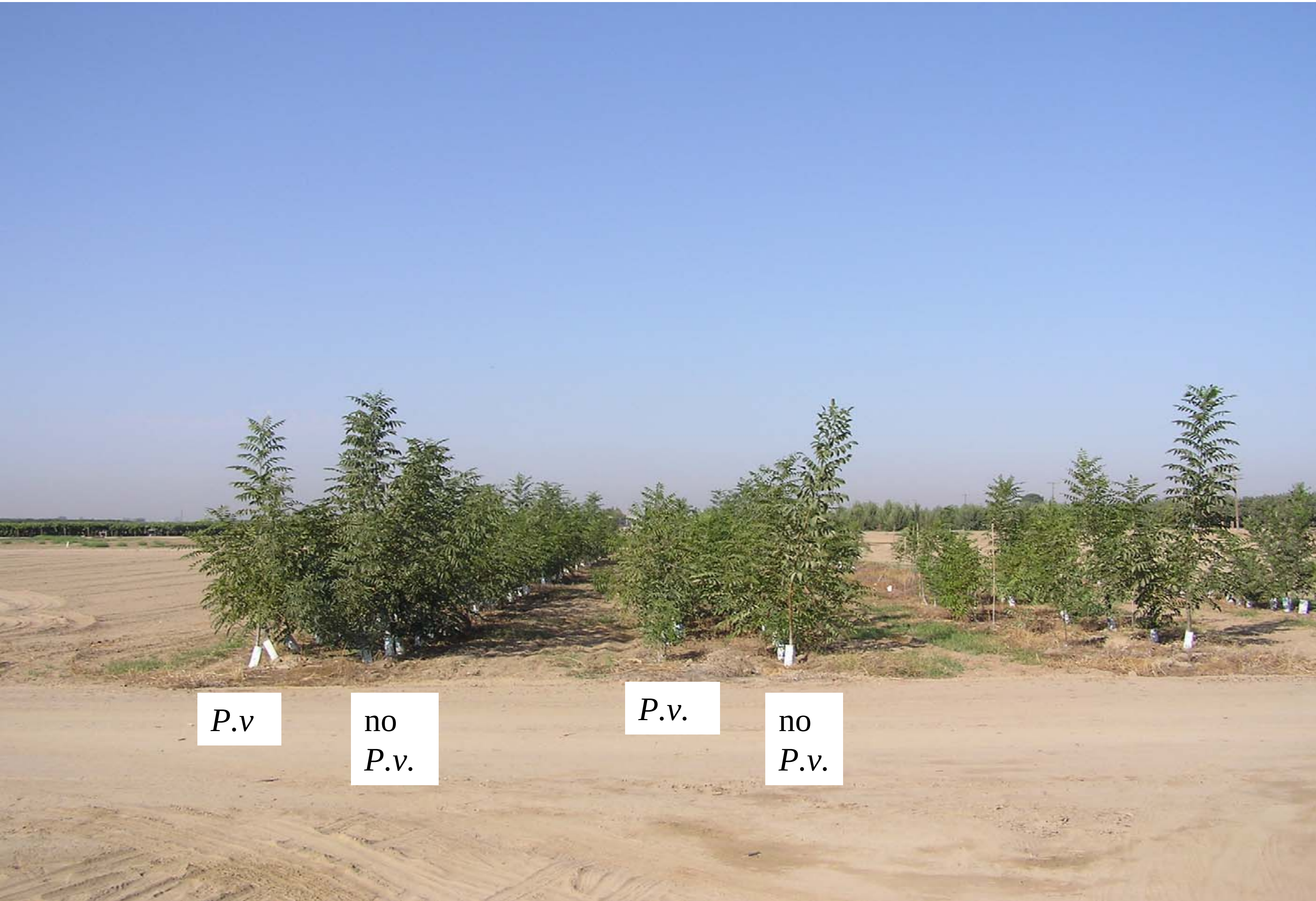
clones	R1	R2	R3	R4	mean	DMRT
Vlach	7871	7286	5813	5352	6580	a
PX1	1673	2431	1800	1870	1944	b
AX1	1037	1691	1132	1846	1426	bc
VX211	1212	1306	1300	1409	1307	bc
UZ229	959	633	621	707	730	c

$P = 0.05$

Field Examinations, year 1



Second-leaf growth of 9 walnut clones with or without *P. vulnus*



First-year tree height of 9 walnut clones with and without *P. vulnus*

Rootstock	Height w/o Pv	Height w/Pv	DMRT P=.05
RX032	136 cm	132 cm	ns
RX1	119	95	*
VX211	117	128	ns
AZ025	110	80	ns
AX1	92	86	ns
Vlach	84	56	*
WIP 3	80	37	*
PX1	75	86	ns
UZ229	62	82	ns

Walnut clone heights (in) grown 2 years with and without *Pratylenchus vulnus*

clone	w/o *P.v*	w/ *P.v*	P=0.05	%diff.
VX211	122	111.6	ns	- 9%
WIP3	116.5	76.8	*	- 34%
AZ025	110.7	73.1	ns	- 34%
Vlach	103.5	86.6	ns	- 16%
AX1	101.4	69.7	*	- 31%
RX032	92	101.9	ns	+ 11%
RX1	91.2	86.9	ns	- 9%
PX1	79	86.5	ns	+ 9%
UZ229	64.4	68.1	ns	+ 6%

Walnut clone girths (cm) grown 2 years with and without *P. vulnus*

clone	w/o *Pv*	w/ *Pv*	P=0.05	% diff.
VX211	7.8	5.5	*	- 29%
AZ025	7.1	4.0	*	- 44%
Vlach	6.7	4.4	*	- 34%
AX1	5.3	3.4	*	- 36%
WIP3	5.3	3.0	*	- 43%
RX032	5.0	4.6	ns	- 8%
RX1	4.8	4.0	ns	- 8%
PX1	4.3	3.9	ns	- 9%
UZ229	3.5	4.0	ns	+14%

First-leaf growth of nine Walnut clones + *P. vulnus*

Is there resistance in elite selections of Juglans?

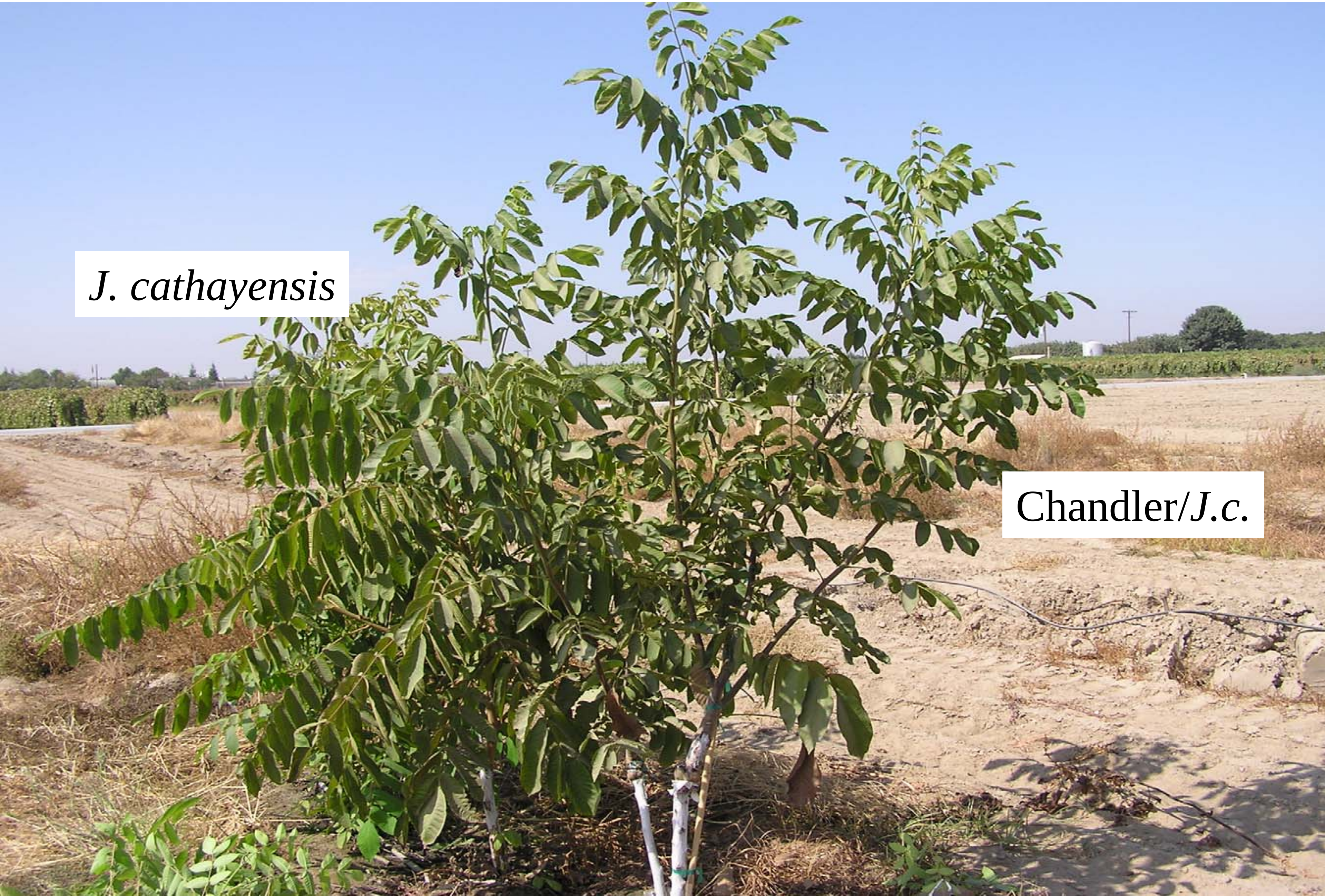
One of the elite *Juglans* spp. provided us with nematode resistance in 5 of 11 plants!!!

Juglans cathayensis

Chinese walnut, a type of butternut

Two-year evaluation of 8 *Juglans* sources from National Germplasm Repository									
	Juglans spp.	seeds	trees	mean root-lesion/g root		mean root-knot/g root		% resistant	
				1st yr	2nd yr	1st yr	2nd yr	RL	RKN
	J. mandschurica	37	13	6.9	272.4	0.2	0.39	0%	92%
	J. ailantifolia	47	26	33.8	422.4	0.13	4.7	0%	15%
	J. cathayensis	47	11	0.25	49.3	0	0.57	55%	18%
	J. hindsii, Rawlins	47	25	6.8	257	24.6	63.5	4%	44%
	J. regia, Hartley	47	6	21.7	118		1.3	17%	33%
	J. microcarpa	47	8	0.06	76.8	2.4	11	12%	12%
	J. major	47	14	0.95	59.4	0.24	0.24	14%	64%
	J. californica	47	11	0.19	75.6	9.4	89.8	18%	27%

First-year Chandler/*J. cathayensis* seedling in foreground



Six of 15 grafted limbs of Chandler/*J.cathayensis* survived 1 yr

There are swollen graft unions

In Summary

NX and UZ Seedlings offer protection from nematode entry unless too many are present. Our studies encourage more study of UZ229.

VX211 clone offers vigor and some tolerance to nematodes because fewer feeding sites are available—but fumigate!

But: to plant without fumigation we will need: Garlon > wait one year> then replant on different parentage having nematode resistance such as *J. cathayensis* #21 or *J. microcarpa* RX032