ROOTSTOCK SELECTION AS A TOOL TO ADDRESS SOIL CHALLENGES AND MAJOR PESTS AND DISEASES

Moderator: Sebastian Saa (ABC)
Speakers: Roger Duncan (UC ANR), Katherine Jarvis-Shean (UC ANR), Greg Browne (USDA-ARS), Andreas Westphal (UC Riverside), Chuck Fleck (Sierra Gold)

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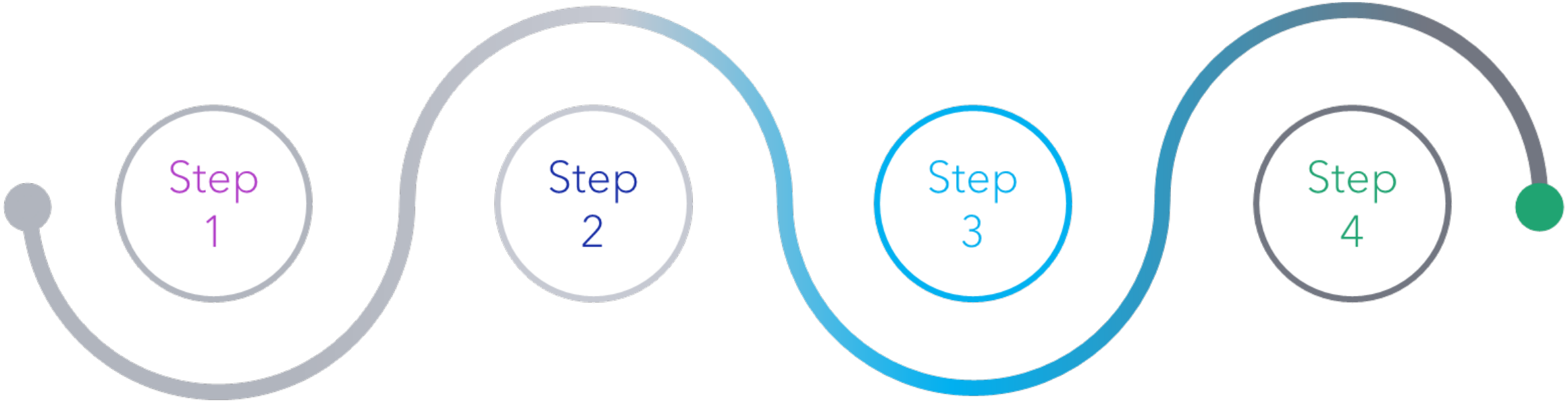
ABC Rootstock Research Portfolio



Almond Rootstocks

Salt tolerance, growth & yield

Roger Duncan

Orchard Crops Advisor

University of California

Cooperative Extension

Stanislaus County

University of California
Agriculture and Natural Resources

Rootstock Influences Many Things

- Nematode tolerance
- Soil-borne disease tolerance
- Soil / water chemistry tolerance
- Vigor
- Nutrition
- Bloom time
- Date of maturity
- Drought tolerance

What is the best rootstock?

Rootstock choice should be site specific and based on the physical, chemical, and biological conditions in your field

Almond Rootstock Parentage
Broad Overview

- **Almond** (***Prunus dulcis)***
- **Peach** (***Prunus persica)***
- **Plum** (***Prunus cerasifera, P. insititia, etc.)***

Almond

- Native to deserts of Western Asia
- Drought tolerant
- Susceptible to wet soil and associated diseases
- Tolerant of alkaline soils (high pH, lime)
- Salt tolerant (Cl & Na)
- Vigorous
- Deep roots
- Long lived

Peach Rootstocks

- Lovell
- Halford
- Nemaguard
- Nemared
- Guardian
- Empyrean 1
- Cadaman (aka Avimag)

Peach

- Highly compatible with almond
- Native to higher rainfall areas of China
- Not drought tolerant
- Less susceptible to wet soil and associated diseases than almond
- Not tolerant of high pH, lime, alkaline soils
- Not salt tolerant
- Less vigorous than almond

Plum

- Tolerant of saturated / low oxygen soil conditions and associated diseases (Phytophthora, oak root fungus, crown gall, heart rot, etc.)
- Low vigor, especially if under-irrigated
- Shallower, finer roots
- Variable compatibility with almond
- Root suckers

Marianna 26-24
Marianna 40
Penta
Tetra
Julior
Adesoto

There are now many hybrid rootstocks from which to choose

- **Peach x Almond hybrids**
  - **Hansen, Brights 5, BB 106, Cornerstone, Titan hybrids, Nickels, FxA**
- **Peach x Plum (Krymsk 86)**
- **Almond x Plum (Rootpac R)**
- **Complex hybrids (peach, almond, plum, apricot)**
  - **Viking, Atlas**

Salt Tolerance

Salinity Tolerance of P/A Hybrid Rootstocks

Atwater rootstock trial, 2006

	Na (%)	***Cl (%)***
Nemaguard	0.64	0.22
Lovell	0.72	0.26
Hansen	0.17	0.09
Brights Hybrid	0.20	0.07
Critical level	>0.25%	> 0.3%

Comparison of Rootstocks for Salt Accumulation in July-Sampled Leaves

- Sandy loam soil; Keyes. CA

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Relative Salt Tolerance of Almond Rootstocks		
	% Sodium	% Chloride
Nemaguard	**0.99**	**0.51**
Lovell	**0.70**	**0.50**
Guardian	**0.76**	**0.41**
Cadaman	**0.38**	0.25
Empyrean 1	0.09	0.07
Hansen	0.09	0.07
GF 677	0.04	0.05
Cornerstone	0.04	0.05
Viking	0.29	0.21
Atlas	**0.94**	0.29
Krymsk 86	**0.60**	**0.32**
Penta	**0.30**	**0.41**
Julior	**0.35**	0.16
Adesoto	0.06	0.04
Critical Level	0.25	0.30

Rootstock Effect on Chloride Accumulation in Leaf Tissue

- July 2020 (8th leaf)
- Clay loam soil, Westley, CA
- Cl critical level = 0.3%

	% Cl	
Krymsk 86	1.21	a
PAC9908-02	1.10	a
Nemaguard	0.96	b
Lovell	0.95	b
HBOK 50	0.68	c
Atlas	0.57	cd
Viking	0.55	d
Cadaman	0.54	d
HM2	0.39	e
Empyrean 1	0.36	e
FxA	0.28	ef
Hansen	0.27	ef
BB 106	0.25	ef
Rootpac R	0.22	f
Brights 5	0.17	f
GF677	0.16	f

*P ≤ 0.05

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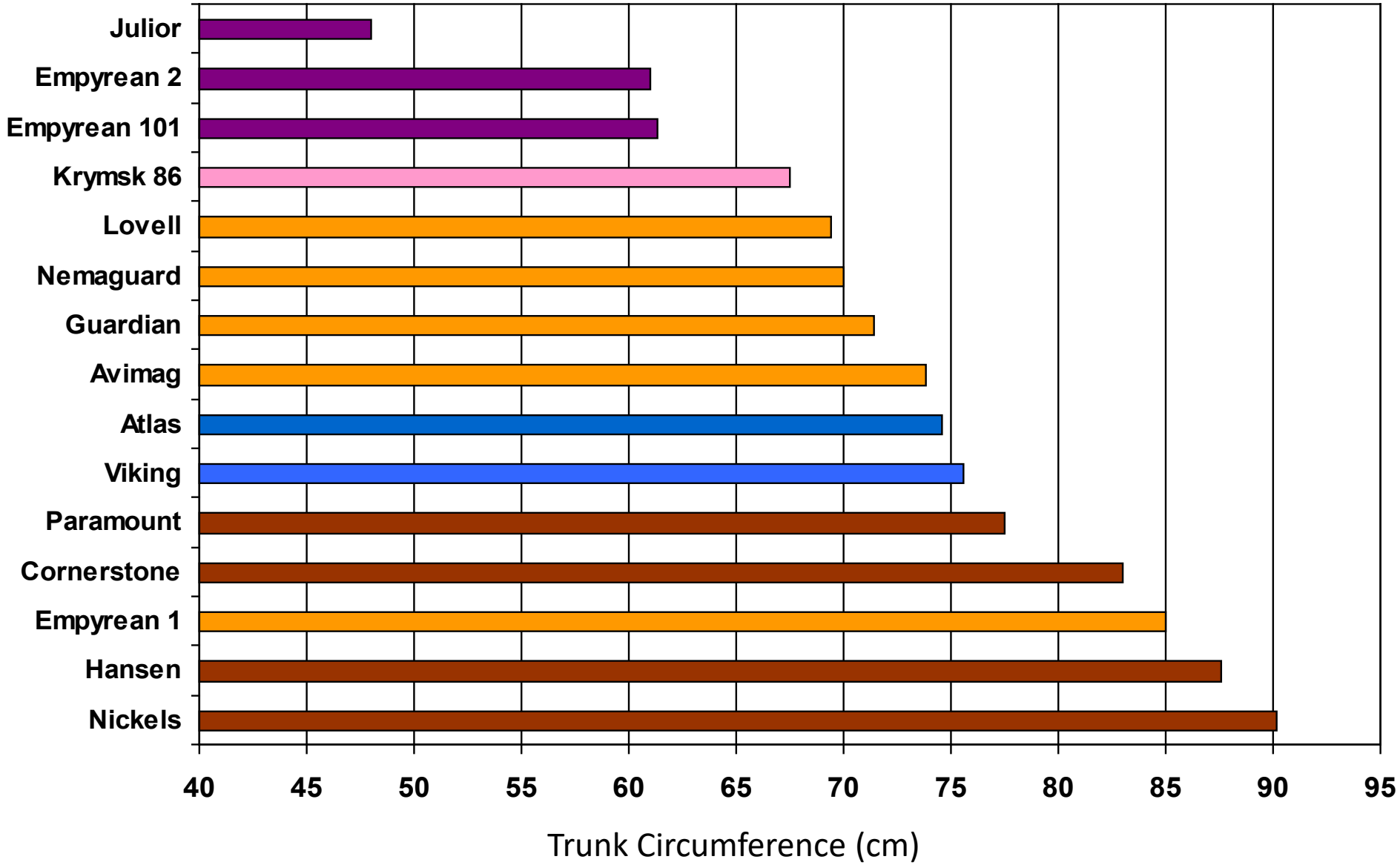
Vigor and Yield

Rootstock Influence on Tree Size

Keyes, CA. Sandy Loam Soil. 10th Leaf



Rootstock Effect on Tree Size

Clay loam soil
Vernalis, CA

2020 (9th leaf)	Genetic Origin	Trunk Circumference (cm)	Canopy Size (PAR)
Flordaguard x Alnem	Peach x almond	73.0 a	77.1
BB 106	Peach x almond	71.4 ab	77.0
Hansen	Peach x almond	70.9 ab	75.6
Empyrean 1	Peach hybrid	68.3 b	69.5
HM2	PA x PA	68.0 b	70.6
PAC9908-02	PA x peach	67.5 b	66.8
Rootpac R	Almond x plum	65.4 bc	64.3
Paramount (GF677)	Peach x almond	62.6 cd	67.5
Brights 5	Peach x almond	61.7 de	72.5
HBOK 50	Peach	61.4 de	62.5
Atlas	Complex hybrid	60.8 de	62.5
Viking	Complex hybrid	60.4 de	62.8
Nemaguard	Peach	59.0 def	63.3
Krymsk 86	Peach x plum	56.3 ef	58.0
Lovell	Peach	56.1 f	52.4

Rootstock Effect on Yield

Top five yielding rootstocks are PA hybrids

	2020 Yield per Acre (9th leaf)	Cum Yield (4th – 7th) & 9th
BB 106	4091 a	16,294
Brights 5	3859 ab	15,423
Hansen	3661 ab	15,016
HM2	3447 ab	14,808
Flordaguard x Alnem	3170 bcd	15,446
Empyrean 1	3096 bcde	14,557
Paramount (GF 677)	3084 bcde	12,663
Rootpac R	2826 cde	13,413
Viking	2791 cde	12,495
Nemaguard	2791 cde	11,624
Atlas	2626 de	13,132
Krymsk 86	2474 de	11,340
PAC9908-02	2470 de	13,386
HBOK 50	2326 ef	11,527
Lovell	1680 f	9,720

Rootstock Effect on Yield Efficiency

	2020 Yield per Acre (9th leaf)	Cum Yield (4th – 7th) & 9th	2020 Yield Efficiency (lb / cm trunk)	2020 Yield Efficiency (lb / % PAR)
BB 106	4091 a	16,294	57.3	53
Brights 5	3859 ab	15,423	62.5	53
Hansen	3661 ab	15,016	51.6	49
HM2	3447 ab	14,808	50.7	49
Flordaguard x Alnem	3170 bcd	15,446	43.4	41
Empyrean 1	3096 bcde	14,557	45.3	45
Paramount (GF 677)	3084 bcde	12,663	49.3	46
Rootpac R	2826 cde	13,413	43.2	44
Viking	2791 cde	12,495	46.2	44
Nemaguard	2791 cde	11,624	47.3	44
Atlas	2626 de	13,132	43.2	42
Krymsk 86	2474 de	11,340	43.9	43
PAC9908-02	2470 de	13,386	36.6	37
HBOK 50	2326 ef	11,527	37.9	37
Lovell	1680 f	9,720	29.9	32

Rootstock Effect on Yield Efficiency

Peach x almond hybrids not just larger, but more yield efficient in this trial

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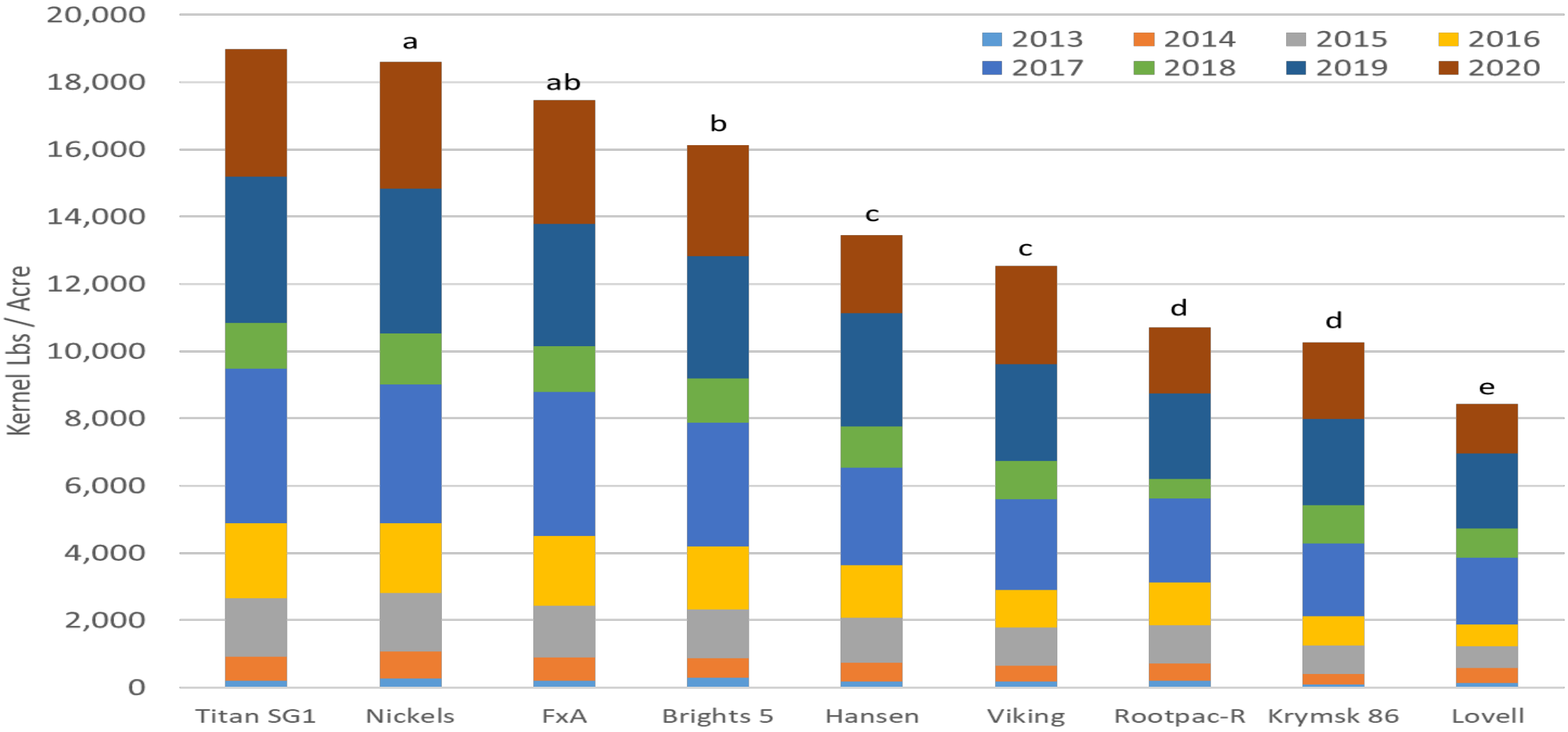
Cumulative yield for 3rd through 10th leaf (2013-2020). Yolo County Rootstock Trial



Yolo County Rootstock Trial – Katherine Jarvis-Shean

Rootstock	Origin	2020 Avg. Yield (kernel lbs/acre)*		Light Intercep't (% PAR)		Size Efficiency (Lbs/PAR)	Trunk Circum (inches 18" above soil)	
Titan SG1	Peach-Alm	3,790		77		49	31	
Nickels	Peach-Alm	3,788	a	77	a	49	32	ab
FxA	Peach-Alm	3,693	ab	80	a	46	33	a
Brights 5	Peach-Alm	3,305	ab	71	ab	46	29	d
Viking	Pch-Al-Myro-Apr	2,911	bc	64	bc	46	29	cd
Hansen 536	Peach-Alm	2,307	cd	72	ab	32	31	bc
Krymsk 86	Myro Plum-Peach	2,278	cde	54	cd	42	27	de
Rootpac-R	Myro Plum-Alm	1,961	de	53	cd	37	29	cd
Lovell	Peach	1,475	e	46	d	32	26	e

Colusa County Rootstock Trial – John Edstrom

Rootstock	Nonpareil yield (kernel lbs/ac)				Yield per unit PAR intercepted			
	2009		2010		2009		2010	
Brights	3671	a	2912	bcd	59.3	a	48.3	abc
Nickels	3721	a	3451	a	56.6	ab	51.9	a
Hansen 536	3955	a	3142	ab	54.1	abcd	42.5	cd
Atlas	2938	b	2889	bcd	49.6	bcde	51.4	ab
Viking	2909	b	2680	cd	47.6	cde	43.8	cd
Nemaguard	3959	a	2616	cd	47.0	de	40.7	cd
Lovell	2672	b	2564	d	43.6	e	41.8	cd

Conclusions

- **Rootstock characteristics tend to fall in behind their almond, peach or plum parents**
- **Peach x almond hybrids are among the most tolerant commercial rootstocks to sodium, chloride, high pH, and alkaline soil / water**
- **They are also the most vigorous and may have higher yield efficiency in many cases**
- **They DO NOT perform well in all conditions**

Rootstocks: Boron & Anchorage

Kat Jarvis-Shean, UCCE Advisor
Sacramento, Solano & Yolo Counties

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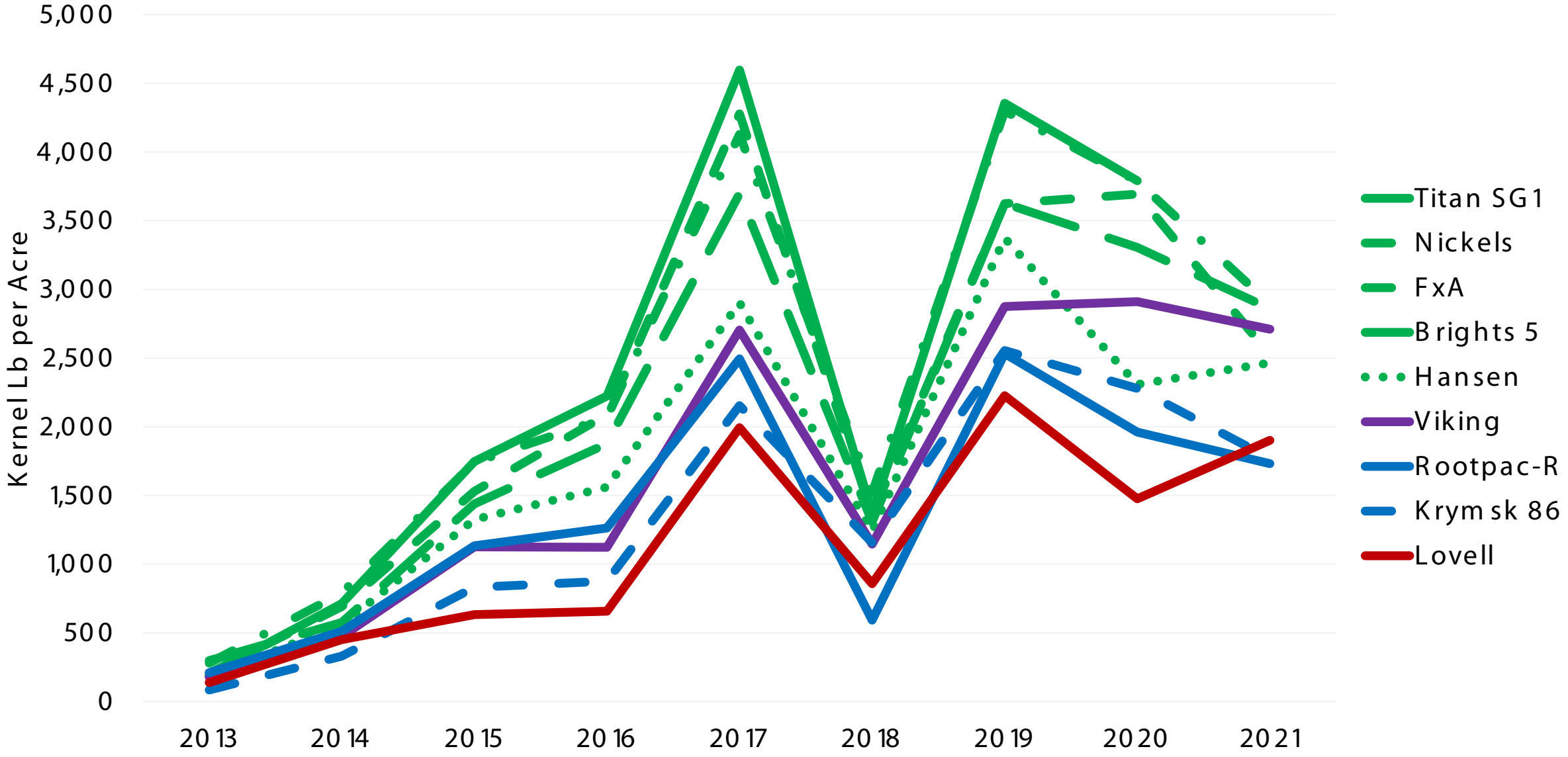
High Boron → Gumming

High Boron → Gumming → Infection

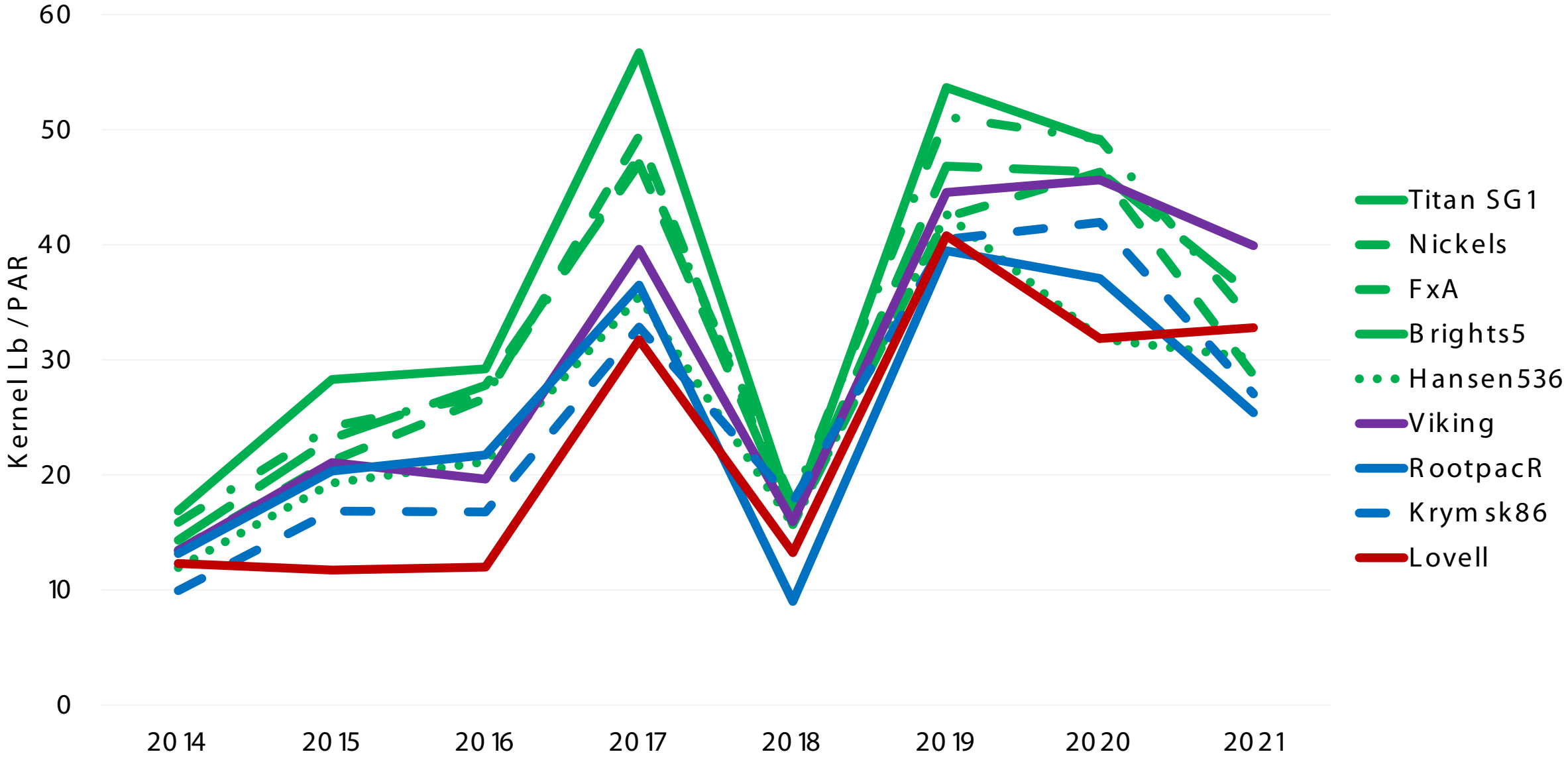
High Boron → Dead Shoots

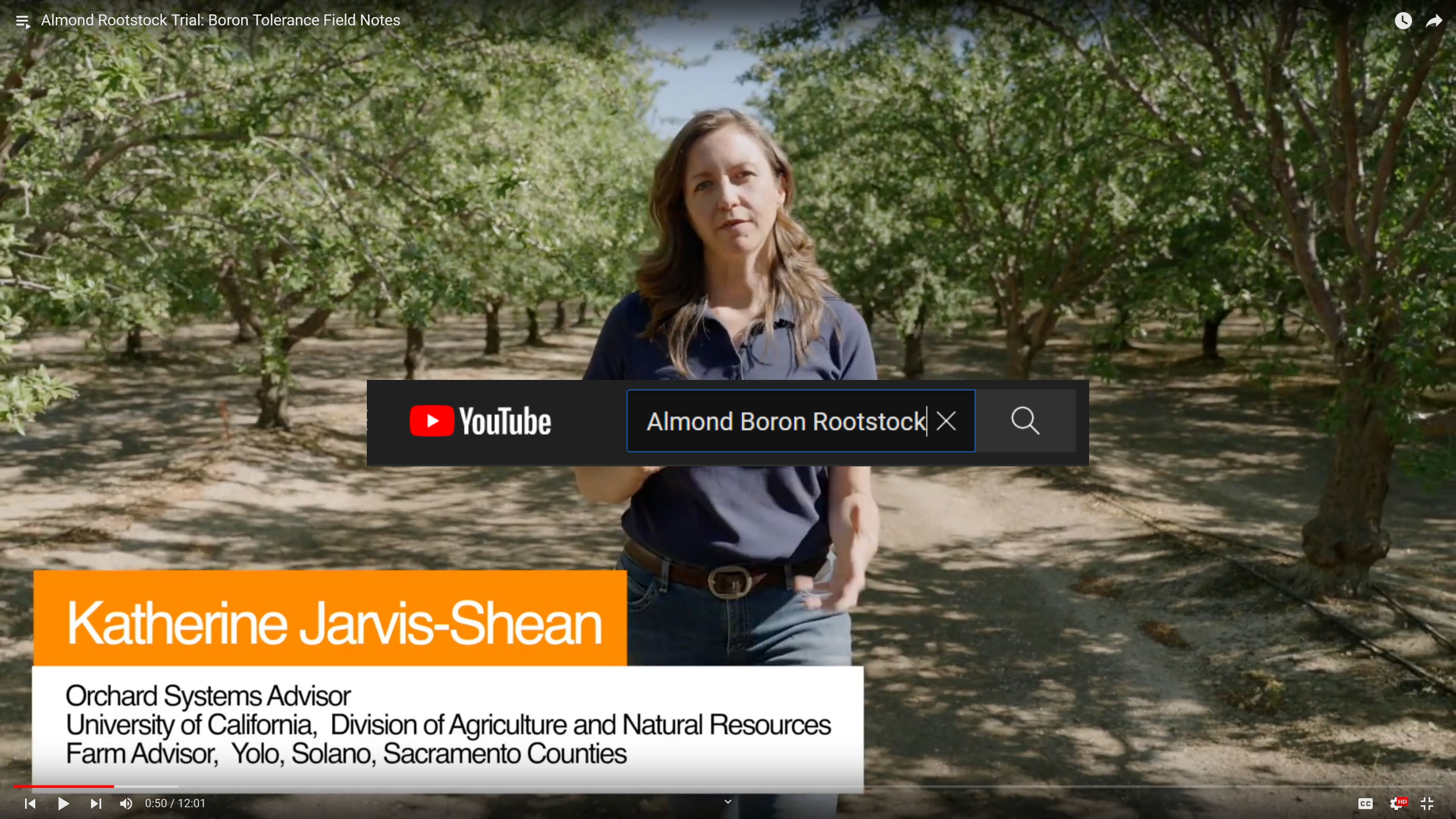
Same Boron, Different Rootstocks

Peach-Almond Hybrid Highest Yields



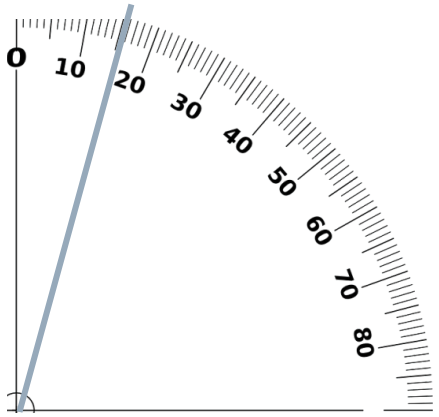
Peach-Almond Hybrid Highest Efficiency

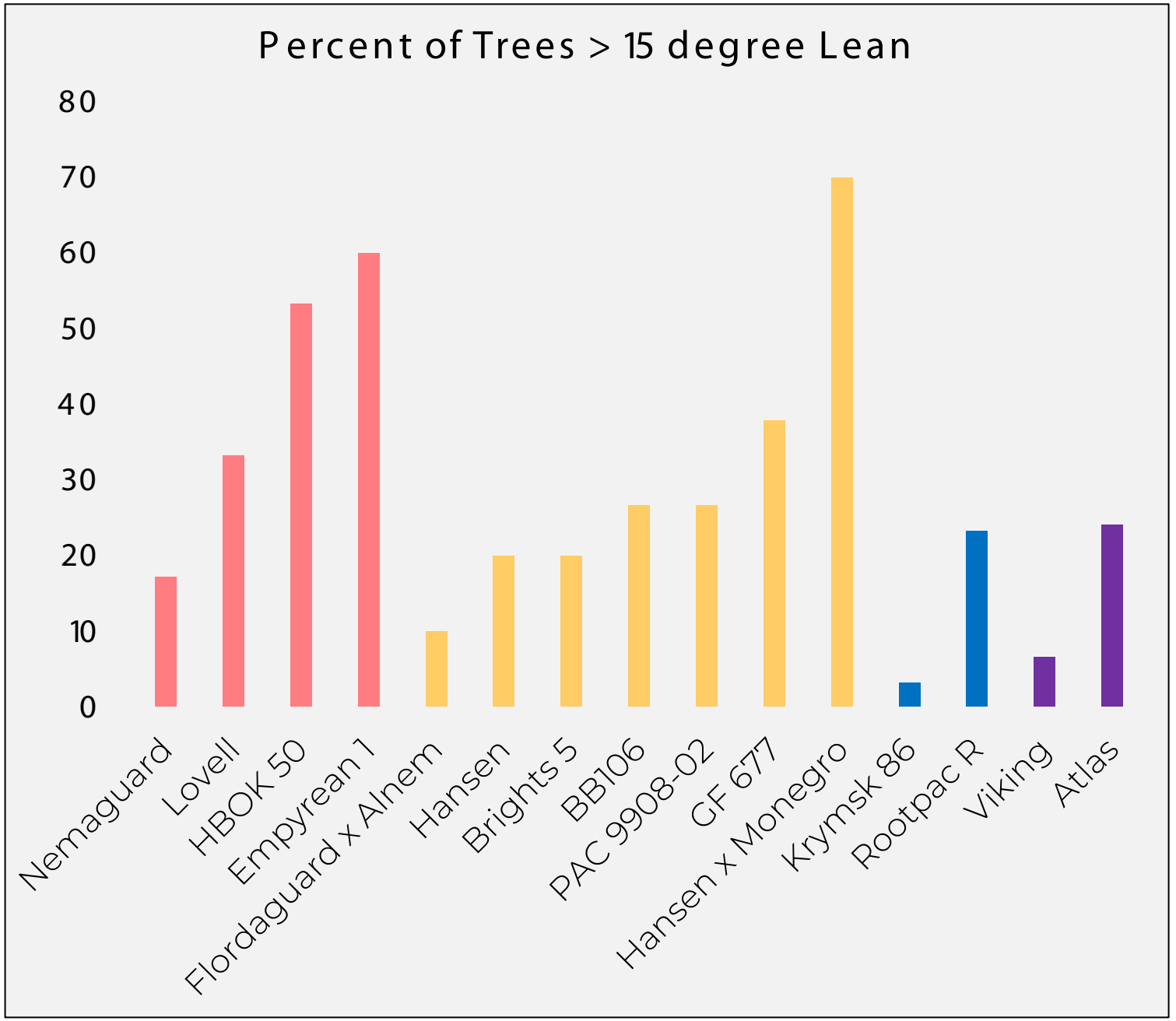



Almond Rootstock Trial: Boron Tolerance Field Notes
YouTube
Almond Boron Rootstock
Katherine Jarvis-Shean
Orchard Systems Advisor
University of California, Division of Agriculture and Natural Resources
Farm Advisor, Yolo, Solano, Sacramento Counties
0:50 / 12:01

Dr. Astrid Volder, UC Davis

Anchorage





Adapted from Duncan, Stanislaus Co.

Acute Anchorage Problems (Gusts)

Gust Anchorage

Gust Anchorage

Kern County. Planted 1997.
March 4, 2001 – 80 mph winds for 5 hrs w/ 1.75” rain

Rootstock	Parents	Blow Over
Bright’s Hybrid	PxA	13%
Hansen 536	PxA	9%
Hansen 2168	PxA	4%
Viking	Complex	4%
Atlas	Complex	30%
Nemaguard	Peach	58%

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Rootstock Selection as a Tool to Address Soil Challenges and Major Pests and Diseases: Nematodes

12/08/2021 / Andreas Westphal, UC Riverside

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Nematodes

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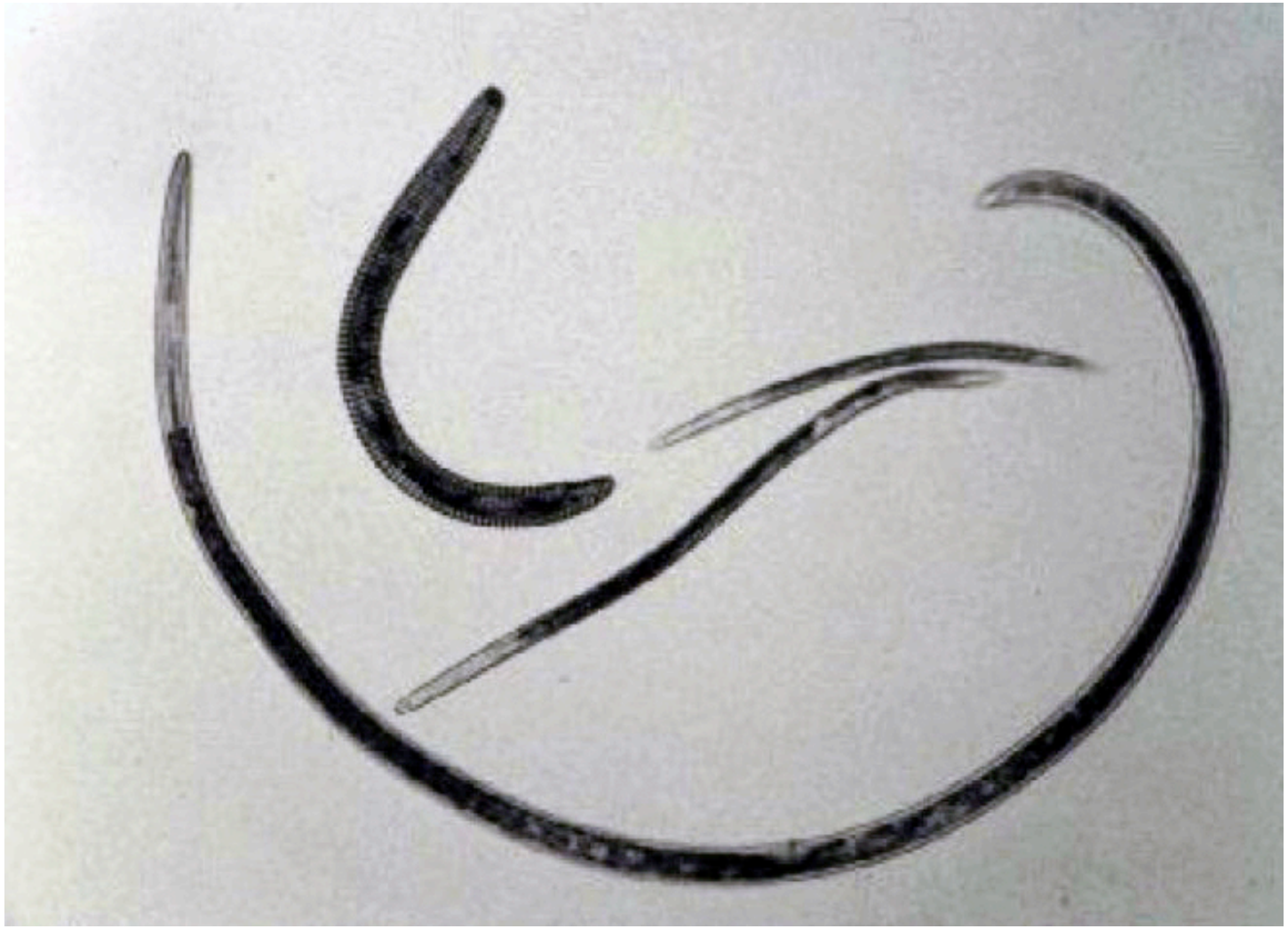
Plant-parasitic nematodes expected in almond orchards

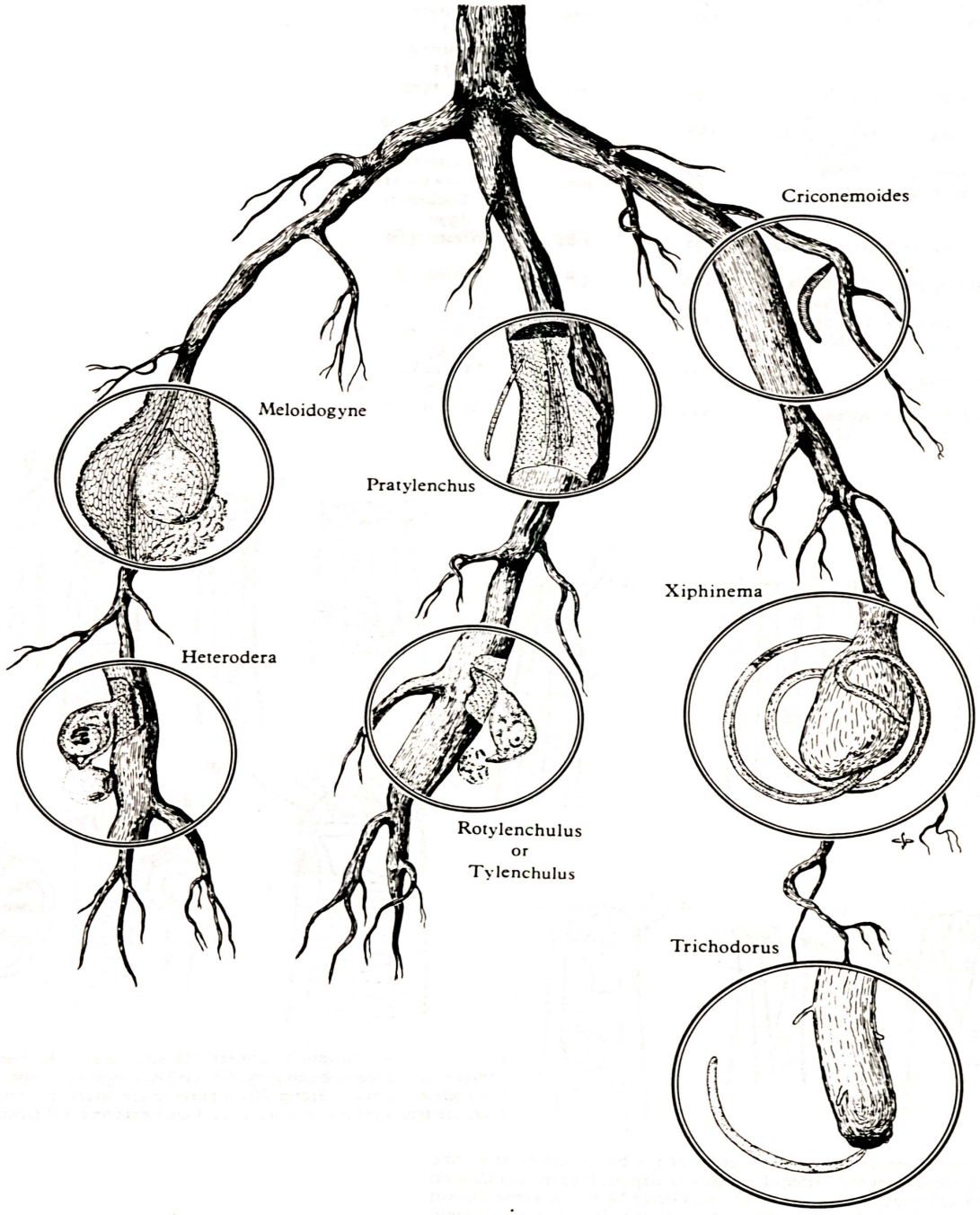
- What species are expected?
- Where do they occur in the field?
- Examples of nematode damage.
- How to develop new rootstock tools?
- New threats on the horizon (??)

Plant-parasitic nematodes expected in almond orchards



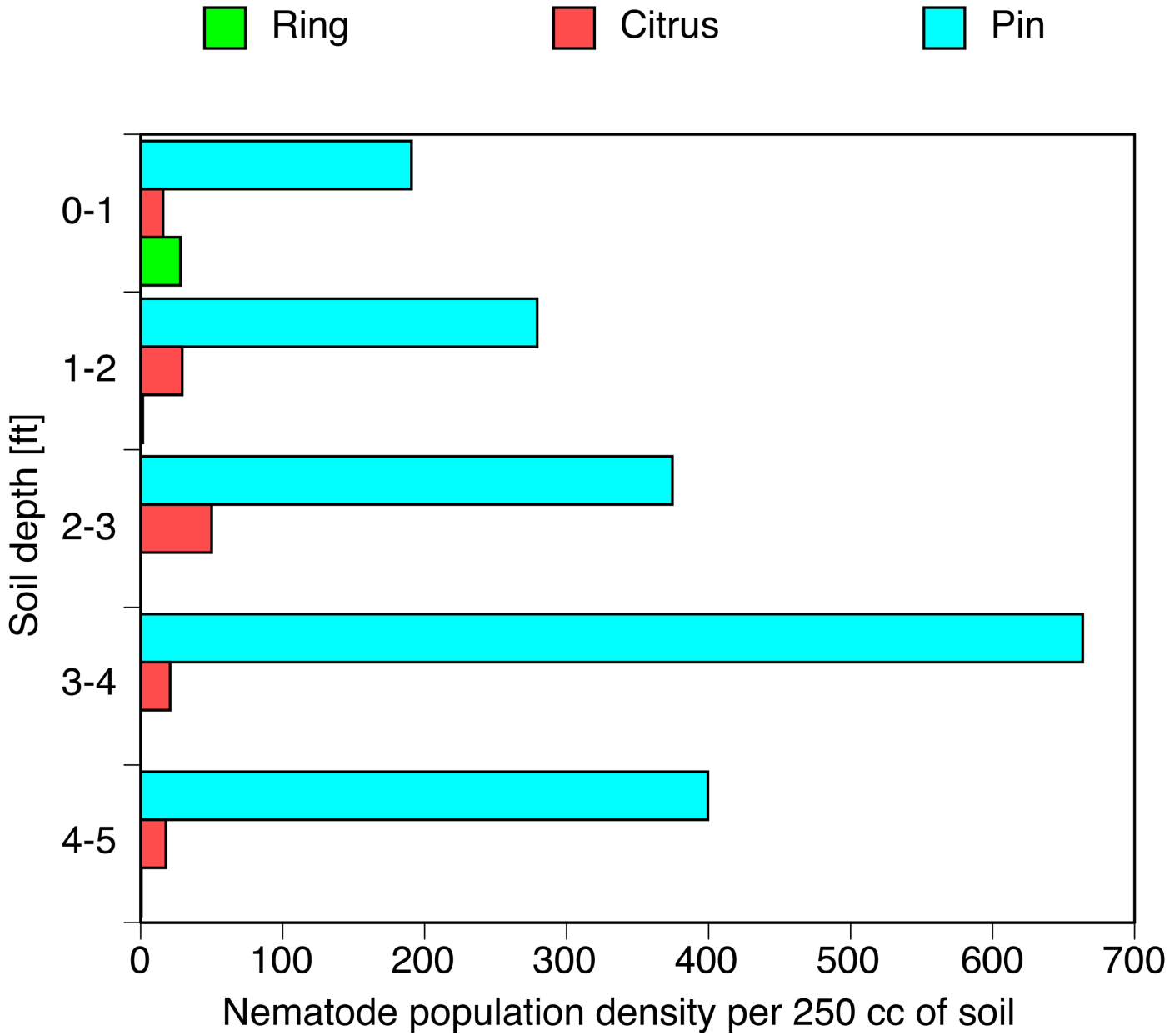
(Photo: Mike McKenry)

Feeding habits of plant-parasitic nematodes



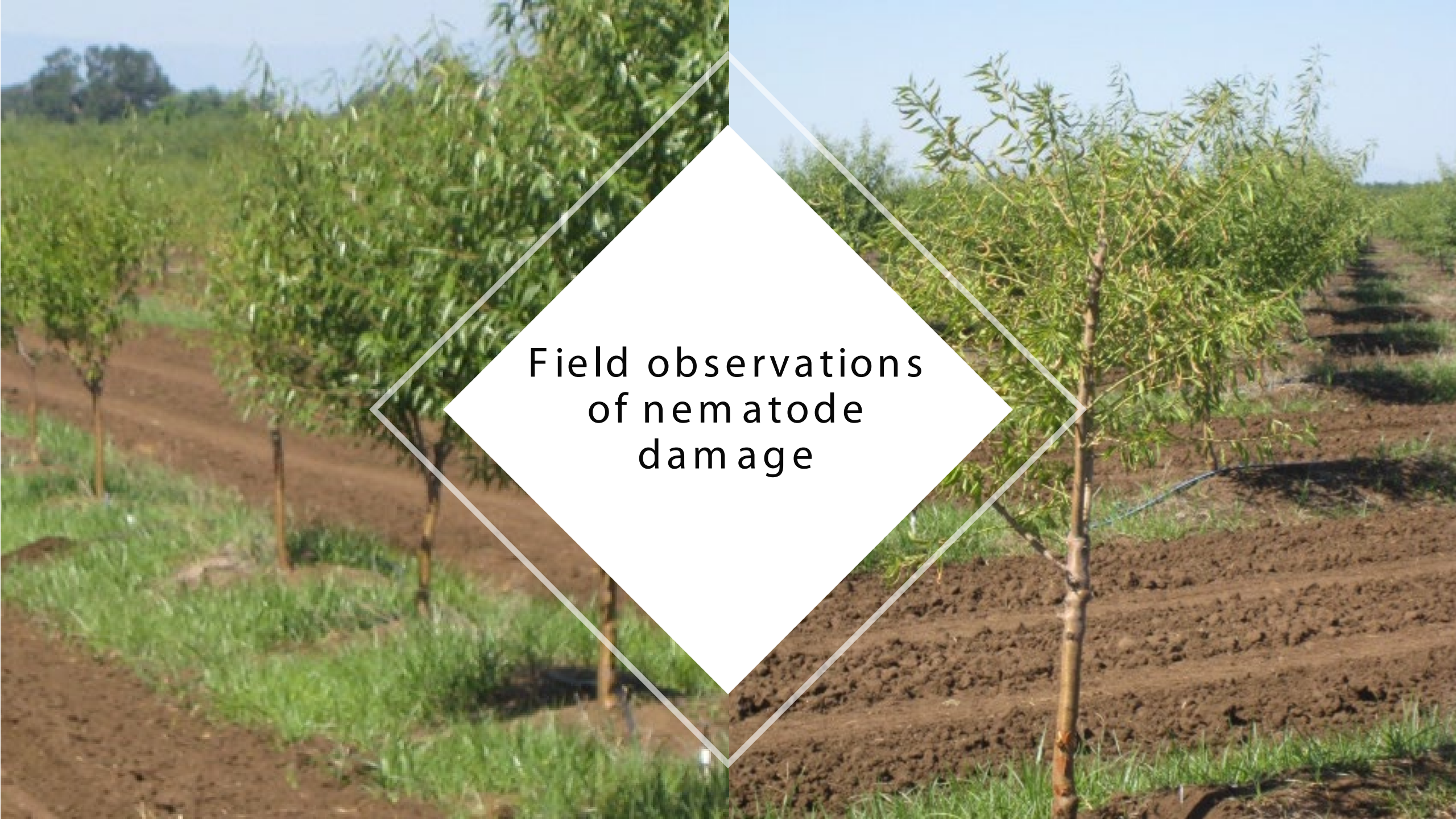
(Drawing: Papp)

Where are they in the soil profile?



Plant-parasitic nematodes: symptoms

Field observations of nematode damage



A healthy almond tree

- Strong anchoring roots
- Vigorous canopy
- Fibrous roots

Weak tree with heavy nematode-induced galling

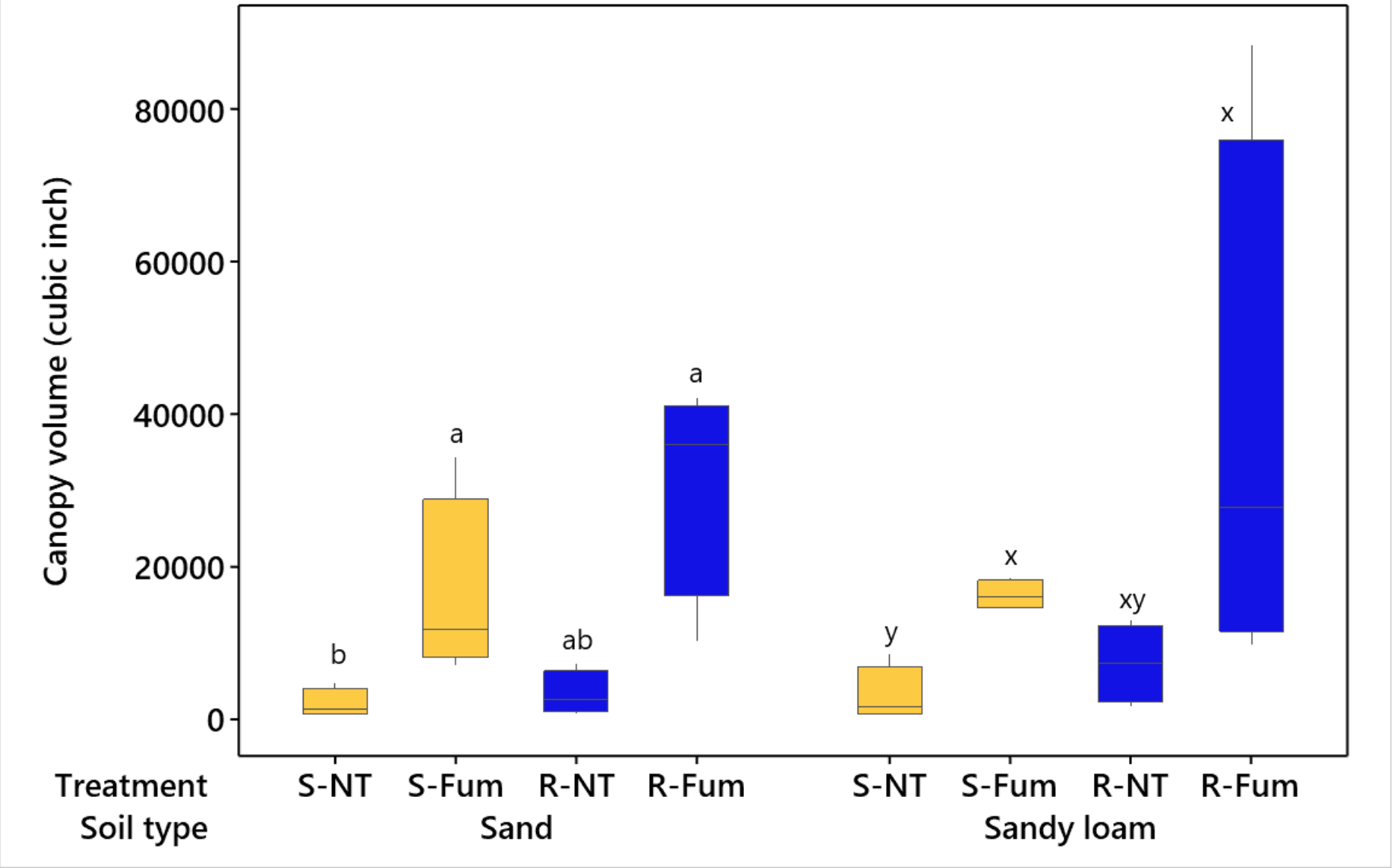
Plant-parasitic nematodes

Success story: **'Nemaguard'**

- Highly resistant against southern root-knot nematodes
- For >60 years protection of Prunus crops

- Limitations:
  - Susceptible to Pratylenchus vulnus, root lesion nematode
  - Susceptible to Mesocriconema xenoplax, ring nematode
  - Susceptible to Meloidogyne floridensis, peach root-knot nematode

Almond grown in different infestation levels with RLN



Plant-parasitic nematodes interacting with the host

Resistance: Reproduction of nematodes

=> population densities?

susceptible ⇔ resistant

Tolerance: Reaction of the plant to nematodes

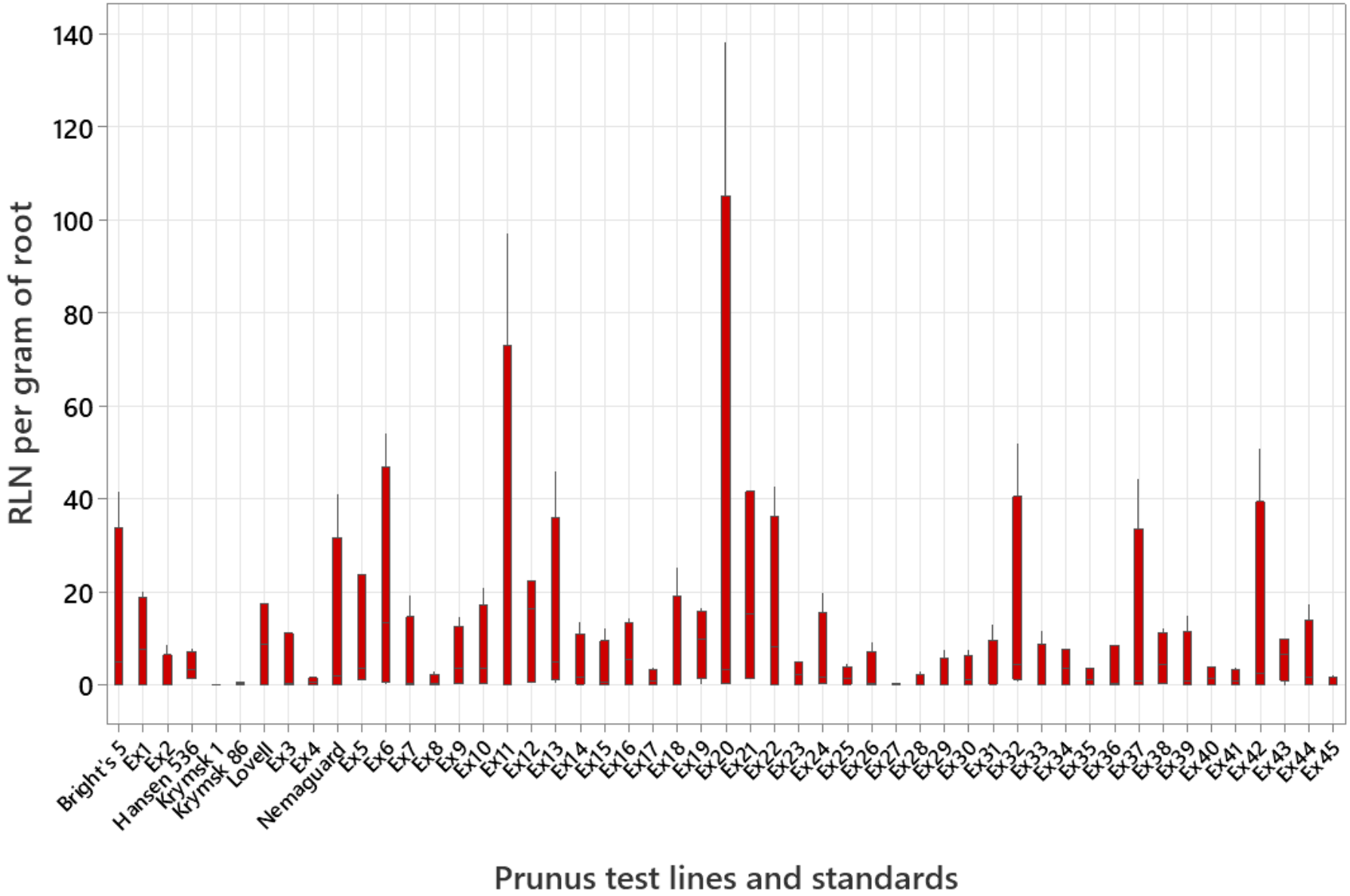
=> plant damage?

intolerant ⇔ tolerant

Screening for nematode resistance and tolerance

- Provision of hybrid genotypes (USDA; UC Davis)
- Field planting and inoculations with RLN and RKN
- Monitoring, preliminary test 1st year; test 2nd year
- Selecting promising genotypes for transplanting for continued monitoring
- Selecting candidates for grafting and intermediary experiments
- Propose candidates for field trialing and release

Example of screening results



Current status of research projects in rootstock improvements

Cooperation: Dan Kluepfel, Greg Browne, Malli Aradhya, Tom Gradziel (USDA-ARS, UC Davis)

- Hybrids with nematode resistance and tolerance identified.
- Hybrids with multiple resistances identified.
- Hybrids under horticultural and susceptibility evaluations.

"I know, I have a zoo of nematodes. I do plant first, and then deal with the problem later"

Plant-parasitic nematodes expected in almond orchards

New potential threat:

Peach root-knot nematode

‘Hansen 536’

Galls on roots

Plant-parasitic nematodes expected in almond orchards

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- How to develop new rootstock tools?
- New threats on the horizon (??)

Acknowledgements

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Nematology research team UCR, Field crew Kearney, Nickels Soils Laboratory, UCANR collaborators…

Tree nurseries, TriCal, many more…

CDFA-IAB, DPR, SCBGP, chemical companies, NIFA-Hatch 1010599

Thank You

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ROOTSTOCK CHOICE and ACCEPTABLE RISK

8 Dec 2021 Chuck Fleck Sierra Gold Nurseries

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Acceptable Risk

Almond Orchard Investment and Rootstock Selection

"Risk is the potential that a threat will exploit a vulnerability, causing harm. Risk management involves determining those risks with the greatest impact and greatest probability of occurring, and handling those first…"

David Schwalenberg,, Tenable.com

Rootstock Selection

Best Choice for a 20+ Year Investment

- Appropriate Vigor
- Rooting/Anchorage
- Tolerance to:
  - ❖ Poorly Drained Soils
  - ❖ Nematodes
  - ❖ Salt & Boron
  - ❖ Root Rots
  - ❖ Intermittent Flooding
  - ❖ Replant Syndrome

ROOTSTOCK RISK AVOIDANCE

The Right Choice for the Life of the Orchard

	Vigor/ Yield	Anchorage	Clay Soils	Nematode	Root Rots	Salt/ Boron	High Water	Replant
Krymsk®86	3	5	5	1	4	1	5	3
Rootpac®-R	2	3	5	4	4	3	5	4
Nemaguard	3	1	2	3	2	1	2	1
Bright's Hybrid®5	4	4	3	4	3	4	2	4
SG1®	5	5	4	4	4	5	3	5
Hansen 536	5	4	2	3	2	3	1	5
Viking	4	3	3	5	3	3	3	4

Unacceptable Risk

Insufficient Vigor

Blowover

Unacceptable Risk

Salt Toxicity

Phytophthora Crown Rot

Oak Root Fungus

Unacceptable Risk

Poor Adaptation to Heavy Soil

Nematode Damage

Unacceptable Risk

Intolerant to Intermittent Flooding

Replant Stunting

ROOTSTOCK RISK AVOIDANCE

The Right Choice for the Life of the Orchard

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SG1®	5	5	4	4	4	5	3	5
Hansen 536	5	4	2	3	2	3	1	5
Viking	4	3	3	5	3	3	3	4

Rootstock Selection

It's All About Optimizing Acceptable Risk

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