What to Consider: Almond Rootstocks

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What to Consider: Almond Rootstocks

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growing ADVANTAGE
The Almond Conference

Katherine Pope,
UCCE-Yolo, Solano, Sacramento Counties

What to Consider – Almond Rootstocks

Katherine Pope, UCCE-Yolo, Solano, Sacramento Counties

What's the 'Perfect' Rootstock?

Yolo Co Lessons on Boron Tolerance

What do rootstocks do?

✓Take up water

✓Take up nutrient, salts

✓Anchor tree in the soil

✓Store carbohydrate overwinter

✓Live and grow in the soil

What's the Perfect Rootstock?

High early vigor

Low later vigor

Heavy soil, wet feet tolerance

Low suckering

No negative impact to bloom or harvest timing

Good anchorage

Root disease resistance

Nematode resistance

Mid-to-high pH tolerance

B, Cl, Na exclusion

Compatibility with all cultivars

What's the Perfect Rootstock?

Rootstock selection: Figure out the biggest limitations of the site; find the rootstock to address those limitations.

Remember,

Some ‘limitations’ are average conditions

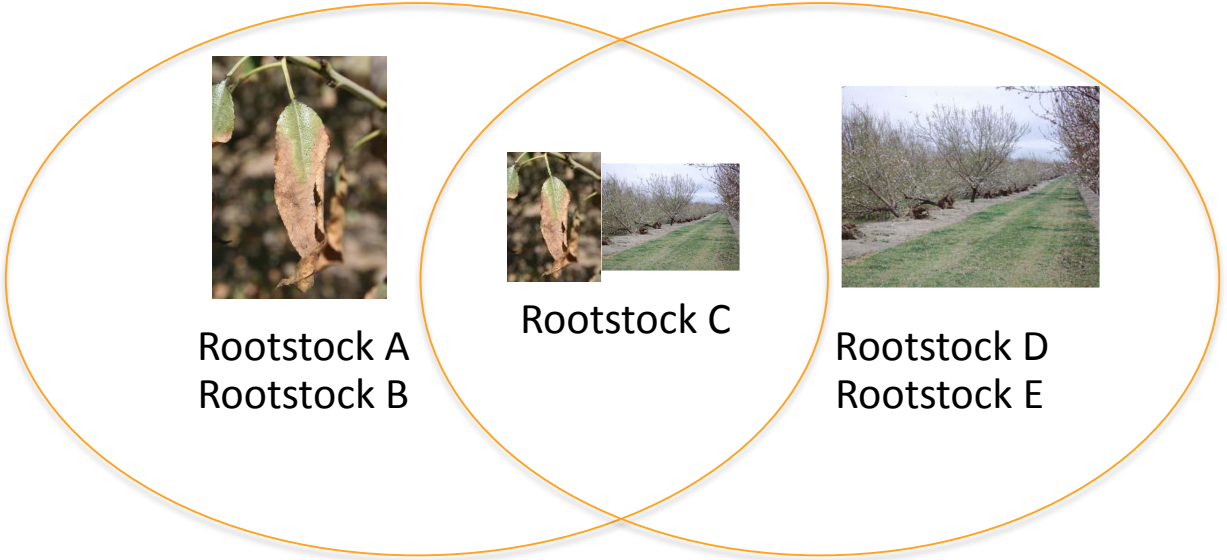
Some ‘limitations’ are rare, but guaranteed eventually

Rootstock selection: Figure out the biggest limitations of the site; find the rootstock to address those limitations.

Rootstock A
Rootstock B
Rootstock C

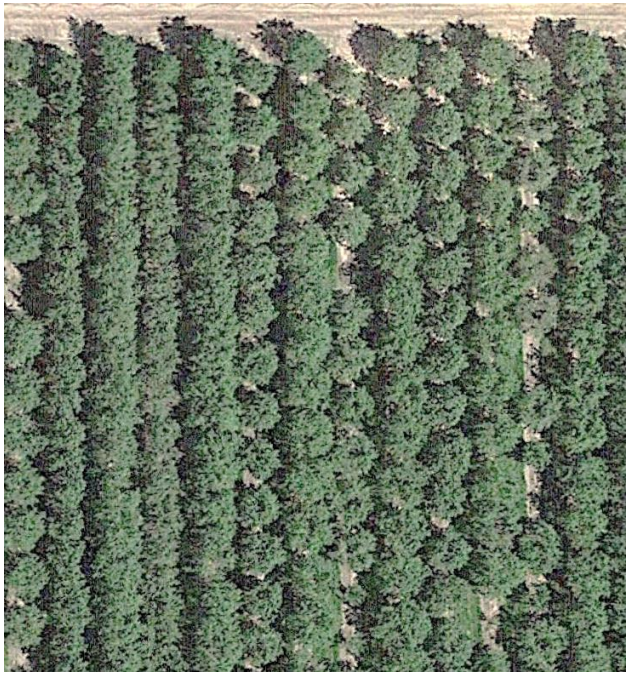
Rootstock C
Rootstock D
Rootstock E

Rootstock selection: Figure out the biggest limitations of the site; find the rootstock to address those limitations.

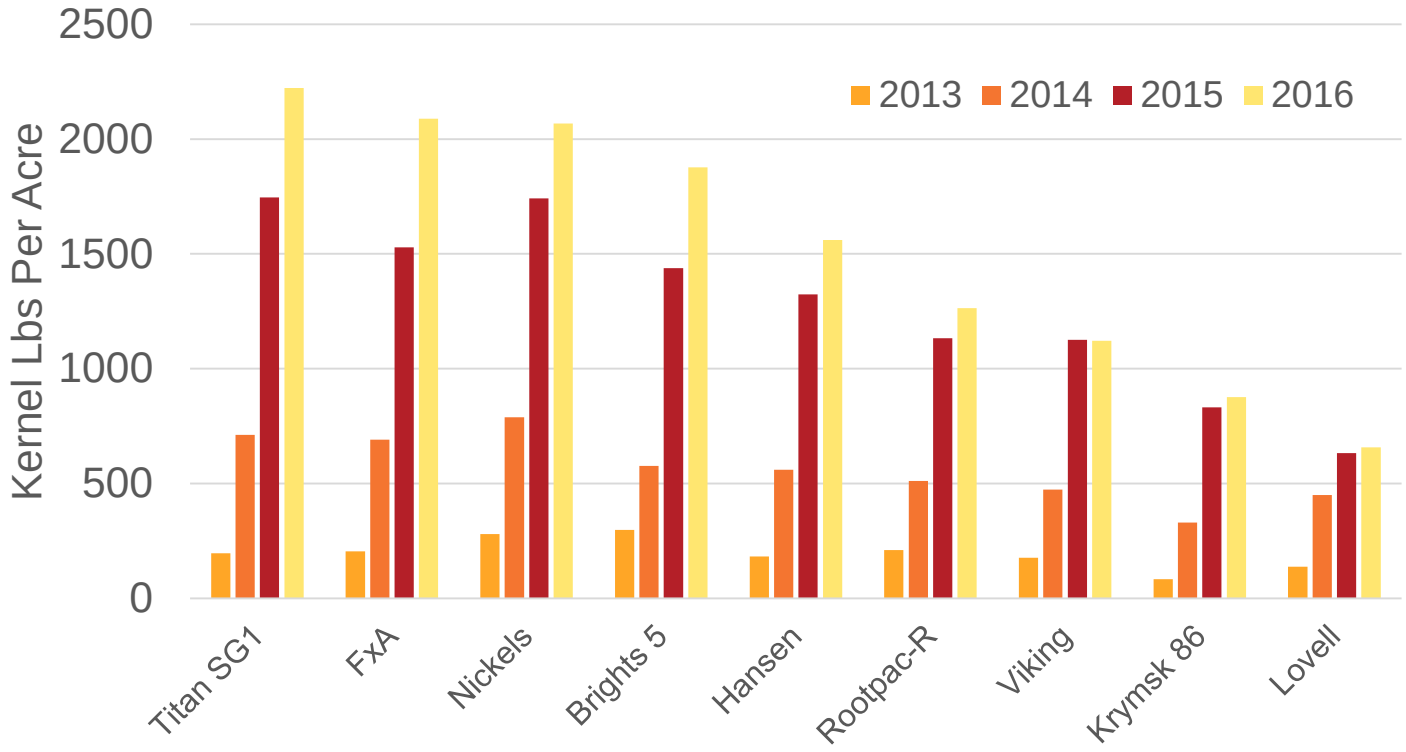


But What About Yield?

- Tighter spacing can often make up for smaller trees, so yield/acre stays high.
- *Important to remember with rootstock trial results.* Bigger isn't always better, if you lose other benefits.



Boron Rootstock Trial – Yield Highly Correlated with Rootstock

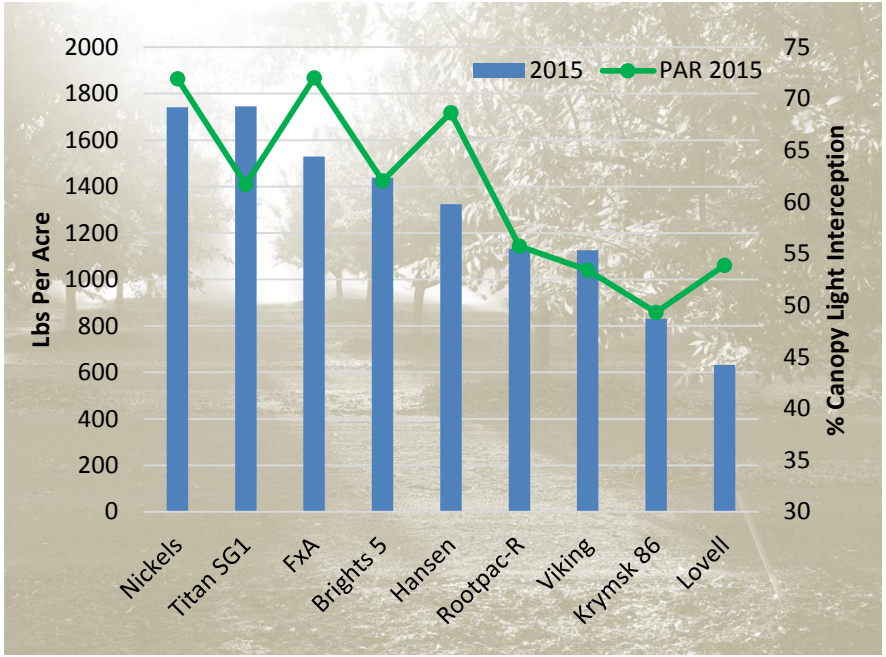


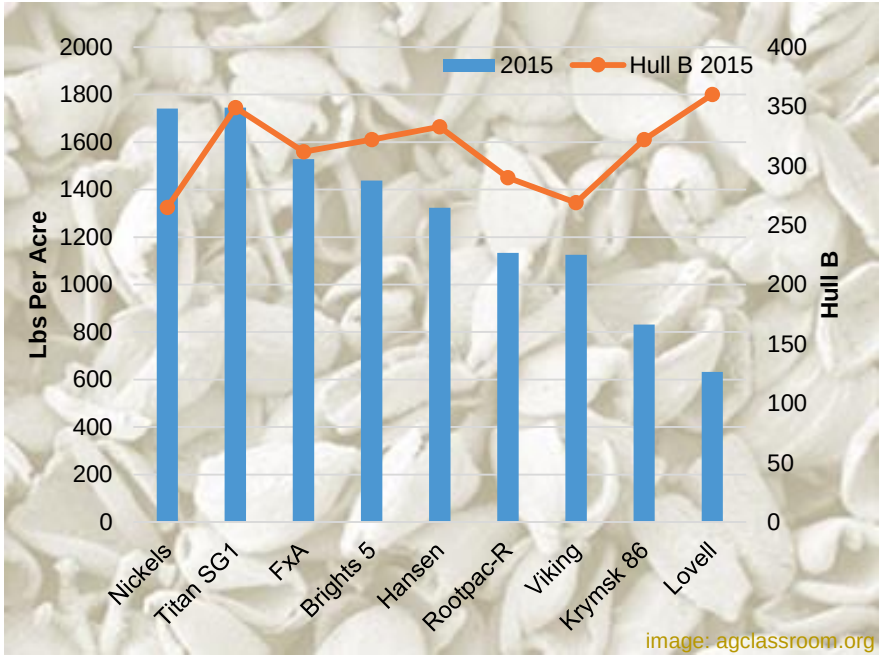
Marvin silty clay loam
Water: <1 - 3.1 mg/l B
Soil: 1.3-2.2 mg/l B

cv. Nonpareil
Nursery grafted
Planted: Feb, 2011
(Titan Apr 2011 not rep'd)
Spacing: 22' x 18'

Different letters indicate statistical diff. values when compared in same year.

Boron Rootstock Trial – PAR, Hull B Content Highly Correlated with Rootstock





Boron Rootstock Trial – Summary (So Far)

- **Poor Yield** related to **Canopy Size**, **Bloom Vigor**, **Hull Boron**. Points to two potential rootstock effects:
  - Vigorous rootstocks → Larger Trees
  - Boron tolerant rootstocks decrease B to scion → Decrease B at growing points (flowers, nuts) where it can do damage.
- **Nickels, Titan and FxA** continue to perform **better** than other rootstocks under high boron conditions
- **Lovell, Krymsk 86** continue to perform **poorly** under high boron conditions
- Looks like Lovell combines worst combination: Low vigor with high B

Mohhammad Yaghmour, UCCE-Kern County

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What to Consider – Almond Rootstocks

Mohhammad Yaghmour, UCCE-Kern County

Lessons from Regional Rootstock Trials

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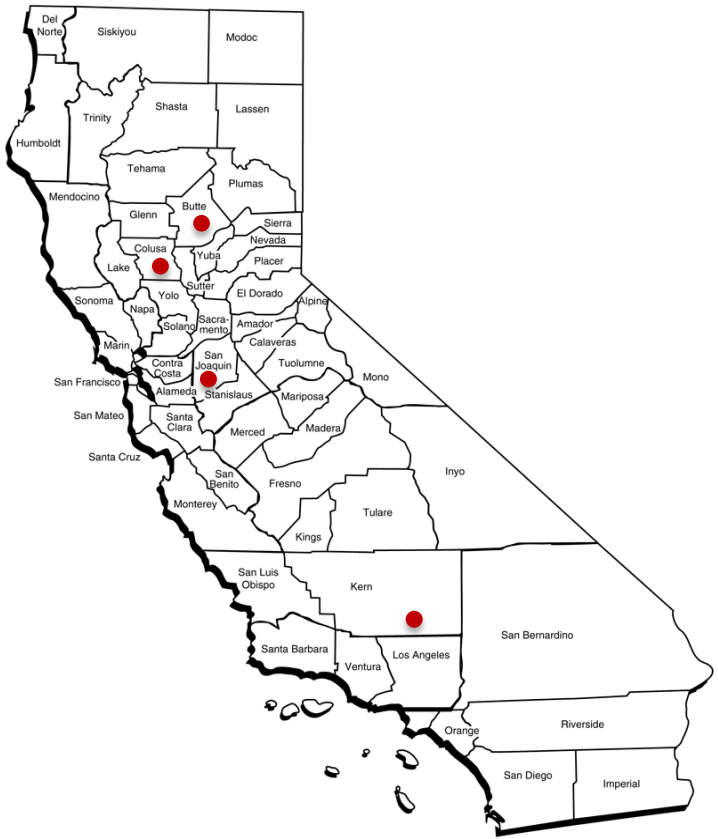
Four Regional Rootstock Trials 1997-2006

Evaluated for effect on growth, yield, mineral nutrition, disease susceptibility and mortality.



Specific Challenges for Regional Rootstock 1997-2006

- Butte: Planted May 1998
  - Joe Connell
- Colusa: Planted March 1997
  - John Edstrom
- Kern: Planted March 1996 &1997
  - Mario Viveros
- San Joaquin: Planted March 1998
  - Roger Duncan & Paul Verdegaal

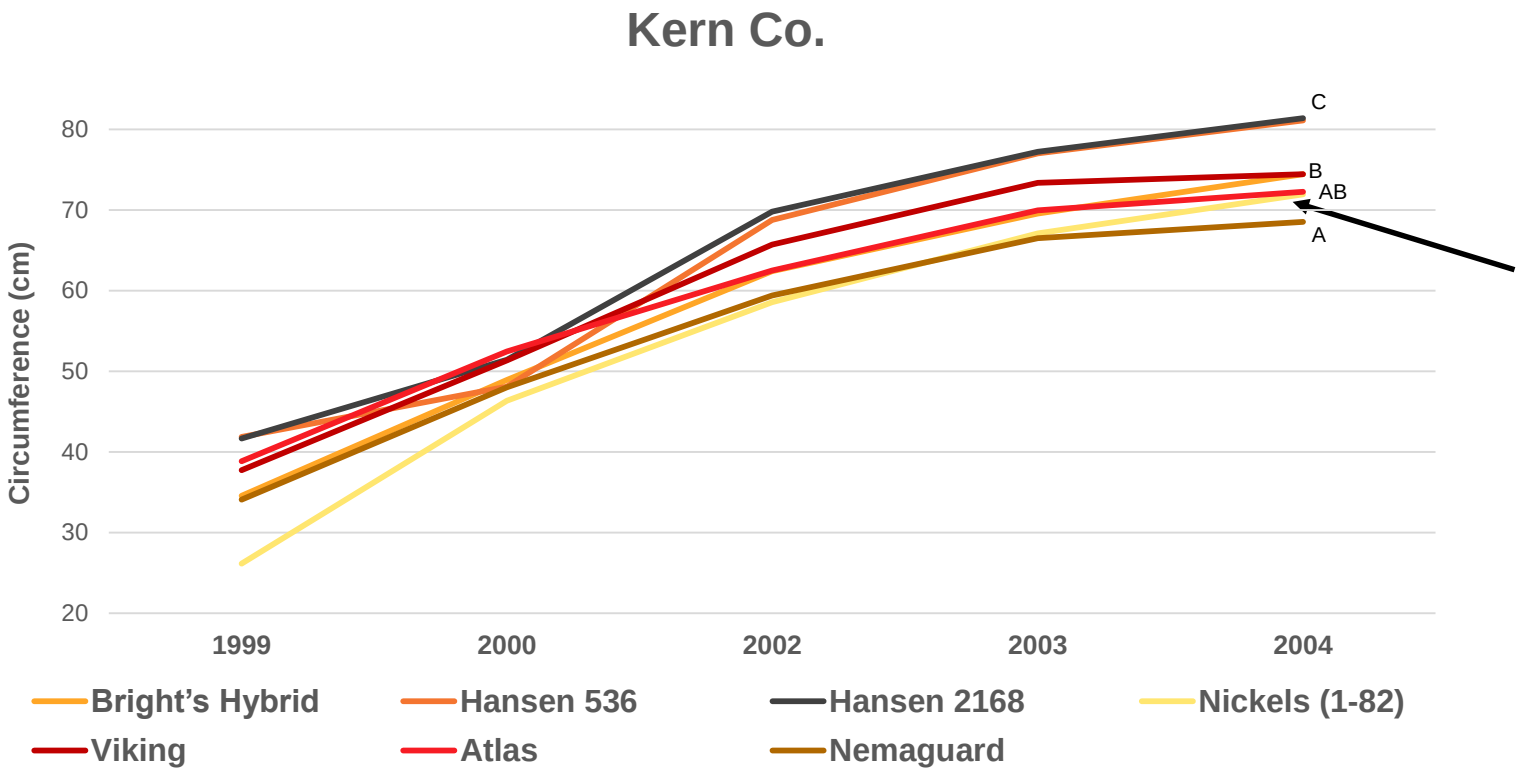
- Rootstock performance in a high rainfall environment
- Rootstock performance on a shallow, hardpan soil
- Rootstock performance vs. ‘Santa Ana’ winds (Anchorage)
- Rootstock performance in a sandy replant location (Bacterial canker resistance)

Nine Rootstocks evaluated

peach rootstocks	peach x almond hybrids	Complex hybrids (peach x almond x plum x apricot)
➢ Guardian ➢ Nemaguard ➢ Lovell	➢ Bright's ➢ Hansen 536 ➢ Hansen 2168 ➢ Nickles (UC 1-82)	➢ Atlas ➢ Viking

*Grafted with "NP" as scion except for Kern "Butte"
- Not every rootstock was tested in all regions

Tree Circumference



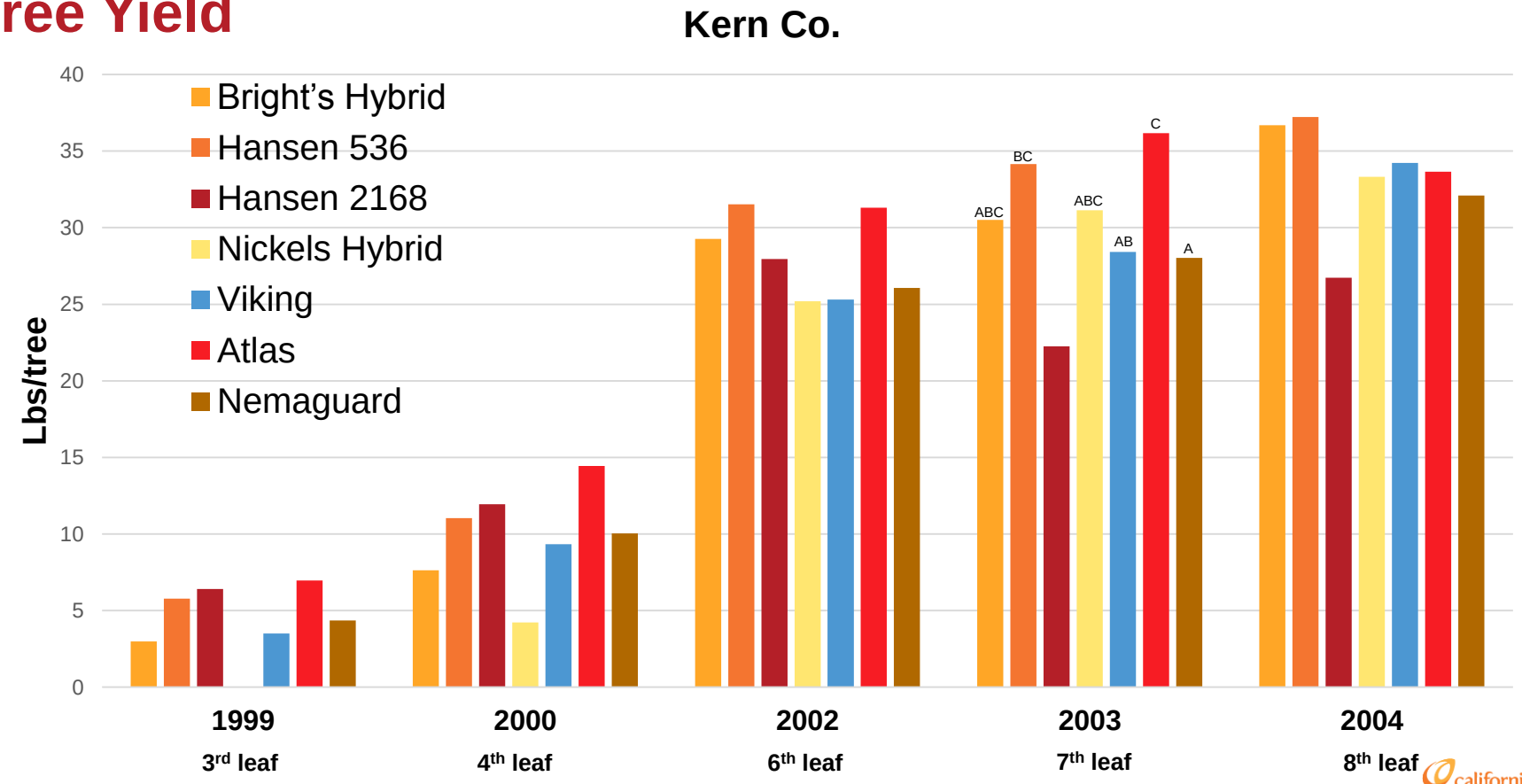
Planted a year later

Tree spacing
24' x 24'

Tree Circumference

Butte Feb. 2005 (64 trees/acre)			San Joaquin Oct. 2004 (138 trees/acre)		
Rootstocks	Circumference (cm)		Rootstocks	Circumference (cm)	
Hansen 536	80.48	A	Nickels Hybrid	68	A
Nickles Hybrid	76.83	B	Bright's Hybrid	67	AB
Bright's Hybrid	73.85	C	Hansen 536	66.5	AB
Nemaguard	72.42	C	Nemaguard	66.3	AB
Viking	69.46	D	Viking	66.1	AB
Gaurdian	68.84	D	Atlas	64.8	B
Lovell	67.95	D	Lovell	64.7	B
Atlas	67.24	D	Guardian	64.3	B

Tree Yield


Kern Co.
Lbs/tree
40
35
30
25
20
15
10
5
0
Bright's Hybrid
Hansen 536
Hansen 2168
Nickels Hybrid
Viking
Atlas
Nemaguard
ABC
BC
ABC
AB
C
A
1999
3rd leaf
2000
4th leaf
2002
6th leaf
2003
7th leaf
2004
8th leaf

Tree Yield

Butte 2005 8th leaf (64 trees/acre)			San Joaquin 2005 8th leaf (138 trees/acre)		
Rootstocks	Yield (Kernel Lbs/tree)		Rootstocks	Yield (Kernel Lbs/tree)	
Hansen 536	44.25	A	Guardian	15.2	A
Nickles Hybrid	39.47	AB	Lovell	13.2	AB
Nemaguard	38.69	AB	Viking	13.1	AB
Atlas	37.99	AB	Nemaguard	11.2	BC
Bright's Hybrid	36.72	BC	Atlas	9.5	C
Gaurdian	30.38	D	Bright’s	9.3	C
Viking	28.68	D	Nickels	9.1	C
Lovell	27.54	D	Hansen 536	3.4	D

Tree Anchorage

March 4, 2001 winds speed at 75 to 84 mph for 5 hours with 1.75” of rain.

‘Santa Ana’ wind in Kern County

Kern County (Plot 1)

Rootstock	Tree Age	% Blown over	Lbs. kernel per Tree Site	Lbs. kernel per tree
Bright's Hybrid	6th Leaf	13.0 a	14.4	16.0
Hansen 536	6th Leaf	9.3 a	14.4	16.0
Hansen 2168	5th Leaf	4.2 a	11.8	12.3
Viking	6th Leaf	4.2 a	13.5	14.0
Atlas	5th Leaf	30.0 b	9.2	13.7
Nemaguard	6th Leaf	58.0 c	6.8	18.9

Effect of Rootstock on Mineral Nutrition

Colusa 2004			Butte 2004			San Joaquin 2005		
Rootstocks	Chloride (%)		Rootstocks	Chloride (%)		Rootstocks	Chloride (%)	
Guardian	***		Guardian	0.1	a	Guardian	0.07	a
Lovell	0.07	a	Nemaguard	0.1	a	Nemaguard	0.07	a
Nemaguard	0.06	a	Lovell	0.1	a	Lovell	0.06	b
Nickels Hybrid	0.04	bc	Viking	0.07	b	Hansen	0.04	cd
Hansen 536	0.03	bc	Atlas	0.06	b	Nickels	0.04	cd
Viking	0.03	bc	Bright's Hybrid	0.05	b	Viking	0.04	c
Atlas	0.03	b	Hansen 536	0.05	b	Atlas	0.04	c
Bright's Hybrid	0.02	c	Nickels Hybrid	0.05	b	Brights’	0.03	d

Effect of Rootstock on Mineral Nutrition

Colusa 2004			Butte 2004			San Joaquin 2005		
Rootstocks	Potassium (%)		Rootstocks	Potassium (%)		Rootstocks	Potassium (%)	
Viking	2.22	a	Nemaguard	1.47	a	Atlas	3.31	a
Nickels Hybrid	2.21	a	Viking	1.41	a	Viking	3.25	a
Atlas	2.15	b	Atlas	1.39	a	Lovell	3.19	ab
Bright's Hybrid	2.14	b	Bright's Hybrid	1.3	ab	Nemaguard	3.16	ab
Lovell	2.14	b	Lovell	1.15	bc	Guardian	2.96	bc
Nemaguard	2.05	bc	Nickels Hybrid	1.14	bc	Brights'	2.95	bc
Hansen 536	1.91	bc	Guardian	1.12	bc	Nickels	2.77	c
Guardian	***		Hansen 536	0.99	c	Hansen	2.49	d

Effect of Rootstock on Mineral Nutrition

Colusa 2004			Butte 2004			San Joaquin 2005		
Rootstocks	Calcium (%)		Rootstocks	Calcium (%)		Rootstocks	Calcium (%)	
Hansen 536	4.08	a	Hansen 536	5.05	a	Hansen 536	4.5	a
Nickels Hybrid	3.72	ab	Nickels Hybrid	4.91	a	Bright's Hybrid	4	b
Bright's Hybrid	3.59	b	Bright's Hybrid	4.49	b	Nickels Hybrid	4	b
Viking	3.19	c	Viking	3.81	c	Viking	3.9	bc
Atlas	3.22	c	Atlas	3.78	c	Atlas	3.7	cd
Nemaguard	3.04	c	Guardian	3.58	d	Nemaguard	3.5	de
Lovell	2.93	c	Nemaguard	3.53	d	Guardian	3.4	ef
Guardian	***		Lovell	3.46	d	Lovell	3.2	f

Effect of Rootstock on Mineral Nutrition

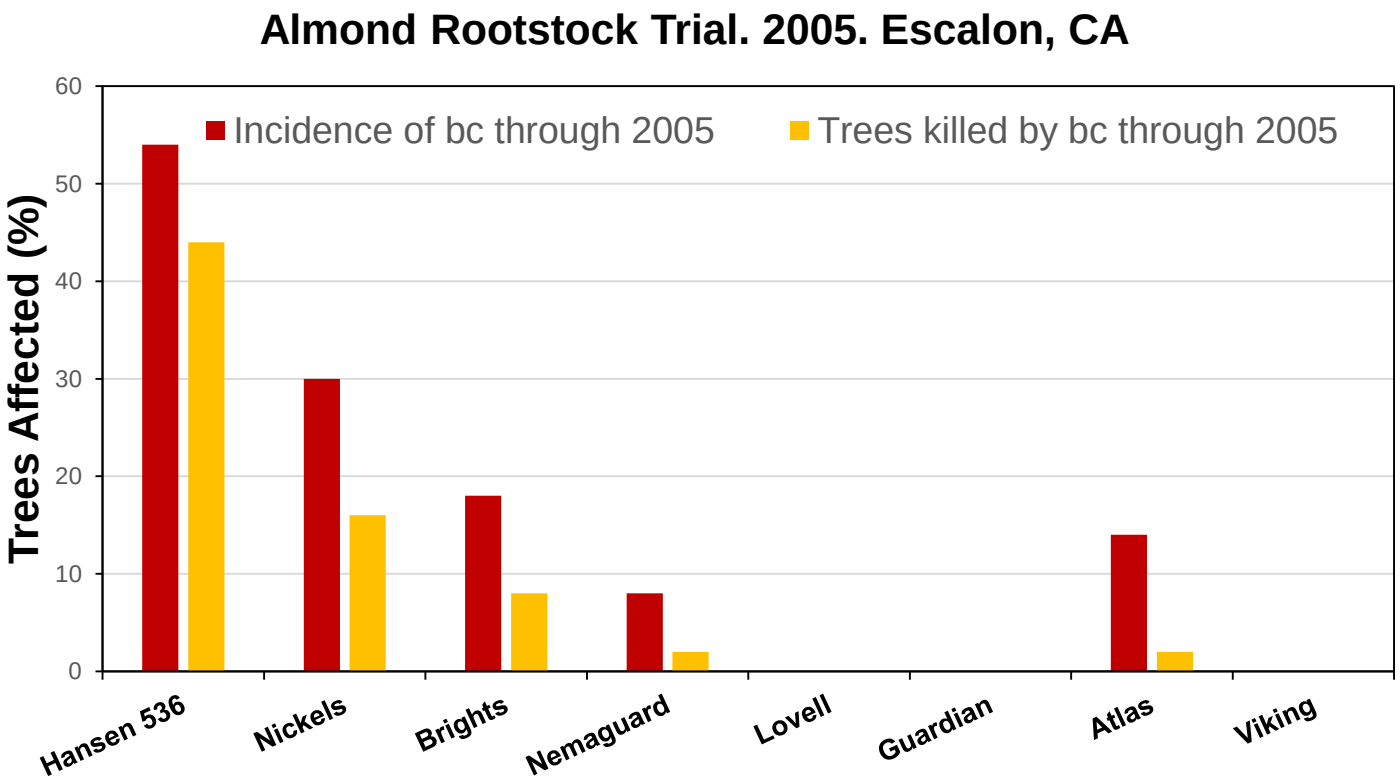
Colusa 2004			Butte 2004			San Joaquin 2005		
Rootstocks	Nitrogen (%)		Rootstocks	Nitrogen (%)		Rootstocks	Nitrogen (%)	
Hansen 536	2.57	c	Hansen 536	2.27	c	Nickels	1.91	c
Bright's Hybrid	2.61	c	Nickels Hybrid	2.38	bc	Brights’	1.93	c
Nickels Hybrid	2.61	bc	Bright's Hybrid	2.48	ab	Hansen	1.96	bc
Viking	2.7	ab	Lovell	2.48	ab	Viking	2.02	abc
Nemaguard	2.76	ab	Guardian	2.51	ab	Guardian	2.06	ab
Lovell	2.78	a	Viking	2.52	a	Atlas	2.07	ab
Atlas	2.79	a	Atlas	2.52	a	Nemaguard	2.1	a
Guardian	***		Nemaguard	2.57	a	Lovell	2.13	a

Susceptibility to Bacterial Canker and Pathogenic Nematodes

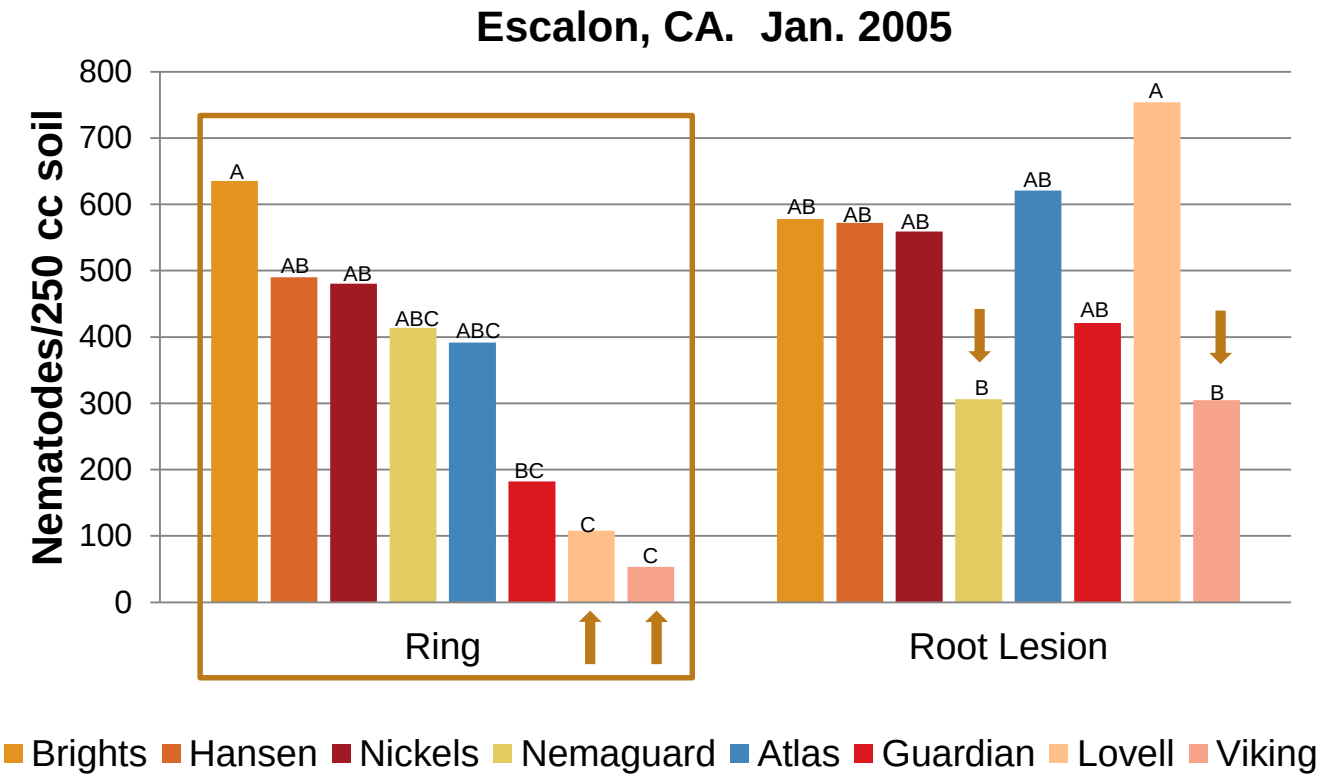
Symptoms of bacterial canker on almond trees.

Causal agent: *Pseudomonas syringae* pv. *syringae*

Rootstock Susceptibility to Bacterial Canker



Soil Numbers of Pathogenic Nematodes as Influenced by Almond Rootstock



Soil sampled from the rhizosphere of all rootstocks harbored large and potentially damaging numbers of root lesion nematodes

Summary of Regional Rootstock Trials

- **Viking** is slightly more vigorous than Nemaguard.
- Yield can be variable depending on many factors in the orchard. However, **Atlas** has the potential for high yields efficiency per canopy size.
- If challenged with high winds and anchorage problems, **Viking** is as good as Peach/Almond hybrid when compared to Nemaguard.
- **Viking**, **Lovell**, and **Guardian** rootstocks supported the fewest ring nematodes (predisposing factor for bacterial canker), and had the lowest BC incidence and mortality.
- Peach rootstocks accumulate more chloride than other rootstocks tested.

Roger Duncan, UCCE-Stanislaus County

What to Consider – Almond Rootstocks

Roger Duncan, UCCE-Stanislaus County

- Lessons from Stanislaus Trials
- Takes Aways for Specific Problems

Nemaguard (peach)

- Advantages
  - “Immune” to rootknot nematode
  - Vigorous rootstock
  - Performs well in sandy loam & loam soils
  - Growers are familiar with it

Nemaguard (peach)

- *Susceptible to:*
  - Sodium, chloride, boron
  - High soil pH / high lime (chlorosis, zinc deficiency)
  - Ring & root lesion nematodes
  - Phytophthora / “wet feet”
  - Oak root fungus
  - Bacterial canker
  - Crown gall
  - “Heart” rot / wood decay fungi
  - Replant disease

Guardian (peach)

- Very similar to nemaguard in almost every way
- More tolerant to ring nematode (bacterial canker)
- *Niche – site normally suitable for Nemaguard but with ring nematodes

Lovell (peach)

- A little better than nemaguard in heavy soil (?)
- More tolerant to ring nematode than most other commercial stocks (comparable to Viking & Guardian)
- Highly susceptible to rootknot nematode, crown gall, wood decay fungi & Verticillium wilt
- Highly susceptible to high pH, sodium, chloride, boron
- Niche – probably no situation where Lovell is best choice

Krymsk 86 (peach x plum)

- Very good anchorage
- Tolerant to heavy soil
- Resistant to Phytophthora, oak root fungus
- Very few root suckers
- Replacement for Lovell

Krymsk 86 (peach x plum)

- Highly susceptible to rootknot, ring and root lesion nematodes
- Highly susceptible to sodium, chloride & boron
- Low vigor in sandy / sandy loam soils
- Niche - heavy soil areas, especially with high rain and wind (Sac Valley & Sierra foothills). Not a good choice for sandy / sandy loam soils or where nematodes, salt or boron are of concern

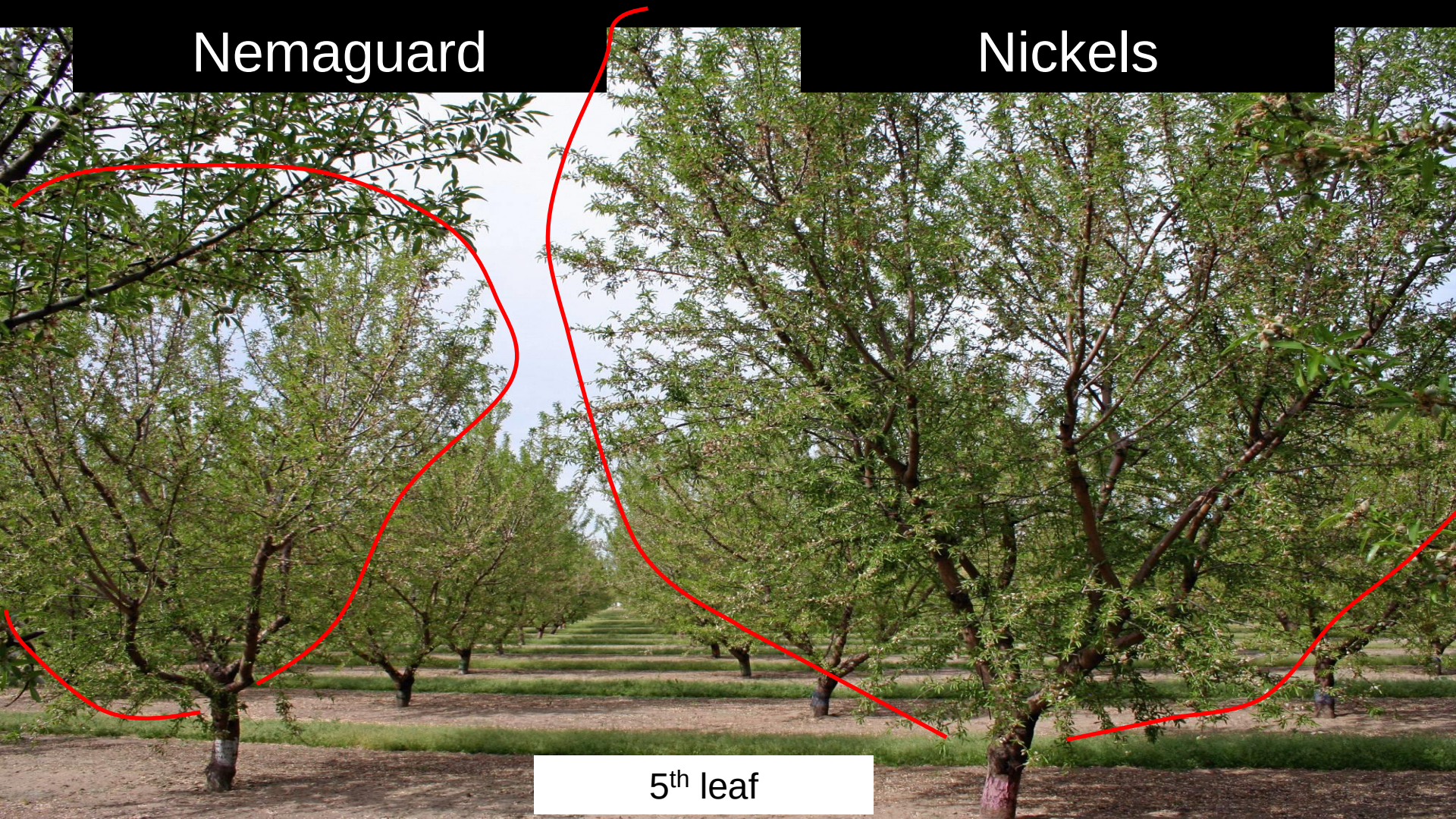
Peach / Almond Hybrids

- Includes Hansen, Nickels, Bright's Hybrid, BB106, Cornerstone, Titan Hybrid

- Advantages
  - Very high vigor
  - Most tolerant to high lime / high pH soils
  - Most tolerant to high boron, sodium & chloride
  - Very good anchorage
  - Resistant to rootknot nematode
  - Perform well in replanted orchards**

Peach / Almond Hybrids

- Disadvantages
  - Very high vigor
  - Highly susceptible to ring nematode and bacterial canker
  - Highly susceptible to most root diseases
    - Phytophthora
    - oak root fungus
    - crown gall
    - Verticillium wilt


Nemaguard
Nickels
5th leaf

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	0.20	0.07
Critical level	>0.25%	> 0.3%

Empyrean 1 (peach hybrid)

- Very vigorous
- Immune to rootknot nematode
- Tolerant to high lime / high pH soil
- Tolerant to sodium, chloride, boron
- Niche - alternative to P/A hybrids (not as susceptible to ring nematode

Viking *(peach x almond x plum x apricot)*

- Slightly more vigorous than nemaguard
- Immune to rootknot nematode
- Tolerant to ring nematode & bacterial canker
- More tolerant to high pH, sodium & chloride than peach rootstocks
- Good anchorage
- Probably best all around rootstock for SJ Valley
- Must be very careful when planting bare root
  - no cold storage

Atlas (peach x almond x plum x apricot)

- Vigor similar to Nemaguard
- Has shown high yield efficiency in several UC trials
- Immune to rootknot nematode
- May be tolerant to Verticillium wilt
- Susceptible to ring nematode (similar to Nemaguard)
- Susceptible to high pH, salt (similar to Nemaguard)
- Must be very careful when planting bare root
  - No cold storage

Rootpac R (almond x plum)

- Tolerant of heavy / wet soil
- Tolerant of sodium & chloride
- Immune to rootknot nematode
- Good vigor in heavy soil

- Low vigor in sandy soil
- Probably susceptible to ring nematode

- Niche - might be good alternative for heavy, alkaline Westside conditions

Specific Site Challenges…Nematodes

- Rootknot Nematode
  - Nemaguard
  - ~~Lovell~~
  - Guardian
  - Empyrean 1
  - ~~Krymsk 86~~
  - Viking
  - Atlas
  - Rootpac R
  - Marianna 26-24
  - Peach x almond hybrids (Hansen, Nickels, Titan, Cornerstone, Brights 5, BB106)

Specific Site Challenges…Nematodes

- Ring Nematode / Bacterial canker
  - ~~Nemaguard~~
  - Lovell
  - Guardian
  - ~~Empyrean 1~~
  - ~~Krymsk 86~~
  - ~~Viking~~
  - Atlas
  - ~~Rootpa~~c R
  - ~~Marianna 26~~-24
  - ~~Hansen, Nickels, Titan, Cornerstone, Brights 5, BB106~~

Specific Site Challenges…Nematodes

- Ring Nematode + Rootknot
  - ~~Nemaguard~~
  - ~~Lovell~~
  - Guardian
  - ~~Empyrean 1~~
  - ~~Krymsk 86~~
  - Viking
  - ~~Atlas~~
  - ~~Rootpac R~~
  - ~~Marianna 26-24~~
  - ~~Hansen, Nickels, Titan, Cornerstone, Brights 5, BB106~~

Specific Site Challenges…Phytophthora

- ~~Nemaguard~~
- ~~Lovell~~
- ~~Guardian~~
- ~~Empyrean 1~~
- ~~Hansen, Nickels, Titan, Cornerstone, Brights 5, BB106~~
- Krymsk 86
- ~~Viking~~
- ~~Atlas~~
- ~~Rootpac R~~
- Marianna 26-24

Specific Site Challenges…Salt

- Sodium & chloride
  - ~~Nemaguard~~
  - ~~Lovell~~
  - ~~Guardian~~
  - Empyrean 1
  - Hansen, Nickels, Titan, Cornerstone, Brights 5, BB106
  - ~~Krymsk 86~~
  - Viking
  - ~~Atlas~~
  - Rootpac R
  - Marianna 26-24

Almond Rootstock Sensitivity to Toxic Salt Ions.

Keyes, CA July, 2014

	Levels of Toxic Ions in July-Sampled Leaves			
	Nonpareil		Carmel	
	% Sodium	% Chloride	% Sodium	% Chloride
Nemaguard	**0.88** a	0.27 bc	**1.19** a	0.26 a
Guardian	**0.66** ab	0.21 cd	**0.69** bcd	0.27 a
Lovell	**0.58** bc	0.28 bc	**0.75** bc	0.25 a
Atlas	**0.57** bc	0.16 de	**0.86** b	0.22 ab
Krymsk 86	**0.55** bc	**0.32** b		
Cadaman	**0.31** cd	0.23 c	**0.47** cde	0.24 ab
Penta	0.24 d	**0.50** a		
Viking	0.21 d	0.12 ef	**0.43** de	0.18 bc
Nickels	0.18 d	0.12 ef	**0.35** ef	0.15 cd
Paramount	0.11 d	0.08 f	0.07 f	0.07 e
Empyrean 1	0.11 d	0.07 f		
Hansen	0.11 d	0.09 ef	0.10 f	0.10 de
Empyrean 101	0.10 d	0.12 ef		
Cornerstone	0.06 d	0.07 f		
Julior			**0.37** ef	0.11 de
Critical Level	**0.25**	**0.3**	**0.25**	**0.3**

Rootstock Effect on Chloride & Boron Accumulation

Westside, Stanislaus County

	% Chloride	ppm Boron
Lovell	0.73 a	180 a
Krymsk 86	0.65 b	152 bc
Nemaguard	0.43 c	153 bc
Atlas	0.37 cd	158 ab
Empyrean 1	0.32 de	133 cd
Cadaman	0.32 de	170 ab
HBOK 50	0.30 def	156 ab
PAC9908-02	0.28 defg	108 e
Viking	0.25 efgh	109 e
Rootpac R	0.25 efgh	132 cd
Hansen	0.23 efgh	126 de
Brights 5	0.22 fgh	106 e
BB 106	0.20 gh	102 e
Paramount	0.20 gh	120 de
F x A	0.20 gh	104 e
HM2	0.18 h	116 de
Critical Level	0.30%	300 ppm

Specific Site Challenges…Salt + heavy soil / poor infiltration

- Sodium & chloride
  - ~~Nemaguard~~
  - ~~Lovell~~
  - ~~Guardian~~
  - ~~Empyrean 1~~
  - ~~Hansen, Nickels, Titan, Cornerstone, Brights 5, BB106~~
  - ~~Krymsk 86~~
  - ~~Viking~~
  - ~~Atlas~~
  - Rootpac R
  - Marianna 26-24

Expression of Verticillium Wilt 2nd Leaf

*P ≤ 0.05

Specific Challenges…

- Anchorage / high wind
  - Krymsk 86
  - Viking
  - Hansen

Anchorage

	Trunk Angle (degrees)
Krymsk 86	85 a
PAC 9908-02	85 a
Viking	84 a
Hansen	84 a
Flordaguard x Alnem	82 ab
Nemaguard	82 ab
Rootpac R	81 abc
Brights 5	81 abc
Lovell	81 abc
Atlas	80 abcd
GF 677	79 abcd
BB106	76 bcd
Empyrean 1	75 cde
HBOK 50	74 cde
Cadaman	73 de
Hansen x Monegro	69 e

Specific Challenges…

- Armillaria (Oak Root Fungus)
  - Marianna 26-24
  - Krymsk 86

Thank you for your attention.

Questions?

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