2017 WAVE

The Clore Center

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MANAGING NEMATODES IN A MATURING WINE GRAPE INDUSTRY

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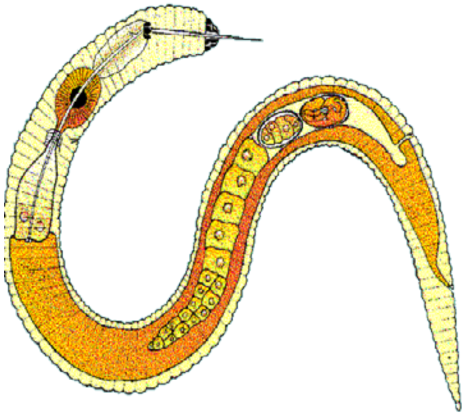
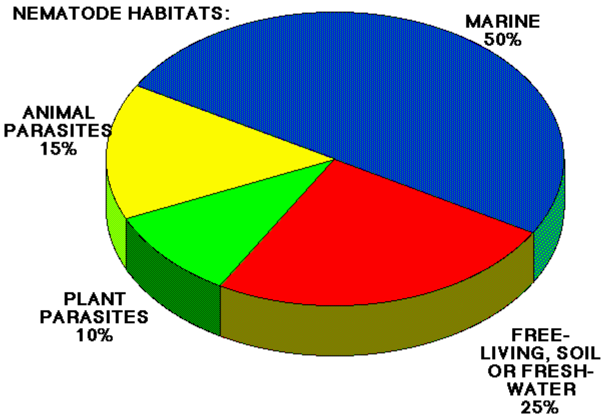
WHAT ARE NEMATODES?

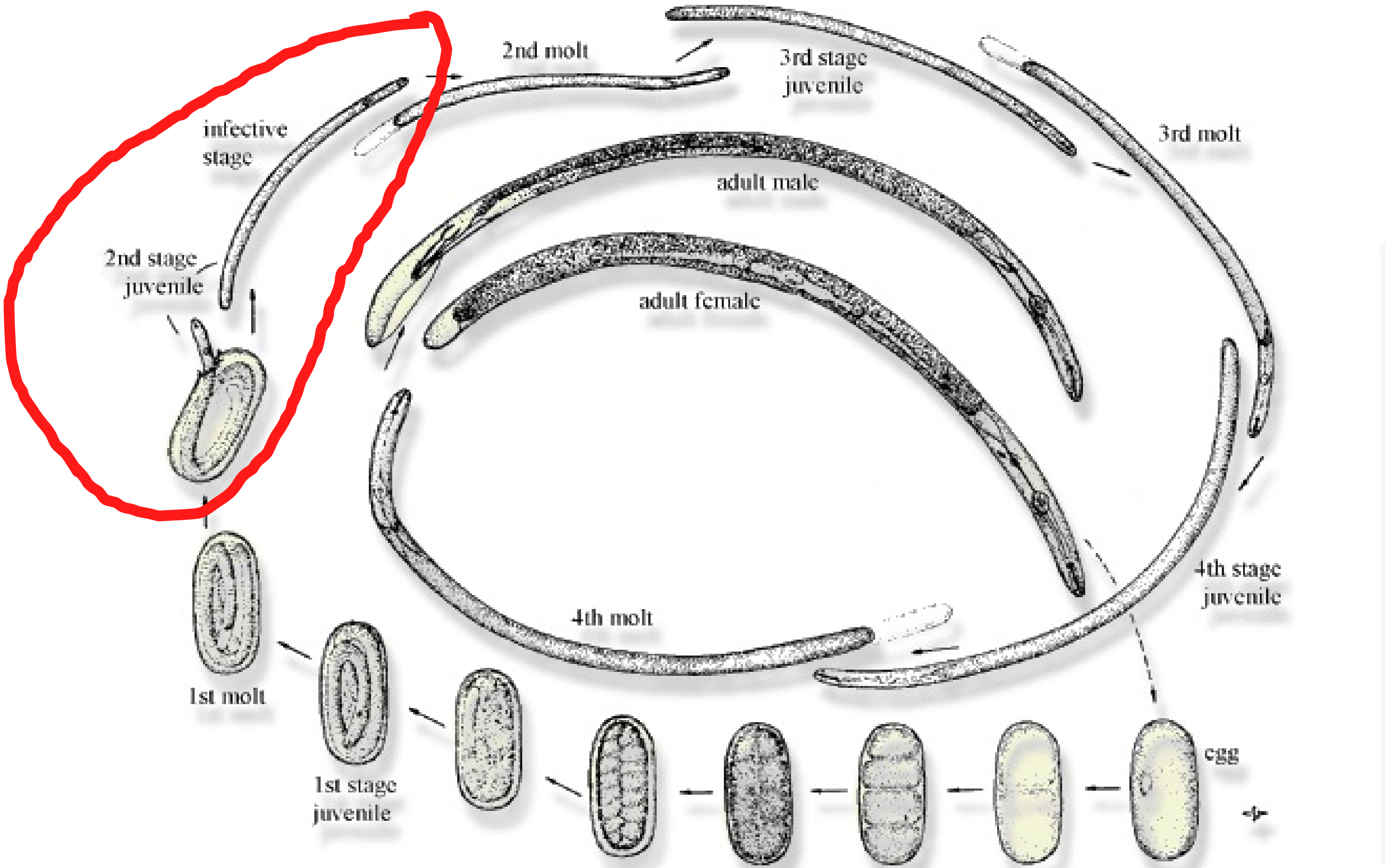
- Non-segmented round worm
  - Very small (0.5-3.0 mm)
  - Very little in common with others in Animal Kingdom
  - 2,000 species of plant-parasitic nematodes
- Global crop loss of $80 billion
  - In 35 USA states, nematodes account for 25% of crop loss
  - WA, $40 million loss (if crops are not treated)





Plant-parasitic nematodes are ~10% of the total nematode species

GENERAL LIFECYCLE



Typical life cycle of a plant-parasitic nematode.

Image from: Ayoub, S.M. 1980. Plant nematology, an agricultural training aide. NemaAid Publications, Sacramento, CA

NEMATODES IN WASHINGTON VINEYARDS

Plant-Parasitic Nematodes Found in Oregon and Washington Vineyards
Most likely and Capable of Causing Economic Damage
Root-knot (*Meloidogyne hapla*)
Ring (*Mesocriconema xenoplax*)
Dagger (*Xiphinema americanum*)
Present but Unlikely to be of Economic Importance
Root-lesion (*Pratylenchus* spp.)
Pin (*Paratylanchus* spp.)
Stunt (*Tylenchorhynchus* spp.)
Spiral (*Helicotylenchus* spp.)

Table from: Field Guide for Integrate Pest Management in Pacific Northwest Vineyards, PNW644

NEMATODE FEEDING TYPES – LOCATION TO ROOT

Endoparasite

- Endo = internal
- Embeds inside the plant tissue to feed
- Survival is often tied to the survival of the host plant
- Creates feeding cells

Ectoparasite

- Ecto = external
- Feeds on roots while remaining external to the plant
- More susceptible to environmental changes

NEMATODE FEEDING TYPES - MOVEMENT

Migratory

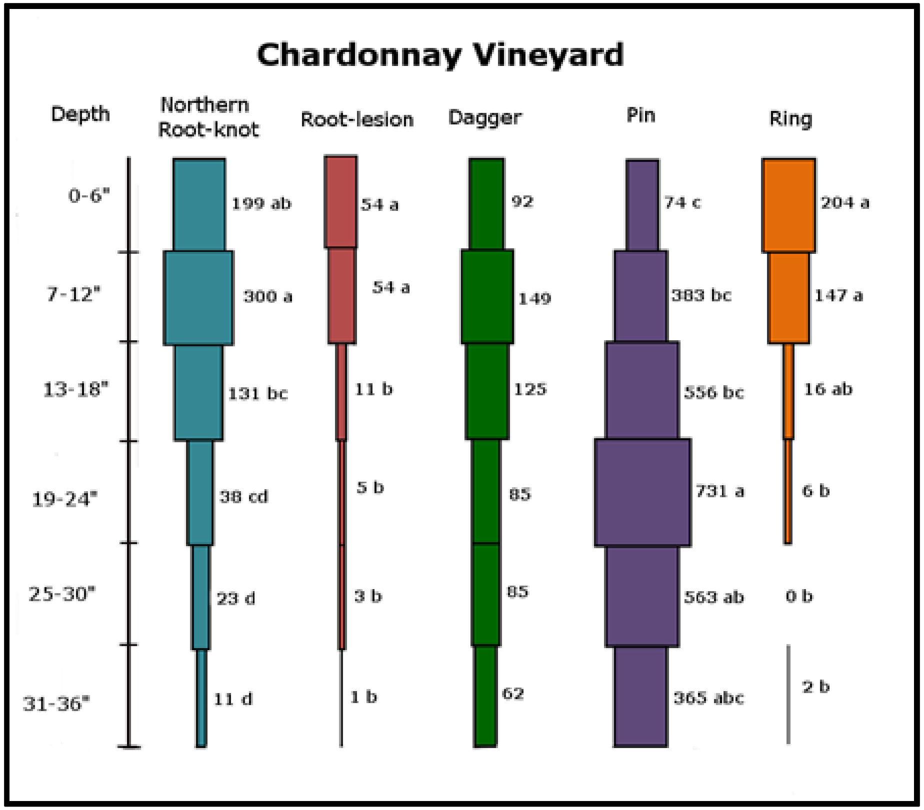
- Moves around
  - Ring, dagger, pin nematodes: migratory ectoparasites
  - Lesion nematode: migratory endoparasite
- No permanent feeding cells

Sedentary

- Does not move
  - Root knot nematode: sedentary endoparasite
- Feeding cells are large and plug the vasculature

NEMATODE DISTRIBUTION IN THE SOIL

*** Project that collected this data was also previously funded by the Washington State Grape and Wine Research Program*



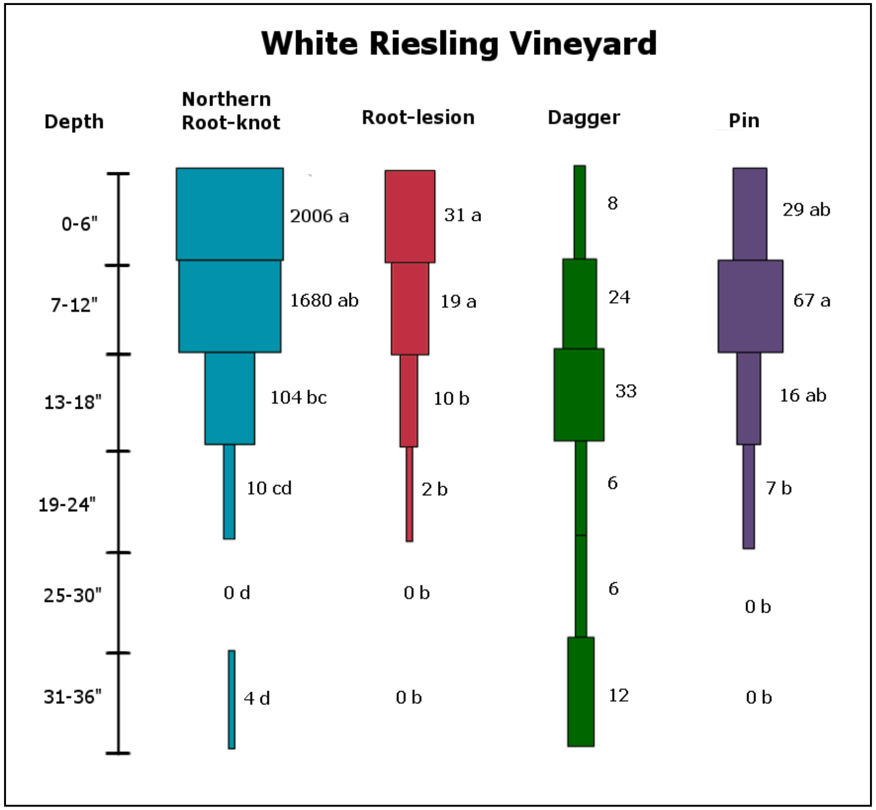


Image modified from Howland, A.D., et.al. 2014. J. Nematology 46:321-330.

PLANT-PARASITIC NEMATODES IN WA VINEYARDS

- Surveys conducted in 2000 and 2003
  - 157 vineyard sampled
  - Nematodes extracted from soil only (no roots)

Nematode species	Common name	Mean (max) per 250 g soil	% Occurrence relative to total samples
Meloidogyne hapla	Northern root-knot	85 (1,088)	60
Xiphinema sp.	Dagger	25 (284)	59
Pratylenchus sp.	Root-lesion	9 (155)	45
Mescocriconema xenoplax	Ring	5 (170)	14
Paratylenchus sp.	Pin	54 (981)	50
Tylenchorynchus sp.	Stunt	0 (12)	8
Trichodorus sp.	Stubby-root	2 (2)	2

Zasada, Schreiner, Pinkerton, Riga, Wilson

SOIL SAMPLING – INTERPRETING RESULTS

Nematode Species	Average Density (WA)	Threshold 1	Threshold 2	Threshold 3
Root-Knot Nematode	85	5-20	50	100+
Dagger Nematode	25	0	5	25+
Ring Nematode	5	5-20	25-250	300+
Lesion Nematode		5-20	25-45	50+

Threshold 1 : Not of general concern
Threshold 2 : Might cause damage if the plant is weak / **young**
Threshold 3 : Will likely cause some crop damage; however, it is site-dependent

MANAGEMENT STRATEGIES OF NEMATODE CONTROL

- There are three main strategies available for nematode control in grapes :
  - Chemical application
    - Synthetic
    - Organic
  - Green manures
    - Release “biofumigants”
    - Must be applied annually
    - In some cases, can be hosts to nematodes as well
  - Cultural strategies
    - Use of rootstocks
    - Fallow periods

NEMATODE MANAGEMENT STRATEGIES

Pre-Plant

- Fumigation
- Fallow periods
- Cover crops / green manure
- Use of rootstocks

Post-Plant

- Some products labeled for post-plant treatment
- Cover crops / green manure for suppression

CHEMICAL APPLICATIONS - PREPLANT

- Synthetic
  - All are ground-applied:
    - Telone II / Cordon (1,2-dichloropropene)
    - Telone C35 / Pic-Clor 60 EC (1,3-dichloropropene + chloropicrin)
    - Vapam HL (metham sodium)
    - Enzone (sodium tetrathiocarbonate)**
- Organic
  - DiTera (*Myrothecium verucaria)*

Chemical recommendations can change frequently, dependent on state and product registration.

CHEMICAL APPLICATIONS – POST PLANT

- Synthetic
  - Foliar application:
    - Movento (spirotetramat)
  - Drip application
    - Enzone (sodium tetrathiocarbonate)**
    - Admire Pro (imidacloprid) (suppression only)
    - Several new products (we are currently testing)
- Organic
  - DiTera (*Myrothecium verucaria)*
  - Azadirachtin (various trade names)

Chemical recommendations can change frequently, dependent on state and product registration.

COMMON MISTAKES WITH CHEMICAL CONTROL

- “Coverage”
  - Fumigants need to reach nematodes
  - Vineyard infrastructure can limit penetration
- Timing
  - Inappropriate timing for the chemical
  - Inappropriate timing for the pest
- Wrong target
  - Only works on certain nematode species

GREEN MANURES – “CHEMICAL” CONTROL

- Green manures:
  - Cover crops grown specifically for a purpose other than soil erosion control
  - “Green” indicates they are mulched into the soil during cultivation
- Green manures come in many different forms, each with their own unique set of attributes

GREEN MANURES – MUSTARD

Mustards contain glucosinolates

myrosinase

They also contain enzymes

These two mix together when plant tissue is damaged

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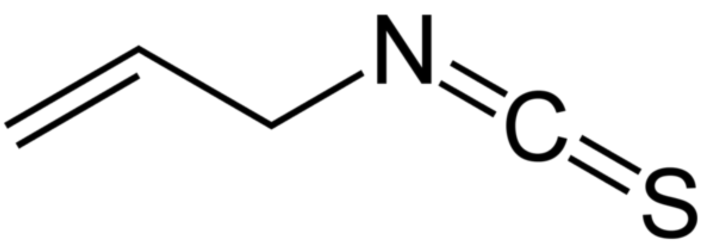

Allyl isothiocyanate (AITC)

GREEN MANURES – SUDAN GRASS

Sudan grass contains dhurrin *

+

glucosidases

Enzymes can degrade dhurrin

+

These two mix together when plant tissue is damaged

*** Dhurrin itself is a natural insect repellent**

=

H—C≡N

Hydrogen cyanide

COMMON MISTAKES IN GREEN MANURE USE

- Assumes it provides “control”
  - At best, it provides a suppression of existing populations
- Used in high-population situations
  - Green manures may help stabilize nematode populations at **low numbers**
  - They do not replace fumigation at high numbers
- Some cover crops are hosts to nematodes

CULTURAL PRACTICES – FALLOW PERIODS

- Fallow periods = period of time when no plants are being produced
  - No crops
  - No weeds
  - No cover crops
- In ideal situations, the ground is also allowed to dry down
  - Many vine parasitic nematodes do not survive in dry conditions
  - Spread can be reduced if a dry “barrier” is provided

CULTURAL PRACTICES – USE OF ROOTSTOCKS

Genotype	Parentage	*M. incognita* Race 3	*M. javanica*	*Meloidogyne* pathotypes Harmony A&C	*M. chitwoodi*	*X. index*	*M. xenoplax*	*P. vulnu*	*T. semipenetrans*	*X. ameriacanum*	*Para. hamatus*
101-14Mgt	*V. riparia, V. rupestris*			R		S	S	MR			S
1103Paulsen	*V. solonis x V. riparia*			S		S	S	MS			S
110Richter	*V. berlandieri, V. rupestris*			MR		S	S	S			S
140Ruggeri	*V. berlandieri, V. rupestris*			MR		S	S	S			MS
1613Couderc	*V. solonis, V. othello*	R	R	S	S	MR	S	MS	S	S	

Take Home:
You need to know what the nematode population *was* before you can properly select a rootstock.

Genotype	Parentage	*M. incognita* Race 3	*M. javanica*	*Meloidogyne* pathotypes Harmony A&C	*M. chitwoodi*	*X. index*	*M. xenoplax*	*P. vulnu*	*T. semipenetrans*	*X. ameriacanum*	*Para. hamatus*
Riparia Gloire	*V. riparia*			R		R	S	MR			S
RS-3	*V. candicans, V. riparia, V. rupestris*	R	R	MR	MR	S	S	MR			S
RS-9	*V. candicans, V. riparia, V. rupestris*	R	R	R	R	S	S	MS			S
Schwarzmann	*V. riparia, V. rupestris*	S	MR	S		MR	MS	S	S	MS	S
St. George	*V. rupestris*	S		S		S	S	MS			MS
Teleki 5C	*V. berlandieri, V. riparia*	MS	MR	S		MR	MS	S	S	S	MS
USDA 10-17A	*V. simpsoni, M. rotundifolia*	R	R	R	R	R	MS	R	R		
USDA 10-23B	*V. doanianna*	R	R	R	R	R	MR	R	R		
USDA 6-19B	*V. champinii*	R	R	MS	R	MR	MR	R	R	R	
VR O39-16	*V. vinifera, M. rotundifolia*	S	S	S		R	R	MR	S	MR	MR

Resistance assessed relative to nematode reproduction on cv Colombard (or other susceptible cultivar):
R <10% (resistant), MR 10-30% (moderately resistant), MS 30-50% (moderately susceptible), S >50% (susceptible).

Table from: Ferris, H., L. Zheng, and M.A. Walker. 2012. J Nematol 44(4) 377-386.

Viticulture and Enology Program
WASHINGTON STATE UNIVERSITY

CURRENT AND FORTHCOMING PROJECTS

Rootstocks, thresholds, and practical management tactics.

PROJECT BACKGROUND

- We do not have “action” thresholds for nematode management in Washington
  - Current numbers are simply “average”
- Recent work shows preplant fumigation does not last long
- Recent work shows that our timing of action does not align with nematode biology
- Work in other systems suggest plant nutrient status influence nematode development

Viticulture and Enology Program
WASHINGTON STATE UNIVERSITY

THE NEMATODE TEAM

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Gertrude
The Elutriator

The essentials

HOST-STATUS OF OWN-ROOTED VINES

Type (*V. vinifera)*	Eggs per gram root	Reproduction Factor
White	83,730 a	34.6 a
Red	9,881 b	12.5 b

Variety (own-rooted)	Eggs per gram root	Reproduction Factor
Chardonnay	46,894 a	45.1 a
Riesling	30,566 b	27.6 b
Cabernet Sauvignon	13,015 bc	18.2 bc
Syrah	9,772 c	7.9 c
Merlot	6,856 c	9.5 c

Work done by I. Zasada at USDA-ARS, Corvallis, OR

ROOTSTOCKS & PREPLANT FUMIGATION


Site preparation for removal Fall 2014


Site preparation for planting Spring 2015


Grafted vines Spring 2015


Direct inoculation pre-planting Spring 2015

ROOTSTOCK SELECTION

Rootstock	Selection Reasoning
101-14 MTG (riparia x rupestris)	**Moderate to high nematode resistance**. Bonus of phylloxera and crown gall resistance. Tends to low vigor and earlier ripening. **Lower drought resistance.**
Harmony ([solonis x Othello] x Dogridge)	Specifically bred for **nematode resistance**. It is not phylloxera resistant, but it is crown gall resistant.
1103 P (berlandieri x rupestris)	Susceptible to Dagger nematode**, but moderate to high resistance to Root-knot nematode.** Tends to high vigor, but is **relatively drought resistant**.
Teleki 5C (berlandieri x riparia)	Decent nematode (except Dagger) and phylloxera resistance. Tends to moderate vigor, and earlier ripening.
Own Rooted (vinifera)	Industry standard control
Own-Rooted, Self-Grafted (vinifera)	Grafting control

PROJECT DESIGN

Rootstock	Soil Treatments			
101-14 Mtg 101-14 Mtg	Bench Field	Field Bench	Field Bench	Bench Field
Harmony Own-Root (NG) 101-14 Mtg Teleki 5C Own-Root (G) 1103 P	Non-fumigated		Fumigated	
Teleki 5C 1103 P Harmony 101-14 Mtg Own-Root (G) Own-Root (NG)	Fumigated		Non-fumigated	
Own-Root (G) 1103 P Teleki 5C Own-Root (NG) Harmony 101-14 Mtg	Fumigated		Non-fumigated	
Own-Root (NG) Harmony Own-Root (G) 101-14 Mtg 1103 P Teleki 5C	Non-fumigated		Fumigated	

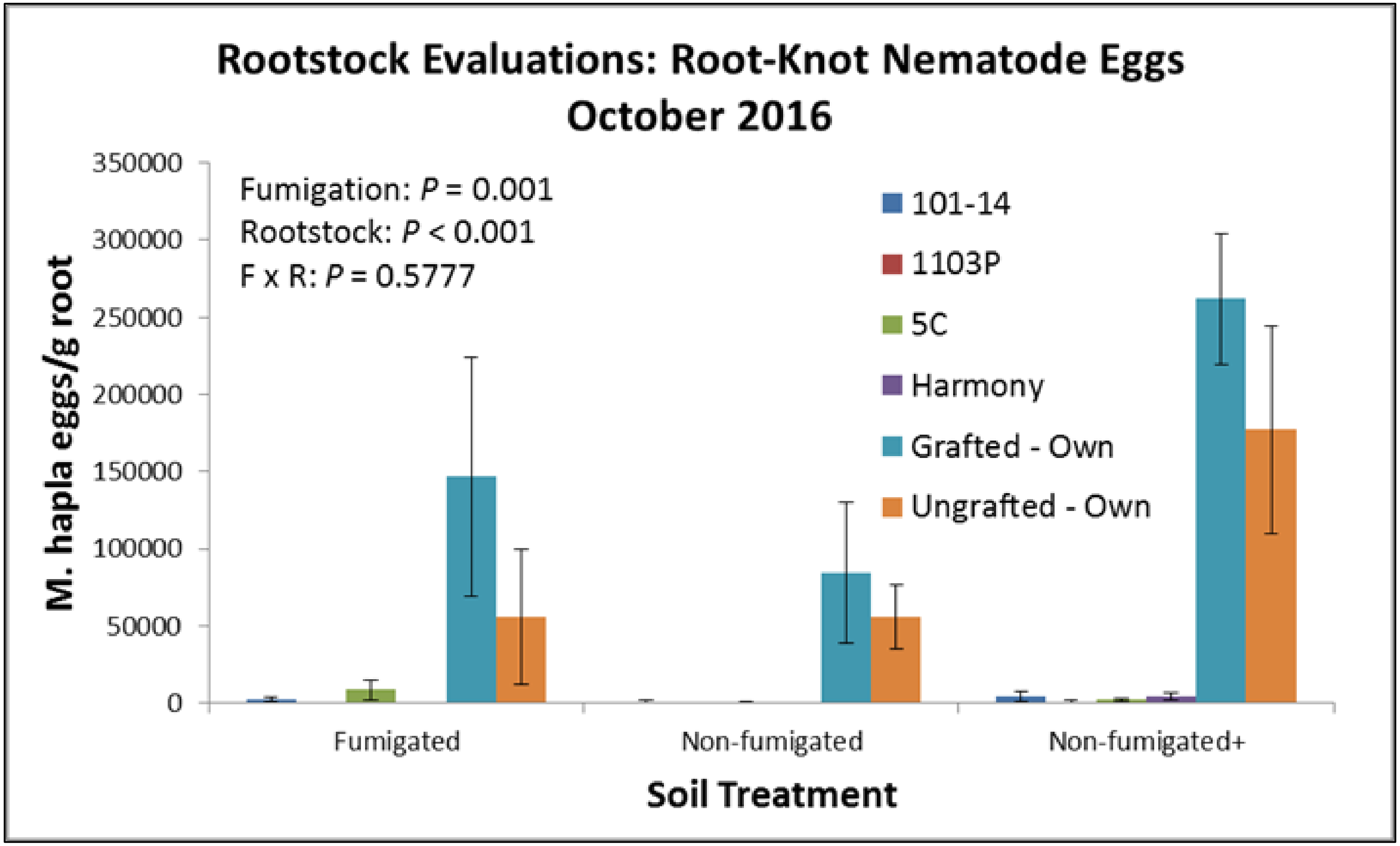
Inoculated
(10 vines)

INFLUENCE OF FUMIGATION ON NEMATODES

Image omitted; research is pre-publication

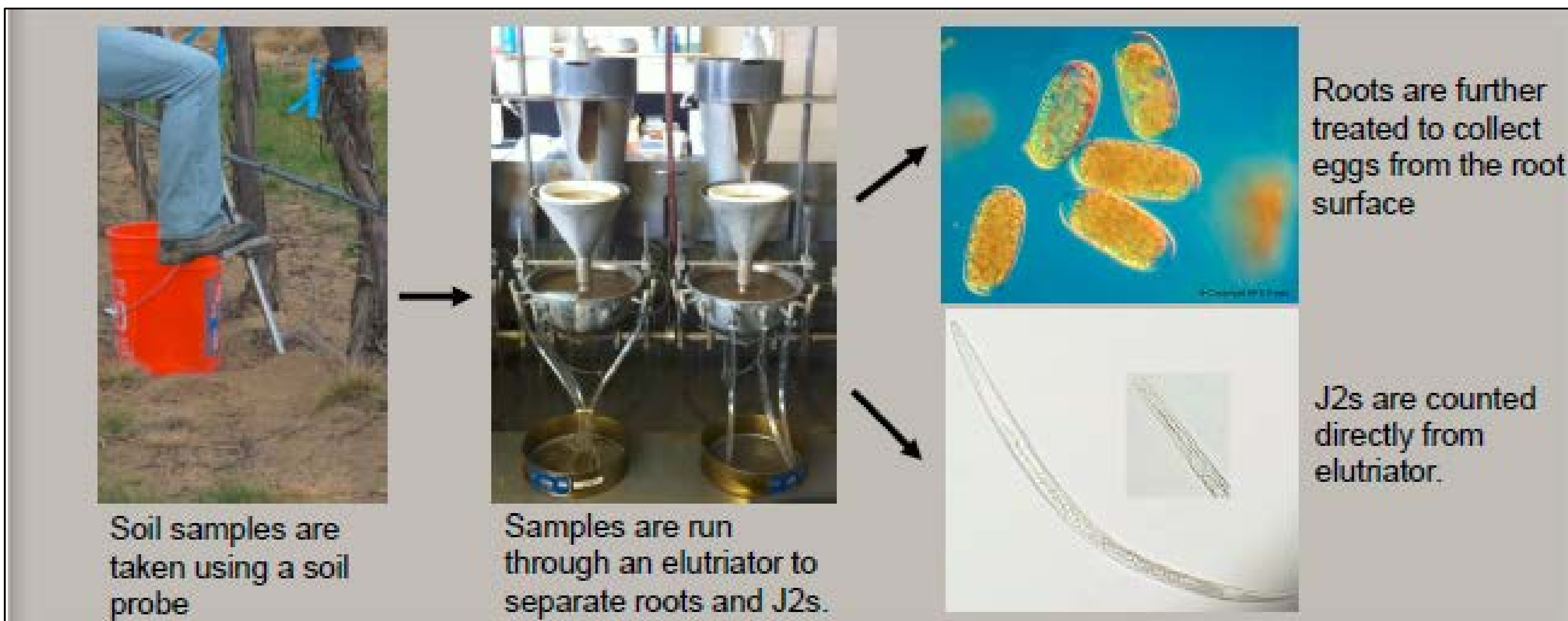
- Fumigation significantly reduced J2s immediately after spring treatment
- J2 populations began to return by fall (6 months) post treatment
- By 18 months post treatment (approximately 12 months post-planting) J2 populations in treated areas returned to pre-treatment levels

INFLUENCE OF FUMIGATION ON NEMATODES



IMPROVE PRODUCT TIMING – NEMATODE MODELING

Soil and root samples collected:
weekly April – Sept;
and monthly Oct – March
Samples collected at 2 sites, over 2 years



IS OUR CURRENT TIMING OFF?

Presented results omitted; research is pre-publication

1. J2 numbers *decline* in the spring to a low-point mid-summer
2. J2 numbers start to climb late-summer to early fall, peaking late in the growing season
3. *M. hapla* overwintering as J2!

NEMATODES RESPONDING TO ROOT GROWTH?

Presented results omitted; research is pre-publication

1. Seeing mid-summer root flush in *Vitis vinifera*
2. This contrasts with most literature (which say 2 flushes, spring and fall)
3. J2 appear to peak after root flush in summer

EVALUATING POST-PLANT NEMATICIDES

Product	Rates	Timing	Application Type
Nimitz	3.5-5 lbs ai/acre	Apr (October 2017)	Drip
Salibro (Dupont Q8U80)	61.4, 30.7, 30.7 fl oz /acre	Apr, May, Jun	Drip
Velum Prime (fluopyram)	6.84 fl oz/ acre	Apr, Oct	Drip
Movento	6.25 fl oz product / acre	May, Jun	Foliar
Velum Prime + Movento	6.84 fl oz/ acre + 6.25 fl oz product / acre	Apr, Oct+ May, Jun	Drip + Foliar
Control	n/a		Drip

Collecting data on:

Nematode response, fruit quality, dormant pruning weights

Presented results omitted: pre-publication

THRESHOLDS AND VINE RESPONSE

- **Experiment 1:** Challenge rootstocks with *M. hapla* to examine the durability of resistance responses over a range of nematode densities.
- **Experiment 2**: Determine if water availability and irrigation affect the host-parasite interaction in establishing vineyards.
- **Experiment 3:** Determine if vine nutritional status (particularly nitrogen) changes the host-parasite interaction and improves vine tolerance to *M. hapla* during vineyard establishment.

ROOTSTOCKS & FUMIGATION (10YRS)

- Continue collecting data at Canoe Ridge trial planting
- Will be able to provide numbers on effectiveness of each practice
  - Is preplant fumigation really enough?
  - Is the use of a rootstock worth it?
  - Do you need both in replant situations?
- Will collect nematode, vine response (dormant pruning weights, yields) over ~10 years

ANTICIPATED PROJECT OUTCOMES

1. Learn what nematode densities elicit damage in new vineyards (**establish action thresholds**)
2. Learn how rootstocks perform against our nematode species (**management practices**)
3. Determine how irrigation and nutritional status of newly-planted vines influence their response to nematode pressure (**management practices**)
4. Determine duration of preplant fumigation relief in replant scenarios (**management practices**)
5. Final evaluation of post-plant nematicides (**management practices**)

QUESTIONS?

VITICULTURE EXTENSION
WASHINGTON STATE UNIVERSITY

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