



Alternative Almond Rootstocks for the West Side of the North San Joaquin Valley

Roger Duncan, UC Cooperative Extension, Stanislaus County
Grower: Lee Del Don

<u>Rootstocks</u>	<u>Genetic Makeup</u>
1. Lovell (purple)	peach
2. Nemaguard (White)	peach
3. Empyrean 1 (Red + Green)	peach
4. Avimag (a.k.a. Cadaman) (Red+White)	peach
5. HBOK 50 (Yellow)	peach (Harrow blood x Okinawa)
6. Hansen (Orange)	peach x almond hybrid
7. Brights #5 (Red)	peach x almond hybrid
8. BB 106 (pink + yellow)	peach x almond hybrid
9. Paramount (Purple + Orange)	peach x almond hybrid
10. Flordaguard x Alnem (blue + yellow)	peach x almond hybrid
11. PAC9908-02 (green + white)	(peach x almond hybrid) x peach
12. HM2 (orange + blue)	Hansen (peach x almond) x Monegro (peach x almond)
13. Viking (Blue)	peach x almond x apricot x plum
14. Atlas (Green)	peach x almond x apricot x plum
15. Krymsk 86 (Green + Blue)	plum x peach
16. Rootpac R (Pink)	almond x plum

- Orchard planted December 2011 at 16' x 20' = 136.1 trees per acre.
- Nonpareil with Carmel & Monterey pollinizers on Nemaguard

Soil Chemistry fall 2020:

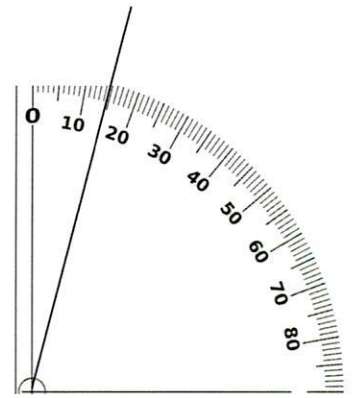
- Zacharias clay loam
- pH 0-18" deep = 7.1-7.8; 18"-36" deep = 7.8-8.2; 36"-52" deep = 8.2-8.4
- Boron 0.4 – 0.7 ppm (moderate)
- EC 0-18" = 0.8-2.3 dS/m; 18-36" = 1.0-2.1; 36-52" = 1.0-2.4 dS/m (high; should be <1.5 dS/m)
- Na 4.9-15.5 meq/liter (mod high; should be below 10 meq/l)
- Cl 1.0 - 5.2 meq/liter (moderately high; should be < 5 meq/l, depending on rootstock)

Water May 2021 (variable depending on year):

- EC 2.0 dS/m (moderately high, should be <1.5 dS/m)
- Adj. SAR 2.7 (moderate, should be < 3)
- Chloride 8.21 meq / l (moderately high)
- Boron 0.52 mg /L (low/moderate)
- pH 7.7 (high)

Table 1. Rootstock Effect on Tree Anchorage. Westside Stanislaus Rootstock Trial

	Average Degrees Trunk Lean	% Trees > 15° Lean
Krymsk 86	6.4 a	3.3
Hansen	7.4 a	20.0
Flordaguard x Alnem (FxA)	8.1 a	10.0
Rootpac R	9.8 a	23.3
Viking	10.2 a	6.7
BB 106	10.8 ab	26.7
Nemaguard	11.0 ab	17.2
GF 677	11.0 ab	37.9
PAC9908-02	11.1 ab	26.7
Lovell	11.9 abc	33.3
Brights 5	12.1 abc	20.0
Atlas	12.1 abc	24.1
HBOK 50	16.3 bcd	53.3
Empyrean 1	17.0 cd	60.0
Hansen x Monegro	21.1 d	70.0



- Hansen x Monegro (HM2), Empyrean 1, and HBOK 50 poorly anchored
- Krymsk 86 and Viking very good anchorage

Table 2. July-Sampled Leaf Chloride Levels of Fourth-Leaf thru Ninth-Leaf Nonpareil Almond Trees Grown on Sixteen Rootstocks. 2015 - 2020

	% Chloride 2015	% Chloride 2016	% Chloride 2017	% Chloride 2020
Krymsk 86	0.65 b	0.77 a	0.89 a	1.21 a
PAC9908-02	0.28 defg	0.45 bc	0.45 d	1.10 a
Nemaguard	0.43 c	0.57 b	0.57 c	0.96 b
Lovell	0.73 a	0.72 a	0.72 b	0.95 b
HBOK 50	0.30 def	0.31 cde	0.31 ef	0.68 c
Atlas	0.37 cd	0.42 c	0.42 de	0.57 cd
Viking	0.25 efgh	0.30 cde	0.30 f	0.55 d
Cadaman	0.32 de	0.38 c	0.38 def	0.54 d
HM2	0.18 h	0.16 e	0.16 g	0.39 e
Empyrean 1	0.32 de	0.33 cd	0.33 ef	0.36 e
F x A	0.20 gh	0.29 cde	0.19 g	0.28 ef
Hansen	0.23 efgh	0.15 e	0.15 g	0.28 ef
BB 106	0.20 gh	0.19 de	0.19 g	0.25 ef
Rootpac R	0.25 efgh	0.17 de	0.17 g	0.22 f
Brights 5	0.22 fgh	0.18 de	0.18 g	0.17 f
Paramount	0.20 gh	0.18 de	0.19 g	0.16 f
Critical Level	0.30%			

- The most sensitive rootstocks to chloride are Krymsk 86 and PAC9908-02, followed by Lovell and Nemaguard
- The peach x almond rootstocks, Rootpac R and Empyrean 1 are relatively tolerant of chloride.
- Viking, Atlas & Cadaman are moderately tolerant to chloride.

Table 3. Rootstock Effect on Leaf Nutrient Content. July 2019.

	N (%)	P (%)	K (%)	Sulfur (ppm)	Ca (%)	Mg (%)	Mn (ppm)	Na (%)
Lovell	2.33 bc	0.11 a	1.38 cd	2600 bcd	2.69 g	1.33 cde	72.4 bcd	0.15 bcd
Nemaguard	2.37 abc	0.11 a	1.85 abcd	2570 bcd	2.93 fg	1.31 cde	65.9 cd	0.25 b
Empyrean 1	2.34 abc	0.11 a	1.95 abc	2480 bcd	3.21 def	1.53 ab	63.9 abcd	0.12 cd
Cadaman	2.43 ab	0.12 a	2.44 a	2003 d	3.53 bcd	1.29 de	74.8 abcd	0.04 d
HBOK 50	2.28 c	0.11 a	1.63 bcd	2578 bcd	2.93 fg	1.49 ab	92.7 a	0.06 d
Hansen	2.34 abc	0.12 a	2.22 ab	2080 cd	4.21 a	1.41 abcd	91.5 ab	0.09 d
Brights 5	2.35 abc	0.12 a	2.46 a	2030 d	3.65 bc	1.32 cde	72.3 bcd	0.04 d
BB 106	2.48 a	0.12 a	2.40 a	2500 bcd	3.79 b	1.39 bcd	61.8 d	0.05 d
GF 677	2.38 abc	0.12 a	2.15 ab	2143 cd	3.66 bc	1.21 e	82.3 abc	0.04 d
F x A	2.44 ab	0.12 a	2.48 a	1923 d	3.64 bc	1.32 cde	90.8 ab	0.06 d
PAC9908-02	2.41 abc	0.11 a	1.23 d	3623 a	3.37 cde	1.55 a	80.8 abcd	0.24 b
HM2	2.41 abc	0.11 a	2.14 ab	2625 bcd	3.29 cdef	1.42 abcd	82.9 abc	0.10 d
Viking	2.37 abc	0.11 a	1.90 abcd	2968 ab	3.27 cdef	1.39 bcd	82.2 abc	0.06 d
Atlas	2.43 abc	0.11 a	1.94 abc	2538 bcd	3.12 ef	1.28 de	81.6 abcd	0.22 bc
Krymsk 86	2.47 a	0.11 a	1.39 cd	3208 ab	3.49 bcde	1.46 abc	92.4 a	0.22 bc
Rootpac R	2.40 abc	0.11 a	1.57 bcd	2808 bc	3.23 def	1.29 de	90.8 ab	0.40 a

¹Measurements followed by the same letters are not significantly different ($P \leq 0.05$).

²Zinc values not shown. In-season foliar sprays made analyses inconclusive.

- Differences in Nitrogen among rootstocks not large
- Very significant difference in potassium nutrition
 - Krymsk and Lovell deficient in potassium
 - Most peach x almond hybrids high in potassium
- Rootpac R high in sodium

Table 4. Hull Boron Levels of Fourth-Leaf Through Seventh-Leaf Nonpareil Almond Trees Grown on Sixteen Rootstocks. September 2015 – 2018

	ppm Boron 2015	ppm Boron 2016	ppm Boron 2017	ppm Boron 2018
Lovell	180 a	125 a	180 a	125 a
Cadaman	170 ab	107 ab	170 ab	110 ab
Atlas	158 ab	123 a	158 ab	122 a
HBOK 50	156 ab	108 ab	158 ab	114 ab
Nemaguard	153 bc	114 ab	153 bc	110 ab
Krymsk 86	152 bc	100 ab	152 bc	97 b
Empyrean 1	133 cd	89 bc	133 cd	93 bc
Rootpac R	132 cd	93 b	132 cd	93 bc
Hansen	126 de	86 bc	126 de	91 bc
Paramount	120 de	78 bc	120 de	79 c
HM2	116 de	82 bc	116 de	86 bc
Viking	109 e	74 c	109 e	77 c
PAC9908-02	108 e	75 c	108 e	80 c
Brights 5	106 e	76 c	106 e	75 c
F x A	104 e	80 bc	104 e	83 c
BB 106	102 e	76 c	102 e	88 bc
Critical Level	300 ppm			

- The rootstocks accumulating the most boron were Lovell, Cadaman, Atlas and HBOK 50. Viking and the peach x almond hybrids accumulated the least boron.

Table 5. Yield for 4th Thru 7th and 9th Leaf Nonpareil Almond Trees on Fifteen Rootstocks. 2015 – 2018 and 2020.

	2020 Yield (9 th Leaf)	Cumulative Yield (4 th thru 7 th & 9 th Leaf)	Trunk Circumference (cm) 2020	2020 Yield Efficiency* (lb / cm trunk)
BB 106	4091 a	16,294	71.4 ab	57.3
F x A	3170 bcd	15,446	73.0 a	43.4
Brights 5	3859 ab	15,423	61.7 d	62.5
Hansen	3661 ab	15,016	70.9 abc	51.6
HM2	3447 abc	14,808	68.0 abc	50.7
Empyrean 1	3096 bcde	14,557	68.3 abc	45.3
Rootpac R	2826 cde	13,413	65.4 bc	43.2
PAC9908-02	2470 de	13,386	67.5 bc	36.6
Atlas	2626 de	13,132	60.8 de	43.2
Paramount (GF 677)	3084 bcde	12,663	62.6 cd	49.3
Viking	2791 cde	12,495	60.4 de	46.2
Nemaguard	2791 cde	11,624	59.0 de	47.3
HBOK 50	2326 ef	11,527	61.4 de	37.9
Krymsk 86	2474 de	11,340	56.3 e	43.9
Lovell	1680 f	9,720	56.1 e	29.9

*Yield efficiency is estimated by dividing 2020 yield by 2020 trunk circumference

- The top 5 yielding rootstocks cumulatively are peach x almond hybrids
- Many peach x almond hybrids and Empyrean 1 are also the largest
- Lovell, Krymsk 86, and Nemaguard are among the smallest trees with the lowest yields

High points:

- Despite the heavy soil, most peach x almond hybrids are performing very well so far in this trial.
- Rootstock standards Lovell, Nemaguard and Krymsk 86 have the lowest yields, have accumulated the most chloride and are not well suited for this area
- At \$2.80 / pound, the top producing rootstocks would have grossed about \$9,000 / acre more than Lovell & Nemaguard through the first four harvests.
- In 2020 (@ \$1.50 / pound), highest yielding rootstocks earned \$1,000 - \$1,800 per acre more than Nemaguard and up to \$3,600 more per acre than Lovell.

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The Expression of Verticillium Wilt Symptoms in Various Rootstocks and Varieties

Roger Duncan, UC Cooperative Extension, Stanislaus County

Percent Incidence of Verticillium Wilt Symptoms Expressed in Nonpareil Almonds Grown on Various Rootstocks¹. Del Don Rootstock Trial, Vineyard Road, Westley		
	2013 (2 nd leaf)	2014 (3 rd leaf)
Lovell	50.0 a	40.0
Paramount (a.k.a. GF 677)	30.0 b	17.2
Cadaman	25.5 bc	33.3
Empyrean 1	13.3 bcd	16.7
Hansen	13.3 bcd	23.3
Nemaguard	10.0 cd	10.0
F x A	3.3 d	20.0
HBOK 50	3.3 d	6.7
HM2	3.3 d	0
Rootpac R	0.7 d	6.7
Krymsk 86	0.3 d	3.3
PAC9908-02	0 d	3.3
Viking	0 d	10.0
Atlas	0 d	0
Brights 5	0 d	3.3
BB 106	0 d	6.7

¹Incidence of Verticillium wilt symptoms expressed as percentage of affected trees out of 30 (six replications of 5 trees each).

Total # trees in row	Number of trees expressing symptoms of Vert per row²		
	Nonpareil	Carmel	Monterey
95	11	34	15
94	13	32	19
91	8	31	12
91	8	30	12
97	13	26	7
100	13	30	16
99	6	17	11
100	10	32	12
	10.7%	30.2%	13.6%

²Survey of eight rows of each variety in affected orchard. Severity not rated.