Field Evaluation of Almond Rootstocks

Project No.: **14-HORT4-Duncan**

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Objectives:

A. Evaluate alternative rootstocks irrigated with low quality (saline) irrigation water in alkaline heavy soil (Stanislaus County) and low pH, sandy soil (Merced County).
B. Evaluate alternative rootstocks under high boron conditions (Yolo County).
C. Continue evaluation of alternative rootstocks for tolerance to Armillaria root and crown rot (Butte & Stanislaus Counties).
D. Continue evaluation of variety compatibility with rootstocks for almond, particularly compatibility with Nonpareil.
E. Continue evaluation of alternative rootstocks in a sandy, unfumigated replant location (Stanislaus).

Interpretive Summary:

- In general, across all trials, trees on peach x almond rootstocks (or hybrids of peach x almond hybrids), including Hansen, Nickels, Cornerstone, BB 106, Flordaguard x Alnem, PAC9908-02, Tempropac and HM2 are the largest and tend to have the highest yields.
- Empyrean 1, a peach x peach hybrid rootstock, is often as large as the peach x almond hybrid rootstocks with similar yields.
- Atlas has high yields for its moderate tree size.
- Several rootstocks are showing much better sodium and chloride tolerance than standard Nemaguard and Lovell.
- While some rootstocks are accumulating less boron than others, none appear to be strongly tolerant to high boron conditions.
- In Merced and Stanislaus trials, trees on Krymsk 86 and RootPac R tend to show more water stress than other rootstocks based on pressure chamber measurements.
- Rootstock is affecting bloomtime and fruit maturity date.
- In a West Stanislaus trial following decades of row crops, Nonpareil trees on Lovell had the highest incidence of Verticillium while Hansen had the most severe

symptoms in the third leaf. Atlas and HM2 appear to be highly tolerant of Verticillium and have shown no signs of the disease after three years.

Field Evaluation of Almond Rootstocks for the West Side of the North San Joaquin Valley

Project Leader: Roger Duncan, UCCE - Stanislaus County
Co-PI: Brent Holtz, UCCE - San Joaquin County

Objective:

Evaluate 16 almond rootstocks for their performance in a heavy, alkaline soil moderately high in boron and irrigated with water high in sodium and chloride.

Interpretive Summary:

- In general, trees on peach x almond hybrid rootstocks are the largest, with the exception of trees on Paramount which are significantly smaller than the rest of the P x A hybrids.
- Trees on Empyrean 1 and Rootpac R are as large as trees on peach x almond hybrid rootstocks.
- Chloride leaf levels are significantly higher in Krymsk 86 and Lovell than in other rootstocks and have surpassed the critical level of 0.3%.
- BB 106, F x A, HM2, Bright's 5 and Rootpac R all have chloride levels significantly lower than Nemaguard.
- Trees on Lovell rootstock have had a significantly higher incidence (number of affected trees) of Verticillium wilt disease expression than other rootstocks while Hansen has the highest severity (amount of affected canopy).
- Atlas and HM2 appear to be tolerant of Verticillium wilt and have shown no signs of Verticillium wilt in this trial.

Background:

Almond planting continues to expand on the west side of the North San Joaquin Valley, replacing lower value row crops. In contrast to the more traditional tree growing areas of the east side with low pH, nematode infested, sandy loam soils, the west side soil is moderately heavy with higher salt levels and the pH is often 7.5 or higher. The irrigation water is typically high in bicarbonates, boron and sodium. Due to their lack of experience or data on alternative rootstocks for this area, most growers' plant on Nemaguard which is ill suited for Westside growing conditions. As a result, growth is reduced, leaves often show signs of marginal salt burn by the end of the season and trees likely have reduced yield potential.

Materials and Methods:

In this trial, the performance of sixteen rootstocks is being tested under "typical" west

side conditions. On December 21, 2011, the trees were planted in a randomized complete block design with six replicates of all rootstocks in a commercial orchard off Highway 33 near the town of Westley. Trees were planted at a spacing of 16' x 20' (136 trees per acre). All tested rootstocks have Nonpareil as the scion. Pollinizer varieties are Carmel and Monterey. Rootstock parentage includes peach (*P. persica*), intra-species peach hybrids, hybrids of peach x almond, peach x plum, almond x plum and complex hybrids that include peach, almond, plum and apricot. The list of rootstocks and their genetic background is shown below (**Table 1**).

Table 1. List of Rootstocks and Their Genetic Background

Rootstock	Genetic Background
Lovell	Domestic peach
Nemaguard	Domestic Peach
Empyrean 1	Domestic peach x wild peach
Avimag (a.k.a. Cadaman)	Domestic peach x wild peach
HBOK 50	Harrow blood peach x domestic peach
Hansen	Peach x almond
Brights #5	Peach x almond
BB 106	Peach x almond
Paramount (a.k.a. GF 677)	Peach x almond
Flordaguard x Alnem (FxA)	Peach x Israeli bitter almond
PAC9908-02	(peach x almond) x peach
HM2 (Hansen x Monegro)	(almond x peach) x (almond x peach)
Viking	((plum x apricot) x almond) x peach
Atlas	((plum x apricot) x almond) x peach
Krymsk 86	Plum x peach
Rootpac R	Almond x plum

The rootstock trial is growing in a Zacharias clay loam. Preplant soil samples indicated moderately high soil pH (7.5), high magnesium (555 ppm), high boron (1.7 ppm) and moderate soluble salts (1.3 mmhos / cm). In previous years, the field was irrigated primarily with West Stanislaus Irrigation District water, which is blended with tail water from area fields and water from the San Joaquin River. This water is often high in salts, especially towards the end of the summer. Due to the ongoing drought, this orchard has been irrigated primarily with well water. The water is treated with sulfuric acid but is still high in sodium, chloride, boron and bicarbonate (**Table 2**). After three years of irrigation with well water, soil samples indicate very high total salinity (2.5 – 3.4 dS/m), high sodium (9.4-14.7 meq/l) and very high chloride (11.0 – 17.1 meq/l) (**Table 3.**). The field has a long history of melons, tomatoes and other row crops, which has led to expression of Verticillium wilt disease in this trial. Preplant soil samples indicated no detectable rootknot or ring nematodes.

Table 2. Analysis of Irrigation Water Indicating High Sodium, Chloride, Bicarbonate, and Boron. Fourth Leaf. April, 2015.

	EC (dS/m)	Na (meq/l)	Adj. SAR	Cl (meq/l)	CO3 +HCO3 (meq/l)	B (mg/l)	pH
Water Sample	1.86	9.40	8.80	8.9	2.50	0.84	7.1
Critical Levels	1.10		3.0	4.0		0.50	

Table 3. Soil Analyses Indicating High pH, Sodium and Chloride. Third Leaf. September, 2014

Sample Depth (in.)	pH	EC (dS/m)	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	Cl (meq/l)	B (mg/l)	ESP (%)
0-18”	7.3 - 7.8	3.42	7.2	14.7	14.7	17.1	0.6	5.0
18”-36”	7.8	2.49	5.9	12.9	9.4	11.0	0.3	3.2
Critical level		1.50				5.0	0.5	5.0

Results & Discussion:

Tree Growth. Trees with the largest trunk circumference are on PAC9908-02, Empyrean 1, F x A, Rootpac R, HM2, BB 106, and Hansen rootstocks (**Table 4**). Most of these are peach x almond hybrids except for Empyrean 1 (peach hybrid) and Rootpac R (plum x almond hybrid). Paramount, the peach x almond hybrid commonly grown in Europe, is significantly smaller than the other PxA hybrids and is similar in size to Nemaguard. Brights 5, Avimag (a.k.a.Cadaman) and HBOK 50 were planted as potted trees and started out smaller than the other trees which were planted as bare root tress. It may take another year or two before Brights 5 catches up to the other P x A hybrid rootstocks.

Table 4. Trunk Caliper of Third-Leaf Nonpareil Almond Trees Grown on Sixteen Rootstocks. July 14, 2014

	Trunk Circumference (cm)
PAC9908-02	37.7 a
Empyrean 1	36.8 a
Flordaguard x Alnem	36.3 a
Rootpac R	36.1 a
HM2	35.8 a
BB 106	35.8 a
Hansen	35.7 a
*Brights 5	33.2 b
Nemaguard	33.1 b
Atlas	32.9 b
Viking	32.8 b
*HBOK 50	32.6 b
Paramount	31.9 bc
Krymsk 86	31.8 bc
Lovell	31.5 bc
*Avimag	30.2 c

*These trees were potted and were therefore younger and smaller than the bare root trees at planting time.

Salt Tolerance. Although no signs of ion toxicity are apparent in the trial yet, leaf analyses show that salt levels, especially chloride, are getting high in some rootstocks. July 2014 leaf analyses showed that chloride levels are significantly higher in Krymsk 86 and Lovell than in other rootstocks and have surpassed the critical level of 0.3% (**Table 5**). BB 106, F x A, HM2, Brights 5 and Rootpac R all have chloride levels significantly lower than Nemaguard. It is noteworthy that PAC9908-02 has chloride levels similar to Nemaguard and had significantly higher chloride leaf levels than other peach x almond hybrids.

Sodium leaf levels were at moderate levels in most rootstocks and all were below the critical level of 0.25% (**Table 5**). Avimag (Cadaman) had the highest sodium level at 0.12% while BB 106 was lowest (0.04%).

There were statistically significant differences in nitrogen leaf levels among rootstocks, but practical variances were small and probably not very important (**Table 5**). As in past rootstock trials, peach x almond hybrid rootstocks tended to have lower leaf nitrogen levels than peach stocks and some were below the published critical value of 2.2%.

Table 5. Sodium, Chloride and Nitrogen Leaf Content of Third-Leaf Nonpareil Almond Trees Grown on Different Rootstocks. July, 2014

	Chloride (%)	Sodium (%)	Nitrogen (%)
Krymsk 86	0.41 a	0.08 abc	2.32 ab
Lovell	0.41 a	0.07 abc	2.30 abc
PAC9908-02	0.28 b	0.11 ab	2.19 d
Avimag	0.28 b	0.12 a	2.36 a
Nemaguard	0.27 bc	0.06 bc	2.30 abc
HBOK 50	0.26 bc	0.09 abc	2.29 abc
Paramount	0.24 bcd	0.05 bc	2.17 d
Viking	0.22 bcde	0.10 abc	2.23 bcd
Atlas	0.19 bcdef	0.07 abc	2.31 ab
Hansen	0.17 cdef	0.08 abc	2.17 d
Empyrean 1	0.17 cdef	0.08 abc	2.23 bcd
Rootpac R	0.16 def	0.07 abc	2.27 abcd
Brights 5	0.15 def	0.08 abc	2.20 cd
HM2	0.14 def	0.08 abc	2.22 bcd
F x A	0.13 ef	0.07 abc	2.17 d
BB 106	0.10 f	0.04 c	2.26 abcd
Critical Level	*0.30*	*0.25*	*2.2 – 2.5*

Expression of Verticillium wilt. As mentioned above, this field had a long history of tomatoes, melons and other row crops that serve as hosts to *Verticillium dahlia*, the fungal pathogen that causes Verticillium wilt. In the spring of 2013 (second leaf), trees on some rootstocks began showing shoot dieback and wilt symptoms characteristic of this disease (see Almond Board report 2013). Symptoms were expressed again in 2014 (3rd leaf). As in the previous year, more trees on Lovell rootstock (40.0%) expressed wilt and dieback symptoms than any other rootstock (**Table 6**). Incidence of wilt was also high for trees on Avimag (Cadaman), Hansen and F x A rootstocks. The severity of wilt expression (percent of canopy affected by wilt) was significantly higher on Hansen (12.6%) than on any other rootstock. No signs of Verticillium wilt have been observed on Atlas or HM2 in this trial.

Table 6. Incidence and Severity of Verticillium Wilt Symptoms Expressed in Nonpareil Almonds Grown on Various Rootstocks. June 2014 (3rd leaf).

	Incidence (% trees with wilt symptoms)	Severity (average % of canopy affected in trees with symptoms)
Lovell	40.0 a	6.1 b
Avimag	33.3 ab	2.0 b
Hansen	23.3 abc	12.6 a
F x A	20.0 abcd	5.7 b
Paramount	17.5 bcd	3.7 b
Empyrean 1	16.7 bcd	2.2 b
Viking	10.0 cd	3.8 b
Nemaguard	10.0 cd	2.3 b
HBOK 50	6.7 cd	1.3 b
BB 106	6.7 cd	2.1 b
Rootpac R	6.7 cd	0.2 b
Brights 5	3.3 cd	3.3 b
PAC9908-02	3.3 cd	0.2 b
Krymsk 86	3.3 cd	0.2 b
Atlas	0 d	0 b
HM2	0 d	0 b

Rootstock effect on tree water status. Midday stem water potential was measured with a gas powered pressure chamber (pressure bomb) one week following an irrigation event. Water potential data indicated that all rootstocks were between 3.2 – 4.6 bars more negative than the baseline of what a fully watered tree would be, indicating moderate water stress (more negative values mean the trees are more stressed). There was relatively little difference in tree water status among rootstocks (**Figure 1**).

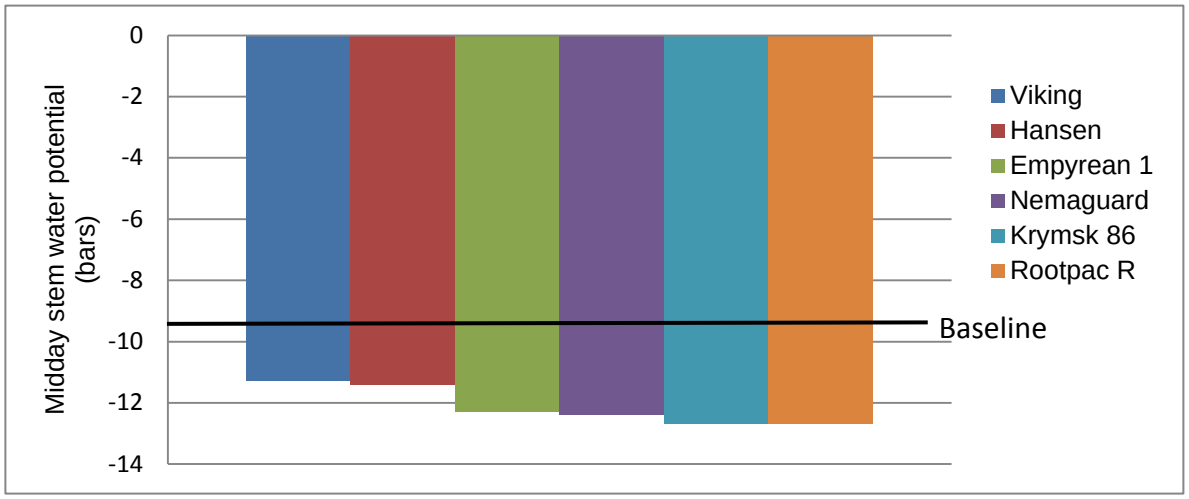

Figure 1. Mid-day Stem Water Potential of Nonpareil Almond Trees Grown on a Sample of Rootstocks One Week After Irrigation. June 16-17, 2015.

Field Evaluation of Plum & Plum Hybrid Rootstocks for Tolerance to *Armillaria* spp. in a Flood-Irrigated, Sandy Loam, Replant Location

Project Leader: Roger Duncan, UCCE - Stanislaus County

Objective:

To evaluate seven alternative rootstocks for field tolerance to *Armillaria mellea* (oak root fungus, ORF) and compare them to Nemaguard and Marianna 2624.

Interpretive Summary:

- Despite rampant oak root fungus disease in the previous orchard, few signs of the disease are apparent in the trial.
- One tree, on Tetra rootstock, showed signs of ORF infection in 2012 but has shown no ill effects of the disease even after three years.
- Trees on Viking rootstock are the largest while trees on Tetra, Hiawatha and Empyrean 2 (Penta) are the smallest.

Background:

Most Armillaria rootstock trials have been conducted in relatively heavy soils with sprinkler or micro-irrigation systems. However, rootstocks that may grow acceptably in heavy soil sometimes perform poorly under sandy, flood-irrigated conditions. Soil type and irrigation method may also influence disease susceptibility.

Materials & Methods:

This replicated trial was planted in 2007 in a flood-irrigated replant location which was fallowed for one year and fumigated with Vapam® prior to planting. The soil is a Hanford sandy loam. The trial is located in an area where the former orchard (on Nemaguard) was ravaged by *Armillaria mellea*. Experimental rootstocks include Ishtara, Krymsk 86, Hiawatha, Empyrean 2, Tetra, Marianna 40 and Viking. Tree performance is compared against standards Nemaguard and Marianna 2624.

Results and Discussion:

Although the previous orchard was ravaged by oak root fungus disease, only one tree in this trial has shown signs of infection by Armillaria after nine years. One tree on Tetra has been infected for at least two years (evidenced by gumming at the base, obvious Armillaria mycelium and mushroom growth at the base of the tree in the winter) but so far shows no obvious ill effects of the disease. This may be evidence of some level of tolerance by the Penta rootstock as a tree on Nemaguard would have likely died by now.

So far, trees on Viking have the largest trunk circumference while trees on Tetra, Hiawatha and Empyrean 2 are the smallest (see Almond Board report 2013). Krymsk 86 is moderate in size, very similar to Nemaguard in this trial. It is interesting to note that the difference in trunk circumference between the Butte and Padre trees is minimal for trees on Viking, Nemaguard, Krymsk 86 and M-40 while there is a substantial difference between the two varieties on Hiawatha, Empyrean 2, Tetra and Marianna 2624. It is unknown whether this infers less compatibility with the Butte variety with these four rootstocks (it is known that Butte is less compatible on Marianna 2624 than is Padre). In 2010, signs of union mild etch were evident in two Butte trees on Marianna 2624, but not on other plum rootstocks. No signs of mild etch has been observed on any tree since.

Field Performance of Fifteen Rootstocks in an Unfumigated, Sandy Loam, Replant Location.

Project Leader: Roger Duncan, UCCE - Stanislaus County

Interpretive Summary:

- The peach x almond hybrid rootstocks and Empyrean 1 are the largest trees have had the highest yields.
- An exception is Atlas which is a moderately sized tree but often produces yields similar to more vigorous rootstocks.
- Trees on the peach x almond hybrids have cumulative yields of 5,268 – 6,160 more Nonpareil kernel pounds than trees on Nemaguard and 7,167 – 8,442 more Carmel kernel pounds than trees on Nemaguard in the six years of collected yield data.
- Nemaguard, Lovell, Guardian, Atlas and Krymsk 86 had significantly higher leaf levels of sodium and chloride than other rootstocks in the trial and expressed severe toxicity injury (leaf burn).
- Sodium leaf levels were very low in Cornerstone, Paramount, Adesoto, Hansen and Empyrean 1.
- Due to high pH of underlying soil layers, leaves from trees on Lovell, Nemaguard, Guardian and Krymsk 86 had lower leaf chlorophyll measurements and were yellower than trees on other rootstocks.

Materials & Methods:

In January 2003, a replicated field trial was planted in a commercial almond orchard to test the performance of sixteen rootstocks budded with Nonpareil and Carmel scions in an unfumigated, sandy loam, replant location. An old almond orchard on Nemaguard rootstock was removed one year prior to replanting. Tree sites were backhoed with an excavator in the fall prior to planting but were not fumigated. The soil is a Hanford sandy loam and had no particular chemical or physical soil problems (pH = 6.8; ECe = 0.9 dS/m; CEC = 5.2) at planting time. The orchard was established on flood irrigation with excellent quality district water but was converted to microsprinklers in 2010. The orchard spacing is 17’ x 21’ (122 trees per acre). Rootstocks and their parentage are

listed in **Table 1** below.

Beginning in 2010, irrigation has been supplemented with well water applied through microsprinklers. Soil tests in 2013 indicate that the soil has become more alkaline than at planting time eleven years earlier. Current tests show that the upper 18 inches have a pH of 6.9 – 7.3, EC is 1.1 dS/m, the SAR is 1.5 and sodium is 2.4 – 3.3 meq/L. The lower soil profile (18-36 inches) has a pH of 7.4 - 7.6 with similar EC and SAR values as the upper profile. Over the past few years, many trees in the trial are showing severe signs of salt burn and chlorosis.

Table 1. List of Rootstocks Planted in Almond Replant Trial. Ceres, CA

Rootstock	Parentage	Origin
Nemaguard	Peach (*P. persica*)	USA
Lovell	Peach 1882 processing peach selection (*P. persica*)	USA
Guardian SC-17	Peach (OP seedling of S-37 x Nemaguard)	Clemson University
Avimag (a.k.a. Cadaman)	Peach (*P. persica x P. davidiana*)	Hungary
Empyrean 1 (a.k.a. Barrier 1)	Peach (*P. persica x P. davidiana*)	Venice, Italy
Hansen 536	Peach x almond	UC Davis
Nickels	Peach x almond	UC Davis
Cornerstone (a.k.a. SLAP)	Peach x almond	Burchell Nursery
Paramount (a.k.a. GF 677)	Peach x almond (open pollinated)	France
Empyrean 2 (a.k.a. Penta)	*P. domestica* open pollinated	Rome, Italy
Empyrean 101 (a.k.a. Adesoto)	*P. insititia*	Zaragoza, Spain
Julior	*P. insititia* x *P. domestica*	France
Krymsk 86 (a.k.a. Kuban 86)	*P. cerasifera* x *P. persica*	Russia
Atlas	Complex hybrids containing Nemaguard, Jordanolo almond, plum and apricot	Zaiger Genetics
Viking		Zaiger Genetics

Results and Discussion:

Several years of data including rootstock effects on tree size, individual year and cumulative yield, bloom time, hull split, leaf chlorophyll readings and root suckering have been reported in previous Almond Board of California research reports.

Cumulatively, Nonpareil trees on peach x almond hybrid rootstocks have cumulative yields from 5,268 to 6,160 kernel pounds more than nonpareil trees on Nemaguard during the six years that yield data have been collected in this trial (previously reported). The Carmel variety has benefitted even more from being on a vigorous rootstock. Cumulatively, Carmel trees on P x A hybrid rootstocks have yielded 7,167 – 8,442 more kernel pounds then trees on Nemaguard during the six years of yield collection in this trial.

Trees on the plum rootstocks (Empyrean 2, Empyrean 101 and Julior) are very small and may not be well suited for a sandy loam soil, especially under flood irrigation. They probably would have significantly lower yields than the peach x almond hybrid

rootstocks even if they were planted very densely. Krymsk 86, a peach x plum hybrid, appears to be slightly less vigorous than Lovell under these growing conditions.

Beginning around 2011, some trees within the trial began to show late season signs of salt toxicity. This may have been due in part to a change from flood irrigating with district water to sprinkler irrigating with ground water and/or the influence of the underlying alkaline soil layer. Symptoms have been more severe on the Carmel variety, especially on the peach rootstocks. In July 2014, leaves were collected from nonbearing spurs and analyzed for sodium and chloride content (**Table 2**). Trees on Nemaguard had the highest levels of sodium (0.88% in Nonpareil & 1.19% in Carmel trees). Guardian, Lovell, Atlas and Krymsk 86 also had very high levels of sodium and chloride. Cornerstone, Empyrean 101, Hansen, Empyrean 1, Paramount, Nickels and Viking all showed strong sodium and chloride tolerance. It is interesting to note that Penta showed relatively strong sodium tolerance but had very high levels of chloride (**Table 2**).

Table 2. Leaf Levels of Sodium and Chloride in Nonpareil & Carmel Almonds on Various Rootstocks. July, 2014.

	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
July Critical Leaf Level	< 0.25	<0.30	< 0.25	<0.30

Effects of Eight Almond Rootstocks on Nonpareil Tree Growth Grown on Marginal Soil High in Boron

Project Leader: Katherine Pope, UCCE - Sacramento/Solano/Yolo Counties

Project Cooperators and Personnel:
David Scheuring, Gold Oak Ranch

Objectives:

To evaluate plant growth, tree crop yield and boron uptake of Nonpareil almond variety on nine different rootstocks in the Sacramento Valley when grown on a marginal soil high in boron.

Interpretive Summary:

More years of data will give a clearer picture of how the nine rootstocks in this trial compare in terms of boron tolerance. But for those who need to make decisions now, based on the results we have so far, it looks like Krymsk 86 is inadvisable for high boron conditions and Nickels is the safest bet for a productive orchard under high boron conditions.

Materials and Methods:

Rootstocks with potential high boron tolerance relative to the commonly planted Lovell peach were identified: Hansen 536, Nickels, FxA, Krymsk 86, Brights-5, Rootpac-R, and Viking. This study assesses potential differences in boron tolerance between these rootstocks. Titan SG1 was added after the initial planting. Data collected from this rootstock is reported but considered observational because it is not replicated.

The trial is located in Yolo County north of Cache Creek. The soil is classified as Marvin silty clay loam (Storie Index (CA) = 65). Soils in this series are listed as moderately well to poorly drained. Irrigation water boron concentrations range between 1-3 ppm B.

Nonpareil almond nursery grafted trees on eight different rootstocks (Lovell, Hansen, Nickels, FxA, Krymsk 86, Brights-5, Rootpac-R, and Viking) were planted on February 9, 2011. All trees were bareroot except Brights-5, which was potted. Trees were planted at 22’ across the row and 18’ down the row. Twenty trees of Titan SG1 (potted) were planted on April 22, 2011 within the same orchard but not in the replicated trial. The trial is a randomized complete block design with 6 replicates of each rootstock, 5 trees per replicate.

In 2014, the orchard was in its 4th leaf. Leaf nutrient assessment was done in July by collecting and bulking leaves from all 5 trees in each replicate into a single sample. Hull samples were similarly taken (bulked for each replicate) at harvest. Samples were

analyzed for boron by UC Davis Analytical Lab. Yield per acre was calculated following harvest of 5-tree replicates by the grower.

Results and Discussion:

Significant differences in average yield per acre were measured between rootstocks in 2014, the second harvested crop (**Table 1**). Peach x almond hybrids Nickels and FxA produced the highest average yields per acre while Krymsk 86 rooted trees produced the lowest yields. The yield ranking of all the rootstocks will require more years of data, but for both years there is a consistent leader – Nickels – and laggard – Krymsk 86 (**Figure 1**).

More than 70% of the variability in yield can be explained by tree size, as measured by canopy light interception (PAR). Are the lower-yielding trees naturally smaller, or are the high levels of boron reducing size? Comparison with performance in other rootstock trials indicates a larger difference in tree size in these high boron conditions than in less challenging conditions. In other words, the smaller tree size, and thus the lower yields, are likely partly due to lower boron tolerance.

Hull samples indicate excessive boron in all rootstock treatments (**Table 1**) in 2014. Tree B status is considered excessive when hulls sampled at harvest exceeds 200 ppm B. Leaf B levels were significantly different among rootstocks, but were not predictive of hull boron or yield (**Table 1**). In other words, trees with high leaf boron did not necessarily have high hull boron or low yields. These data highlight the need to use hull sampling at harvest, not July leaf samples, to accurately assess almond orchard boron status.

Table 1. Almond boron rootstock trial results, 2014. Letters behind numbers indicate statistically significant differences (REGWQ, α=0.05)

Rootstock	2014					2013
	Yield (lbs/ac)	Trunk Diam (cm)	PAR (% intrcpt)	Hull B (ppm)	Leaf B (ppm)	Yield (lbs/ac)
Nickels	789 a	16.2 a	49.7 ab	439 a	52 b	280 a
Titan SG1	712	15.3	42	540	60	196
FXA	691 a	16.3 a	51 a	471 a	52 b	205 bc
Brights-5	576 b	14.4 b	40 cd	541 bc	56 a	298 a
Hansen536	560 b	16 a	47 b	566 c	54 ab	182 bc
Rootpac-R	511 b	15.9 a	39 de	497 ab	53 ab	210 b
Viking	473 b	14.6 b	35 fg	444 a	49 c	177 bc
Lovell	450 b	14.3 b	37 ef	582 c	53 b	138 cd
Krymsk86	330 c	14.5 b	33 g	493 ab	53 b	83 d

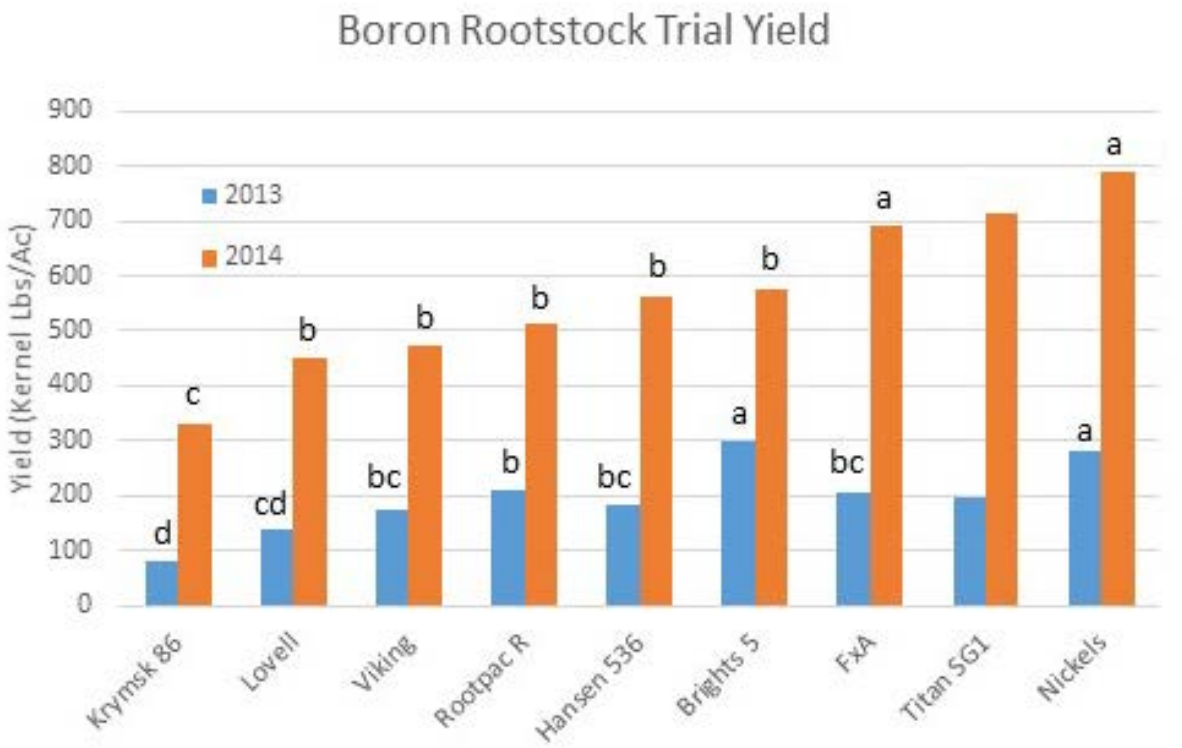

Figure 1. Boron rootstock trial yield results for 3rd and 4th leaf (2013, 2014). Scaled from the 5 tree sample average to per acre yields based on the 110 trees per acre spacing.

Note: Different letters indicate groupings of statistically significantly different yields. Nickels is the only "a" rootstock both years, and Krymsk 86 is the only rootstock with the lowest ranking both years ("d" in 2013, "c" in 2014). Because there are not as many later planted Titan trees, we cannot make statistical comparisons with other rootstocks. However, based on limited yield data, Titan seem to be performing about the same as FxA.

Research Effort Recent Publications:

"Rootstock Trial for Boron Tolerance: Different Varieties Tested", Pacific Nut Producer, February 2015

Performance of 14 Almond Rootstocks in a Sandy Location Irrigated with Well Water

Project Leader: David Doll, UCCE - Merced County

Cooperating Personnel and Cooperators:
Glen Arnold, Arnold Farms; Matt Jones and Andrew Ray, UCCE Staff Research Associates

Objective:

To compare rootstock performance based on growth, tissue sampling, stem water potential, and yield on a test site that has sandy, low exchange-capacity soils with shallow areas and hardpans, as well as presence of ring, root-knot, and root-lesion nematodes, and is irrigated with high sodium and high nitrate groundwater. Efforts will also be made to observe various phenological differences of these rootstocks such as bloom and harvest timing and influence on various diseases.

Background:

This replicated trial was established in January 2011 on a site with Atwater Sand in Winton, CA. The trial compares the performance of Nonpareil on 14 rootstocks, and the performance of Fritz and Monterrey on seven rootstocks (**Table 1**). Each of 6 replicate blocks is comprised of six trees of each rootstock and variety combination. Many of the rootstocks selected for the trial are peach/almond hybrids (P/A-Hybrids), as the grower developed an interest in P/A-Hybrids after participating in a previous UC rootstock trial. Prior to planting, the location was cover cropped with Merced Rye, tree sites were excavated, and the row-strips were fumigated with Telone-II at 33 gallons per acre. Trees were planted in January 2011 with the exception of the trees grafted to Cadamen and Cornerstone, which were planted in April 2011. Trees are spaced at 22'x18' and irrigated using double line drip.

Methods: Soil mapping was done using Veris Electrical Conductivity Mapping (Strategic Farming). Differences in soil zones were identified (**Figure 1**), analyzed (**Table 2**), and used to design experimental blocks. Trunks were measured shortly after planting and subsequently after the end of each growing season through 2013. Yields (kernel pounds per acre) were determined after harvest in August 2013 and 2014. Approximately 100 leaves from three trees in each rootstock x block combination were collected from 'Nonpareil' trees in mid-July 2014 and analyzed for nutrient content by Dellavalle Laboratory, Inc (Fresno, CA). Stem water potential (SWP) was measured on three trees of each 'Nonpareil' rootstock within blocks 1-3 using established UC procedures. Each of the three blocks was measured four times throughout the season, for a total of 12 SWP measurements for each rootstock ('Red Titan III' was excluded from SWP analysis due to high tree losses). Water samples from irrigation lines were collected during the growing season to determine water quality, and sent to DellaValle Laboratory Inc for analysis. Nematode samples were collected in November 2014 and

sent for analysis by Nematodes, Inc (Selma, CA). Observations of bloom percentage as influenced by variety and rootstock were taken on February 24, 2012, March 4th, 2013, February 14, 2014, and February 17, 2015.

Results and Discussion:

Initial analysis indicated soil quality was suitable for almond production (**Table 2**), though differences in soil nutrient and water holding capacities (as measured by soil EC) were observed. Well water used for irrigation has shown to have higher-than-normal nitrate-nitrogen concentrations since 2011 (**Table 3**), and may be contributing to the high observed vigor (see 2014 report). We found higher calcium concentrations in leaves from 'Nonpareil' on all rootstocks except 'Krymsk-86' and 'RootPac(R)', and higher magnesium concentrations in all rootstocks except 'RootPac(R)' and 'Viking', which may suggest differential nutrient allocation strategies among these rootstocks (**Table 4**).

Overall yields from the 2014 season were highest among rootstocks grafted to 'Monterey' for the second consecutive year (**Tables 5, 6, 7**). Yields of 'Nonpareil' varied among rootstocks, with 'Floridaguard x Alnem' producing significantly greater kernel pounds-per-acre than 'BB#106', 'BH#5', 'RootPac(R)', 'Viking' and 'Nemaguard' (**Table 5**). Yields among rootstocks grafted to 'Fritz' and 'Monterey' were not significantly different in 2014 (**Tables 6 and 7**). 'Empyrean-1', 'Floridaguard x Alnem' rootstocks on 'Nonpareil' have greater cumulative yields (2013-2014) than 'RootPac(R)' and 'Nemaguard' (**Table 5**), while 'Atlas' on 'Fritz' has produced significantly higher cumulative yields than 'BH#5' (**Table 6**). Cumulative yields were similar among rootstocks grafted to 'Monterey' (**Table 7**).

Average stem water potential (SWP) measurements, which indicate tree water stress, were similar to values observed last year, with greater (more negative) deviation from baseline (and thus indicative of higher water stress) than in 2011 and 2012. 'RootPac(R)' has consistently shown higher stress values than other rootstocks since 2011 (**Table 8**).

Differences in bloom period, as determined by the proportion of open flowers on a given data, were observed among varieties and some rootstocks (**Tables 9, 10, 11**). 'Nonpareil' flowers showed similar bloom periods across rootstocks, though all rootstocks except 'Atlas' bloomed earlier than 'Nonpareil' flowers on 'Viking' (**Table 9**). 'Fritz' bloom periods were identical among rootstocks (**Table 10**), while 'Monterey' flowers bloomed slightly earlier on 'Empyrean-1' and 'Red Titan III' than on other rootstocks (**Table 11**). It is worth noting that 'Fritz' and 'Monterey' showed more complete bloom than 'Nonpareil' in late February, which is contrary to what was observed in previous years. 'Nonpareil' trees exhibited uneven bloom, with many upper canopy flowers unopened on the observation date. This delayed bloom may be the result of inadequate chilling hours or uneven chilling within the canopy.

Nematode counts varied among rootstocks (**Table 12**). The differences were not statistically significant, but the nature of nematode sampling results in high variability among samples that can obscure potentially real differences. Root knot nematodes (*Meloidogyne* spp.) were found only in Krymsk-86. Ring nematodes (*Criconemella* spp.) were found on 'Hansen 536', 'BH #5', 'BB #106', 'Floridaguard x Alnem', and 'Krymsk-86'. Pin nematodes (*Paratrichodorus* spp.) were found at low levels on all rootstocks except, 'Hansen 536', 'Nemaguard', and 'Viking'. Pin (*Paratylenchus* spp.) nematodes were found only on root samples from 'RootPac(R)'.

Table 1: Almond rootstocks selected for January, 2011 planting at a location with sandy soil and low quality irrigation water. Seven rootstocks were planted on 'Nonpareil', 'Fritz', and 'Monterey'; seven additional rootstocks were planted on 'Nonpareil' only. Asterisk indicates rootstocks planted in April 2011 due to nursery availability.

Rootstocks Planted on Nonpareil, Fritz, & Monterey	Rootstocks Planted on Nonpareil Only
Nemaguard	RootPac (R)
Hansen 536	TemproPac
BH5	Krymsk-86
Viking	Cornerstone*
Atlas	Cadaman*
Empyrean-1	BB#106
	Floridaguard x Alnem (USDA)

Table 2: Soil analysis of the six blocks established within the rootstock trial. Samples were collected in October, 2010 and analyzed by the UC Davis Analytical Laboratory.

Block	Soil Classification	Organic %	P - Weak PPM	K PPM	Mg PPM	Ca PPM	Na PPM	pH	CEC meq/100	Base Saturation % K	Mg	Ca	H	Na
1	Sandy Loam	0.7	16	68	264	1172	85	7	8.6	2	25.4	68.3	0	4.3
2	Sandy Loam	0.5	36	63	141	668	39	6.6	5.1	3.1	22.6	64.9	6	3.3
3	Loamy Sand	0.4	55	56	73	366	16	6.7	2.8	5.2	21.8	66	4.5	2.6
4	Loamy Sand	0.4	72	52	62	290	25	6	2.6	5.2	19.7	55.9	15	4.2
5	Loamy Sand	0.5	33	58	81	377	25	6.5	3	4.9	62.1	62.1	7.5	3.6
6	Loamy Sand	0.7	82	64	207	845	82	6.6	6.8	2.4	24.8	61.5	6	5.2

Table 3: Water analyses (2011-2014) from well supplying water for the trial. Blue indicates values are below normal, red indicates values are above normal.

Sampling Period	pH	EC dS/m	SAR	Ca meq/L	Mg meq/L	Na meq/L	Cl meq/L	B mg/L	HCO_3 meq/L	NO_3-N mg/L	N lbs/acre in.
2014 Late season	7.6	0.31	0.90	1.47	1.05	1.00	0.30	0.05	1.80	10.3	2.3
2013 Mid-season	7.2	0.43	0.90	1.82	1.36	1.10	0.50	0.10	1.50	18.5	4.2
2012 Late season	7.4	0.48	1.30	1.69	1.20	1.50	0.80	0.10	1.60	13.9	3.2
2011 Late season	7.9	0.52	0.8	2.44	1.47	1.18	0.42	0.03	2.1	17.2	3.9
2011 Mid-season	7.9	0.52	0.9	2.50	1.50	1.23	0.42	0.03	2.1	19.6	4.5

Table 4: 'Nonpareil' leaf nutrient analysis among 13 rootstocks. Different letters indicate statistically significant differences (log10 normalized one-way ANOVA, Tukey-Kramer HSD or Steel-Dwass All pairs, p <0.05). Blue indicates nutrient concentrations are deficient, red indicates nutrient concentrations are higher than recommendations.

Rootstock	N %	P %	K %	Zn ppm	Mn mg/kg	Na %	B ppm	Ca %	Mg %	Fe ppm	Cu ppm	Cl %
Atlas	2.18 A	0.10 A	1.69 ABC	18.0 A	96.4 A	<0.01 A	42.4 A	5.52 A	0.95 A	303 A	5.4 A	0.20
BB#106	2.08 A	0.09 A	1.55 BC	16.4 A	95.8 A	<0.01 A	39.4 AB	6.29 AB	0.93 BC	261 A	5.0 A	<0.1
BH#5	2.18 A	0.10 A	1.55 BC	16.4 A	93.8 A	<0.01 A	37.6 ABC	5.93 ABC	0.88 BCD	263 A	5.4 A	<0.1
Cadamen	2.39 A	0.10 A	1.66 ABC	18.2 A	112 A	<0.01 A	41.8 AB	5.07 AB	0.97 BCD	279 A	5.2 A	0.18
Cornerstone	2.19 A	0.10 A	1.53 BC	13.8 A	91.4 A	<0.01 A	35.2 C	5.37 BC	0.95 BC	270 A	3.8 A	<0.1
Empyrean 1	2.11 A	0.10 A	1.31 C	15.0 A	116 A	<0.01 A	38.8 AB	5.66 ABC	1.18 BC	230 A	4.4 A	0.08
F x A	2.17 A	0.10 A	1.52 BC	13.8 A	108 A	<0.01 A	40.4 AB	6.13 ABC	1.04 AB	266 A	5.2 A	<0.1
Hansen	1.99 A	0.09 A	1.33 C	15.6 A	138 A	<0.01 A	39.8 ABC	6.32 AB	1.04 AB	242 A	4.6 A	0.02
Krymsk-86	2.27 A	0.10 A	1.60 ABC	14.0 A	100 A	<0.01 A	38.2 ABC	4.61 C	0.87 BCD	277 A	5.0 A	0.12
Nemaguard	2.19 A	0.10 A	1.68 ABC	11.8 A	78.0 A	<0.01 A	39.2 ABC	5.09 BC	0.86 BCD	280 A	4.2 A	0.20
Rootpac R	2.24 A	0.11 A	2.04 A	13.8 A	118 A	<0.01 A	37.2 BC	4.46 C	0.77 CD	288 A	4.6 A	0.04
TemproPac	2.12 A	0.10 A	1.48 BC	17.0 A	119 A	<0.01 A	39.4 ABC	5.57 ABC	1.02 AB	289 A	4.8 A	0.02
Viking	2.13 A	0.10 A	1.84 AB	15.2 A	100 A	<0.01 A	37.2 BC	5.67 ABC	0.73 D	272 A	4.6 A	<0.1

Table 5: Mean 2013 and 2014 yields for 'Nonpareil' scion grafted to 14 different rootstocks. Measurements with different letters indicate statistically significant differences at p<0.05 (ANOVA and Tukey-Kramer HSD). Asterisk denotes treatments planted as potted trees in mid-April.

Rootstock (Nonpareil)	Yield (lbs/acre)		
	2013	2014	Cumulative
Atlas	536 A	1262 ABC	1798 AB
BB #106	399 ABC	1165 BCD	1564 ABC
BH #5	349 BC	1167 BCD	1516 ABC
Empyrean-1	503 AB	1494 AB	1997 A
Floridaguard x Alnem	375 ABC	1604 A	1980 A
Hansen 536	442 ABC	1280 ABC	1722 ABC
Krymsk-86	321 C	1256 ABC	1578 ABC
Nemaguard	398 ABC	814.0 D	1212 C
Rootpac(R)	370 ABC	1041 CD	1411 BC
TemproPac	361 ABC	1366 ABC	1727 AB
Viking	478 ABC	1151 BCD	1628 ABC

Table 6: Mean 2013 and 2014 yields for 'Fritz' scion grafted to 7 different rootstocks. Measurements with different letters indicate statistically significant differences at p<0.05 (ANOVA and Tukey-Kramer HSD).

Rootstock (Fritz)	Yield (lbs/acre)		
	2013	2014	Cumulative
Atlas	435 A	1420 A	1855 A
BH #5	223 A	1137 A	1360 B
Empyrean-1	377 A	1402 A	1779 AB
Hansen 536	418 A	1420 A	1837 AB
Nemaguard	317 A	1182 A	1499 AB
Viking	428 A	1414 A	1842 AB

Table 7: Mean 2013 and yields for 'Monterey' scion grafted to 7 different rootstocks. Measurements with different letters indicate statistically significant differences at p<0.05 (ANOVA and Tukey-Kramer HSD).

Rootstock (Monterey)	Yield (lbs/acre)		
	2013	2014	Cumulative
Atlas	753 AB	1841 A	2595 A
BH #5	563 B	1709 A	2271 A
Empyrean-1	829 A	1850 A	2679 A
Hansen 536	626 AB	1759 A	2385 A
Nemaguard	631 AB	1516 A	2147 A
Viking	593 B	1603 A	2196 A

Table 8: Stem water potential measurements sampled from 14 rootstocks grafted to 'Nonpareil' for the 2011-2014 growing seasons. Number reported is difference from baseline determined from temperature and humidity of the day measurements were taken. Measurements with different letters indicate statistically significant differences at p<0.05 (ANOVA and Tukey-Kramer HSD).

Rootstock (Nonpareil Scion)	2011 SWP off Baseline	2012 SWP off Baseline (bars)	2013 SWP off Baseline (bars)	2014 SWP off Baseline (bars)
Atlas	-1.49 AB	-0.98 ABCD	-2.45 A	-2.62 A
BB #106	-1.86 AB	-1.48 CDE	-3.38 AB	-3.21 A
BH #5	-1.94 AB	-1.10 ABCD	-2.68 AB	-3.37 A
Cadaman	-2.20 AB	-1.59 DE	-2.82 AB	-3.51 A
Cornerstone	-2.07 AB	-1.30 BCDE	-3.91 AB	-3.06 A
Empyrean-1	-2.06 AB	-0.43 A	-3.07 AB	-2.22 A
Flor x Alnem	-1.17 A	-0.96 ABCD	-2.01 A	-3.21 A
Hansen 536	-1.57 AB	-1.34 BCDE	-1.86 A	-2.97 A
Krymsk-86	-2.54 B	-1.20 BCDE	-4.94 B	-2.03 A
Nemaguard	-1.62 AB	-0.86 ABCD	-2.69 AB	-2.36 A
RootPacR	-2.54 B	-1.76 E	-4.96 B	-5.65 B
TemproPac	-2.04 AB	-0.79 ABC	-2.92 AB	-2.46 A
Viking	-1.52 AB	-0.67 AB	-2.68 AB	-2.81 A

Table 9: Mean estimated percent bloom for four seasons among rootstocks grafted to 'Nonpareil'. Bloom period in 2013 was too compact to reliably determine % bloom differences among rootstocks. Measurements with different letters indicate statistically significant differences at p<0.05 (ANOVA and Tukey-Kramer HSD of arcsin transformed bloom percentages).

Rootstock, cv 'Nonpareil'	2012	2013	2014	2015
Atlas	43% DEF	100%	34% ABC	74% BC
BB #106	63% BCD	100%	25% C	88% A
BH #5	43% DEFG	100%	32% ABC	88% A
Cadaman	22% GHI	100%	29% ABC	82% AB
Cornerstone	11% I	100%	30% ABC	80% ABC
Empyrean-1	76% A	100%	53% AB	84% AB
Flor x Alnem	38% DEFGH	100%	35% ABC	86% A
Hansen 536	63% ABC	100%	56% A	86% A
Krymsk-86	7% I	100%	33% ABC	83% AB
Nemaguard	54% CDE	100%	23% C	83% AB
RootPac(R)	23% HI	100%	28% BC	89% A
TemproPac	35% EFGH	100%	31% BC	83% AB
Viking	74% AB	100%	28% ABC	71% C

Table 10: Mean estimated percent bloom for four seasons among rootstocks grafted to 'Fritz'. Bloom period in 2013 was too compact to reliably determine % bloom differences among rootstocks. Measurements with different letters indicate statistically significant differences at p<0.05 (ANOVA and Tukey-Kramer HSD of arcsin transformed bloom percentages).

Rootstock, cv	2012	2013	2014	2015
Atlas	31% B	100%	6% A	94% A
BH5	12% C	100%	5% A	92% A
Empyrean-1	66% A	100%	11% A	92% A
Hansen 536	55% A	100%	12% A	91% A
Nemaguard	28% BC	100%	3% A	94% A
Viking	36% B	100%	4% A	92% A

Table 11: Mean estimated percent bloom for four seasons among rootstocks grafted to 'Monterey'. Bloom period in 2013 was too compact to reliably determine % bloom differences among rootstocks. Measurements with different letters indicate statistically significant differences at p<0.05 (ANOVA and Tukey-Kramer HSD of arcsin transformed bloom percentages).

Rootstock, cv 'Monterey'	2012	2013	2014	2015
Atlas	42% BC	100%	36% AB	93% AB
BH5	21% D	100%	28% AB	89% B
Empyrean-1	71% A	100%	48% A	94% A
Hansen 536	64% AB	100%	53% A	91% B
Nemaguard	27% D	100%	18% B	89% B
Viking	53% AB	100%	27% AB	90% B

Table 12: Average nematode counts among blocks per 500g of soil. Soil samples were taken at 12-18 in depths from within the dripline of rootstocks grafted to 'Nonpareil'. No significant differences were observed among rootstocks at p<0.05 (Steel-Dwass All Pairs ln count +1).

Nematode Species	**Root Knot**	**Ring**	**Lesion**	**Stubby Root**	**Pin**	**Free Composite**
Rootstock	**----- nematodes/500g soil -----**					
Atlas	0	0	0	0.4	0	7785.2
BB #106	0	45.6	0	20.4	0	2660.8
BH #5	0	122.8	37.6	1.2	0	3863.2
Cadaman	0	0	0	4.8	0	1330.8
Cornerstone	0	0	0	2.4	0	3497.2
Empyrean-1	0	0	0	0.8	0	7777.2
Flor x Alnem	0	12.4	0	29.2	0	1604.8
Hansen 536	0	1832.0	0	0	0	3329.2
Krymsk-86	131.2	247.2	546.8	5.6	0	1374.4
Nemaguard	0	0	0	0	0	5232.8
RootPac(R)	0	0	8.8	22.4	326.8	2402.0
TemproPac	0	0	33.6	4.8	0	3713.2
Viking	0	0	0 B	0	0	3661.6

Exploring Alternative Rootstocks in Butte County

Project Leader: J.H. Connell (Emeritus), UCCE - Butte County

Project Personnel and Cooperators:
Almont Orchards - Brouwer Orchards, Sam Lewis & Son Orchards, M&T Chico Ranch, and Keeney & Son Orchards

Objective:

Evaluate Nonpareil compatibility with rootstocks for almond. Assess tree field performance and/or tolerance to oak root fungus.

Materials and Methods:

A) Replants on alternative rootstocks are planted in non-fumigated oak root fungus spots to gauge their survival when exposed to the fungus. 'Nonpareil' on 'Empyrean 101' rootstock has been observed in two orchards since 2004. Nine 'Nonpareil' trees on 'Krymsk 86' were replanted in oak root fungus spots in spring 2010 and ten trees on another experimental rootstock were planted in 2012.
B) Following the removal of a Lovell peach rooted orchard, Greg Browne and I planted a randomized replant disease fumigation trial in 2004 with Almont Orchards in Durham. 20 single tree replicates of 'Krymsk 86', 'Lovell', 'Marianna 2624', and 'Ishtara' rootstocks were planted in both fumigated and non-fumigated tree sites. Although the fumigation trial is complete, observations related to vigor and mortality of the trees on these rootstocks still have value. Trunk circumference measurements are taken periodically to characterize tree size differences and tree anchorage and mortality will be noted.
C) Working with Brouwer Orchards in Durham and Fowler Nursery, a rootstock trial was planted in March 2010 following the removal of a previous 'Lovell' peach rooted orchard containing some plum rooted replants. This replicated randomized trial has six rootstocks, all with 'Nonpareil' as the scion, planted with five replicates of ten trees each. Trees were planted on Farwell Loam soil, a relatively heavy series bordering Stockton Clay Adobe. The rootstocks 'Rootpac'®, 'Atlas', 'Krymsk 86', and 'Empyrean 1' are compared to standard rootstocks 'Nickels' and 'Lovell'. Tree growth is documented with trunk circumference measurements, mortality and anchorage will be noted, and yield data is collected annually.

Results to Date:

A) All nine 'Nonpareil' trees on 'Krymsk 86' planted in spring 2010 in three different oak root fungus spots continue to be healthy through the 5th growing season. Ten 'Nonpareil' trees planted in 2012 on another new rootstock being screened for potential *Armillaria* resistance established well and have so far remained healthy. 'Nonpareil' trees on 'Empyrean 101' are prone to leaning but are similar in size and vigor to nearby trees on 'Marianna 2624'.

B) There were no observations made on this old fumigation/rootstock trial during the 2014 season. 'Krymsk 86' trunk circumference was largest while 'Lovell' benefited most from fumigation. After 8 years, 47% of 'Ishtara' trees and 8% of 'Lovell' trees were leaning. There were no leaning trees on 'Krymsk 86' rootstock.

C) In this Six Rootstocks trial, four of the six rootstocks established well in the first growing season with no tree losses. 'Atlas' suffered 10% mortality at planting and 'Nickels' lost 16% of the new trees (data presented in 2012 annual report). After five growing seasons, trees on the 'Empyrean 1' rootstock are largest in circumference followed by those on 'Nickels'. Trees on 'Krymsk 86' and those on 'Lovell' are similar in size. 'Rootpac-R' rooted trees are numerically smallest but similar statistically to trees on 'Krymsk 86' (**Figure1**).

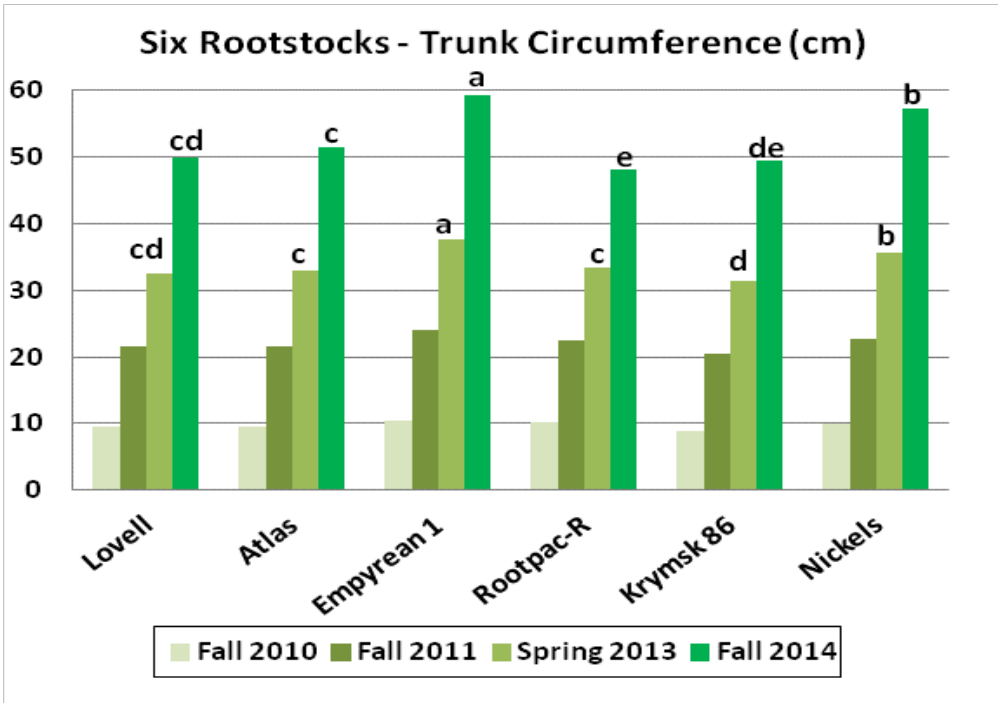

Figure 1. Trunk circumference of 'Nonpareil' almond in centimeters after five growing seasons.

Yield data was collected starting in the third leaf. Fourth leaf 'Nonpareil' yields were heaviest in trees on 'Empyrean 1' rootstock and lightest on 'Rootpac-R' and 'Krymsk 86' rootstocks. Other rootstocks produced intermediate yields (**Table 1**). By the fifth leaf, yield is mainly a reflection of differences in tree canopy size related to rootstock vigor. Tree spacing in this orchard is 24 feet x 16 feet down the row giving a tree population of 113 trees per acre. 'Nonpareil' yields are heaviest on the largest trees, 'Empyrean 1', 'Nickels', and 'Atlas' and lightest on the smaller trees 'Rootpac-R', 'Krymsk 86', and 'Lovell'.

Table 1. Yield of 'Nonpareil' almond on six rootstocks planted in Durham, California.

Rootstock	Kernel Pounds per Tree		
	3rd Leaf	4th Leaf	5th Leaf
Empyrean 1	0.61 d	11.7 a	19.3 a
Nickels Hybrid	0.85 abc	10.3 bc	19.1 a
Atlas	1.00 a	10.5 ab	18.2 a
Rootpac R	0.79 bcd	9.1 d	13.7 b
Krymsk 86	0.93 ab	9.0 d	13.5 b
Lovell	0.67 cd	9.2 cd	12.6 b

Values followed by the same letter are not significantly different from one another at P<0.05 using Fisher's Least Significant Difference (LSD) procedure