

Project: Field Evaluation of Almond Rootstocks

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Four Regional Rootstock Trials were established in Butte, Colusa, Kern, and San Joaquin counties. Rootstock effects evaluated in these ongoing trials include rootstock influence on growth, mineral nutrition, yield, disease susceptibility, and tree mortality. Trial sites were selected for specific challenges to the rootstocks such as the need for better anchorage, bacterial canker resistance, and tolerance to shallow soils or high rainfall environments. Although not all rootstocks are in all trials, the peach rootstocks; 'Nemaguard', 'Lovell', and 'Guardian', the peach x almond hybrids; 'Hansen 536', 'Hansen 2168', 'Bright's' and 'Nickels' (UC 1-82), and the inter-specific (peach x almond x plum x apricot) hybrids; 'Viking' and 'Atlas' are included. Another continuing aspect of this project includes preliminary investigations into alternative rootstocks for almond.

Objectives:

1. Collect Regional Rootstock Trial data in Butte, Colusa, Kern, and San Joaquin counties.
 - 1a. Butte County: rootstock performance on deep soil in a high rainfall environment.
 - 1b. Colusa County: rootstock performance on a shallow, hardpan soil.
 - 1c. Kern County: rootstock performance vs. 'Santa Ana' winds.
 - 1d. San Joaquin County: rootstock performance in a sandy replant location.
2. Alternative Rootstocks: evaluate the compatibility and field performance of Hiawatha and other plum rootstocks for almond; study the compatibility of newer almond varieties on Marianna 2624 plum; and, evaluate other new European rootstocks.

Methods:

Trees for these trials were grown by commercial nurseries and were planted bare root in cooperators fields as conditions permitted. The scion variety in the Kern trial is 'Butte' while the scions in the other three trials are 'Nonpareil'. All orchards are managed under normal commercial irrigation, fertilization, pruning, disease and pest control practices.

Field trials in all counties were planted using a randomized complete block design. To provide uniform pollination and maximum yield potential pollenizer rows are planted on both sides of the scion cultivar used for data collection and beehives are moved into all orchards

during bloom.

Results:

1. Regional Rootstock Trials

1a. Butte County: Rootstock Performance on Deep Soil in a High Rainfall Environment

Joe Connell, UC Farm Advisor Butte County; Rick Buchner, UC Farm Advisor, Tehama County; Almont Orchards, Chico.

This orchard is irrigated with solid set sprinklers. Sixty trees of each rootstock were planted in 10 replications of six trees with the exception of the ‘Nickels’ stock where 10 replications of 3 trees were used.

‘Hansen 536’ has the largest tree trunk circumference followed by ‘Nickels’, ‘Bright’s’ and ‘Nemaguard’ (Table 1). This difference in tree size is also reflected in yield per tree shown in table 2.

Table 1. Butte County Mean Trunk Circumference in centimeters*

Rootstock	At Planting June 1998	After 1st April 1999	After 2nd Oct. 1999	After 3rd Oct. 2000	After 4th Oct. 2001	After 5th Feb. 2003	After 6th Feb. 2004	After 7th Feb.2005
Bright's Hybrid	4.01 cde	9.62 cd	20.75 d	35.88 c	47.90 d	54.92 c	64.90 cd	73.85 c
Hansen 536	4.18 bc	11.43a	24.50a	41.32a	54.12a	61.53a	72.15a	80.48a
Nickels Hybrid	5.22a	10.79ab	23.17 b	38.79 b	51.34 b	57.48 b	67.49 b	76.83 b
Viking	4.50 b	9.11 d	21.24 cd	36.35 c	47.82 de	54.73 c	63.07 de	69.46 d
Atlas	4.33 bcd	10.06 bc	21.98 c	36.16 c	46.33 e	53.36 c	60.99 e	67.24 d
Guardian	3.52 f	10.01 bc	22.02 c	36.42 c	47.01 de	53.81 c	61.79 e	68.84 d
Nemaguard	3.74 ef	10.79ab	23.17 b	38.45 b	49.76 c	57.15 b	65.67 bc	72.42 c
Lovell	3.94 de	9.67 cd	21.33 cd	35.86 c	46.58 de	53.45 c	61.12 e	67.95 d

Values followed by the same letters are not significantly different from one another at P< 0.05 using Fisher's least significant difference (LSD) procedure.

* Replants are not included in the calculations for mean circumference.

Table 2. Nonpareil yield on various rootstocks in pounds of kernel per tree*.

	2000 <u>3rd leaf</u>	2001 <u>4th leaf</u>	2002 <u>5th leaf</u>	2003 <u>6th leaf</u>	2005 <u>8th leaf</u>
Bright's Hybrid	0.72 c	8.10 d	18.54 bc	19.24 cd	36.72 bc
Hansen Hybrid	1.24ab	9.28 cd	22.04a	26.06a	44.25a
Nickels (UC I-82)	1.00 b	9.39 bc	19.36 b	23.20abc	39.47ab
Viking	1.24ab	8.59 cd	17.72 bc	19.73 bcd	28.68 d
Atlas	1.45a	10.95a	19.35 b	23.77ab	37.99ab
Guardian	1.26ab	8.40 cd	17.52 c	20.32 bcd	30.38 cd
Nemaguard	1.16 b	10.63ab	21.51a	23.65ab	38.69ab
Lovell	1.09 b	8.34 cd	15.40 d	18.21 d	27.54 d

Values followed by the same letters are not significantly different from one another at P< 0.05 using Fisher's least significant difference (LSD) procedure.

* Missing trees & non-bearing replants not included in calculations when determining per tree yield. Greater yield primarily reflects larger tree size. Many more large trees have been lost due to splitting.

Influence of rootstock on yield

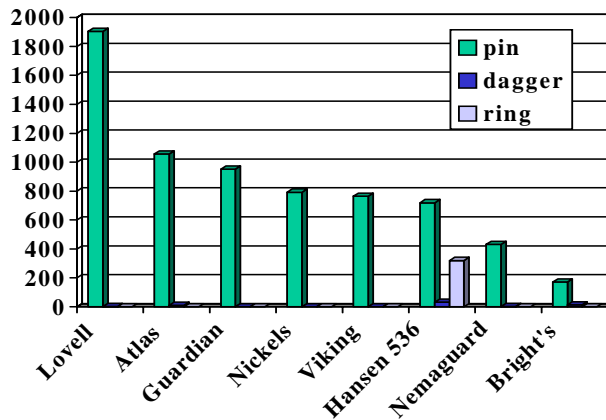
Yield differences are more commonly a result of differences in tree size rather than differences in productivity. For the most part, the largest trees (Table 1) have the greatest yield

per tree (Table 2). The only exception to this are trees on the 'Atlas' rootstock. In this orchard, the larger trees are also much more likely to split out the primary scaffolds resulting in tree losses. These tree losses make a significant difference in per acre productivity and this is a factor that should be considered in making tree spacing and rootstock choices. The trend in percentage of trees lost over the past several years is shown in Figure 2. The 'Viking' rootstock has increased in percentage of trees present as replants have come into bearing (it suffered significant losses at planting).

Nematodes by rootstock

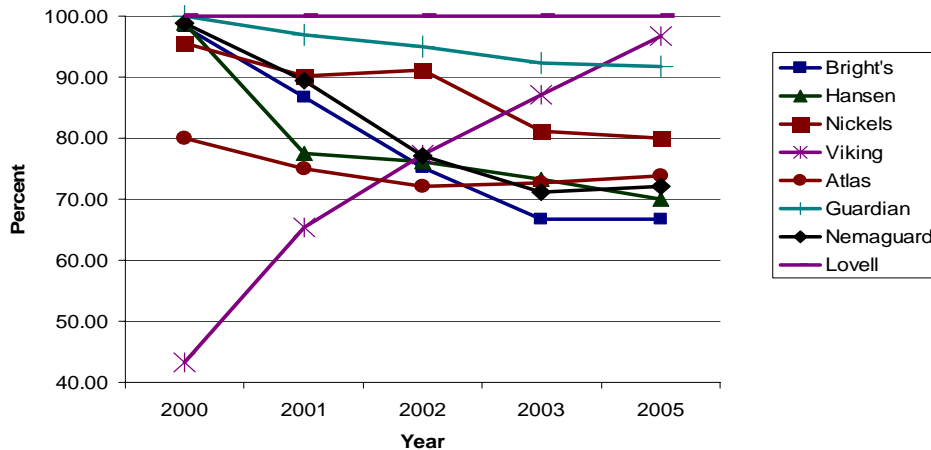
In a preliminary spring 2005 sampling by Mike McKenry from several replicates there were no species except pin nematode that were well distributed across the field. Abundance of pin nematode is oftentimes a good indication of abundant root development. Only 'Hansen 536' had a measurable population of ring nematodes. This field trial did not receive further, more extensive soil sampling.

Figure 1. Pin and dagger nematodes / 250 cc soil, Butte County.



Note: Inadequate nematode presence to justify sampling from each replicate

Figure 2. Percentage of Producing Trees by Rootstock



1b. Colusa County: Rootstock Performance on a Shallow, Hardpan Soil.

J. Edstrom, UC Farm Advisor, Colusa Co., Nickels Estate Trustees.

This orchard is on shallow soil with a hardpan that was slip plowed prior to planting in March 1997. It is irrigated with dual microsprinklers. Sixty-four trees of each rootstock were planted in 8 replications of 8 trees each.

Yield figures appear to show differences in productivity between the seven rootstocks in the Colusa location. Higher yielding rootstocks are: Hansen 536, Nickels and Atlas. Brights, Lovell, Nemaguard and Viking are all slightly behind in production. However, this may simply reflect the current tree size and not potential production per acre **if** each rootstock were planted at its optimal density. Trees are widely planted at 22x24 ft. spacing, far too wide to be optimum for the peach rootstocks. Realistic yield comparisons can't be made from this type of test when a common spacing is used. No differences in any other trait, except tree size, have been found to date. Trees on Hansen, Bright's and Nickels are larger than on the other four rootstocks.

Colusa County Rootstocks Yields

	Lbs/Acre				
	<u>2002</u>	<u>2003</u>	<u>2004</u>	<u>2005</u>	<u>Mean</u>
Brights	2,224	2,117	1,563	1,363	1,817
Hansen 536	2,315	2,480	1,881	1,747	2,106
Lovell	2,050	1,877	1,538	1,508	1,743
Nickels 1-82	2,108	2,431	1,816	1,612	1,992
Viking	2,025	1,829	1,573	1,462	1,722
Atlas	2,207	2,195	1,880	1,686	1,992
Nemaguard	2,149	2,023	1,540	1,280	1,748

22' X 24' spacing, 83 trees per acre

Leaf mineral analysis data appear to show that PA hybrids accumulate less nitrogen, but more calcium in leaves compared to the other four candidates. The peach rootstocks accumulate more chloride than the other stocks. Tree survival rates are similar for all rootstocks at this location despite some soil layering.

Nonpareil Leaf Analysis vs. Rootstock 2004

<u>Rootstock</u>	<u>N</u>	<u>K</u>	<u>B</u>	<u>Ca</u>	<u>Mg</u>	<u>Na</u>	<u>Cl</u>	<u>Zn</u>	<u>Mn</u>
	<u>%</u>	<u>%</u>	<u>ppm</u>	<u>%</u>	<u>%</u>	<u>ppm</u>	<u>%</u>	<u>ppm</u>	<u>ppm</u>
Bright's Hybrid	2.61 c	2.14 b	35b	3.59 b	0.76 b	104a	0.02 c	32	219 bc
Hansen 536	2.57 c	1.91 bc	35b	4.08 a	0.95 a	59 b	0.03 bc	40	345 a
Nickels Hybrid	2.61 bc	2.21 a	36b	3.72 ab	0.75 bc	59 b	0.04 bc	36	229 b
Viking	2.70 ab	2.22 a	36b	3.19 c	0.70 c	59 b	0.03 bc	32	223 b
Atlas	2.79 a	2.15 b	40a	3.22 c	0.78 b	60 b	0.03 b	34	229 b
Lovell	2.78 a	2.14 b	37b	2.93 c	0.83 b	68 b	0.07 a	34	211 b
Nemaguard	2.76 ab	2.05 bc	37b	3.04 c	0.79 b	68 b	0.06 a	32 ns	185 c

P=.001-.02

Nonpareil Leaf Analysis vs. Rootstock, July 2005

<u>Rootstock</u>	<u>% Nitrogen</u>	<u>% Potassium</u>
Bright's Hybrid	2.59	1.99
Hansen 536	2.51	1.87
Nickels Hybrid	2.57	2.05
Viking	2.73	2.06
Atlas	2.71	2.06
Lovell	2.74	1.86
Nemaguard	2.8	2.07

1c. Kern County: Performance of Rootstocks vs. 'Santa Ana' Winds

Mario Viveros, UC Farm Advisor, Kern Co., Peggy Schrader, Field Assistant & Dosanjh Bros. Farm.

The orchard is irrigated with solid set sprinklers. Large plots designed to evaluate the resistance of each rootstock to "Santa Ana" windstorms were planted in February 1997 on very deep sandy soils a few miles north of the Tehachapi Mountains. The trial was planted at 30 trees per plot each replicated six times with the exception of 'Nemaguard' and 'Nickels' which are replicated five times and 'Hansen 2168' replicated two times. Tree spacing is 24' x 24'.

Tree Size

In Kern County, the 'Atlas', 'Hansen 2168', and 'Hansen 536' were significantly larger than 'Bright's' and 'Nemaguard' for the first three years (Table 1) but by the fourth season there were no significant differences in trunk growth among any rootstocks. The 'Hansen 536' has been the largest tree since the fifth season while 'Nickels', 'Atlas', and 'Nemaguard' were the smallest during the same period. In the 8th season 'Bright's Hybrid' showed an increase in tree growth.

Table 1. Kern county mean trunk circumference in centimeters.

	Following: 1 st Season	2 nd Season	3 rd Season	4 th Season	5 th Season	6 th Season	7 th Season	8 th Season
<u>Rootstock</u>	<u>Fall 1997</u>	<u>Fall 1998</u>	<u>Fall 1999</u>	<u>Fall 2000</u>	<u>Fall 2001</u>	<u>Fall 2002</u>	<u>Fall 2003</u>	<u>Fall 2004</u>
Bright's Hybrid	9.34 c*	22.24 b	34.57 d	48.91	54.1 b	62.43 ab	69.56 ab	74.43 b
Hansen 536	12.71 a	27.73 a	41.85 a	48.1	63.0 d	68.75 c	77.01 c	81.10 c
Hansen 2168	12.41 a	27.61 a	41.65 ab	51.41	61.8 cd	69.78 c	77.21 c	81.38 c
Nickels (1-82)	**	12.79 c	26.17 e	46.36	50.4 a	58.55 a	67.10 a	71.92 ab
Viking	11.08 b	25.50 a	37.72 c	51.35	59.1 c	65.72 bc	73.35 bc	74.44 b
Atlas	12.38 a	26.11 a	38.85 bc	52.47	58.3 c	62.50 ab	69.97 ab	72.25 ab
Nemaguard	8.95 c	21.81 b	34.10 d	48.01 ns	54.2 b	59.42 a	66.50 a	68.54 a

* Values followed by the same letter are not statistically different as measured by the least significant difference test at P < 0.05 or, are ns, not significantly different.

Tree height measurements (Table 2) were significantly different between rootstocks through the 2000 (4th) growing season. Trees on 'Nemaguard' were shorter than trees on 'Hansen 536'. Tree height averaged five meters following the 5th growing season in the Kern trial, and, there were no significant differences between rootstocks until the 2004 season. In

2004, 'Hansen 536' grew the most. All other rootstocks grew also but there were no significant differences between them.

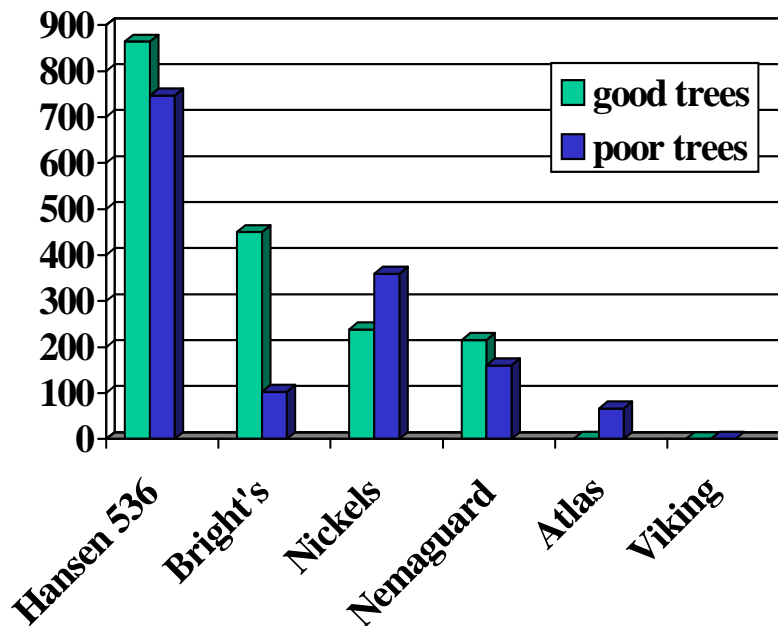
Table 2. Kern County Tree Height in meters.

Rootstock	1999	2000	2001	2002	2003	2004
Bright's Hybrid	3.79 b	4.76 abc	4.88 a	5.10 a	5.07 a	5.77 ab
Hansen 536	4.29 c	4.93 c	5.00 a	5.13 a	5.30 a	6.10 b
Hansen 2168	3.83 bc	5.06 c	5.13 a	5.10 a	5.30 a	5.60 b
Nickels (1-82)	3.04 a	4.47 a	4.94 a	5.07 a	5.05 a	5.71 ab
Viking	3.83 bc	4.83 bc	4.99 a	5.14 a	5.09 a	5.40 a
Atlas	3.78 bc	4.94 c	5.04 a	5.18 a	5.23 a	5.72 ab
Nemaguard	3.71 b	4.57 ab	4.90 a	4.93 a	4.94 a	5.45 a

Nematodes by rootstock

Mike McKenry conducted extensive nematode sampling in winter 2005 with collections from good growing and poor growing trees infested with *Mesocriconema xenoplax*. Poor growth of the trees did not appear to be associated with nematode presence and no Bacterial Canker was present in the block. This ring nematode is slightly smaller in size than the ring nematode from Stanislaus County but we currently do not know if this difference has any implications relative to tree damage.

Figure 1. Ring nematodes / 250 cc soil, Kern County.



1d. San Joaquin County: Performance of Rootstocks In A Sandy Replant Location.

Roger Duncan, UC Farm Advisor Stanislaus County; Paul Verdegaal, UC Farm Advisor, San Joaquin County; Bruce Lampinen, Dept. of Pomology, UC Davis; Darpinian and Sons, grower.

There are two main objectives in this trial:

1. To document growth and yield characteristics of the Nonpareil almond variety on eight rootstocks growing in a sandy, replant site.
2. To evaluate rootstock tolerance to the bacterial canker complex.

Introduction: In the fall prior to trial establishment, a second generation peach orchard with a history of bacterial canker (*Pseudomonas syringae*) and ring nematode (*Mesocriconema xenoplax*) was removed and the soil solid fumigated with a tarped application of methyl bromide (400 lbs. per acre). On March 12, 1998, fifty Nonpareil almond trees on each of eight rootstocks were planted with Carmel and Sonora as pollinators. Twenty-one of the fifty trees on Viking rootstock (42%) failed to grow, probably due to cold storage sensitivity, and were replaced in February 1999. Replacement trees have grown well. The grower experienced no problems establishing trees on the other rootstocks.

Tree Size. In October, 2004, tree size was compared for each rootstock by measuring trunk circumference (Table 1). Trees on all rootstocks have grown well. In general, trees on all three peach / almond hybrid rootstocks are fairly large, but occurrence of bacterial canker has slowed growth in affected trees (see bacterial canker section below). Trees on Nickels are the largest. Trees on Guardian, Lovell and Atlas are the smallest. The orchard was planted at a spacing of 15' x 21' (138 trees per acre). This fairly high density planting restricts tree size due to inter-tree competition. Trees on peach / almond hybrid rootstocks may have been significantly larger if the orchard was planted to a more traditional spacing of 110 trees per acre.

Rootstock	Trunk Circumference (cm)
Nickels	68.0 A ¹
Brights	67.0 AB
Hansen	66.5 AB
Nemaguard	66.3 AB
Viking ²	66.1 AB
Atlas	64.8 B
Lovell	64.7 B
Guardian	64.3 B

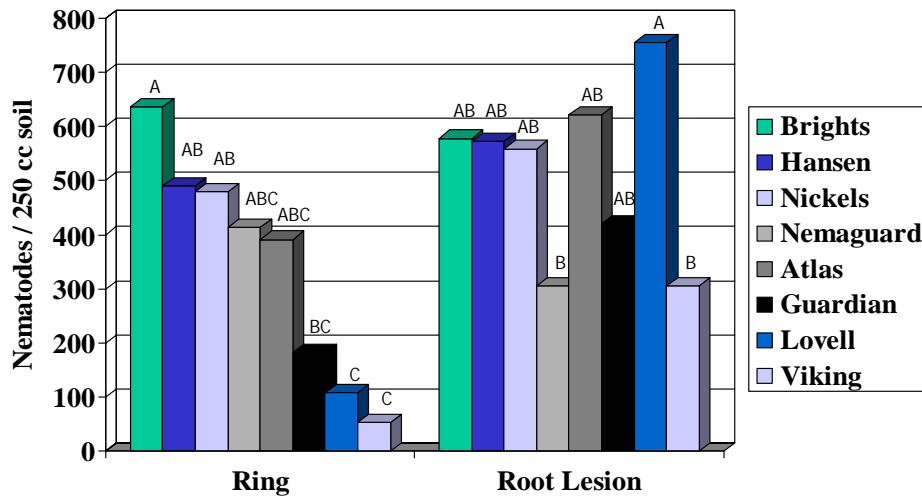
¹ Data followed by the same letters are not significantly different as measured by the Duncan's Multiple Range Test ($P \leq 0.05$).

² Due to the high mortality rate of Viking at planting, data for Viking include many trees one year younger than trees of other rootstocks.

Nematodes. Soil was sampled from the rhizosphere of all rootstocks in January, 2005. Pathogenic nematode species were extracted, identified and enumerated by Dr. Mike McKenry's laboratory at the UC Kearney Agricultural Center (Figure 1). Peach / almond hybrid rootstocks

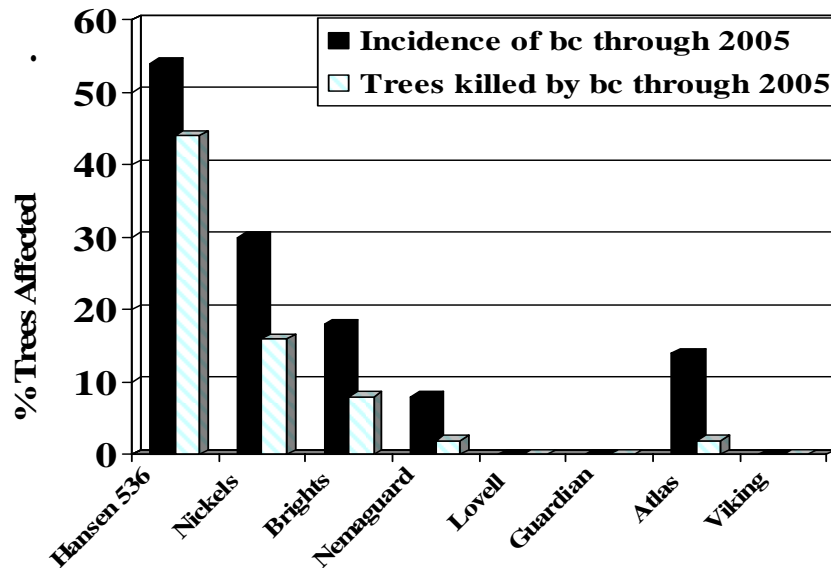
harbored very large numbers of ring nematodes (*Mesocriconema xenoplax*). Viking, Lovell, and Guardian rootstocks supported the fewest ring nematodes. Ring nematode is known to be associated with the bacterial canker complex. It is interesting that the three rootstocks that have not shown bacterial canker symptoms also harbored the fewest ring nematodes (see bacterial canker section below). The peach / almond hybrid rootstocks have the highest ring nematode numbers and are being decimated by bacterial canker in this trial. Although Viking and Nemaguard harbored the fewest root lesion nematodes (*Pratylenchus vulnus*), all rootstocks harbored large and potentially damaging numbers.

Fig. 1 Soil Numbers of Pathogenic Nematodes as Influenced by Almond Rootstock
Escalon, CA. January, 2005



Bacterial canker. Signs of bacterial canker became evident for the first time in spring 2002 (fifth-leaf) and have progressed through 2005. Bacterial canker is most severe in the three peach-almond hybrid rootstocks (Figure 2.). Fifty-four percent, 30%, & 18% of Hansen, Nickels, and Bright's hybrid trees, respectively, showed moderate to severe bacterial canker symptoms in 2005. Four out of fifty trees (8%) on Nemaguard were affected by bacterial canker. For the first time in this trial, trees on Atlas were affected by bacterial canker with 14% showing moderate to severe signs of the disease. Through the eighth-leaf, 44% of Hansen, 16% of Nickels, 8% of Bright's, 2% of Nemaguard and 2% of Atlas trees have died from bacterial canker. As trees die from bacterial canker, tree sites are fumigated with methyl bromide and rootstocks are replanted. Most of the replanted trees on Hansen have subsequently died from bacterial canker within two years of replanting.

Fig. 2. Rootstock Susceptibility to Bacterial Canker
Almond Rootstock Trial. Escalon, CA



Influence of Rootstock on Leaf Tissue Nutrient Content.

In July, 2005, leaves were sampled from all ten replications of each rootstock and sent to the DANR lab at UC Davis for nutrient analysis. In general, results confirm those found in 2004 (see 2004 Almond Conference Proceedings). Results of 2005 leaf analyses are shown in Table 2 below. Trees on all rootstocks are low in nitrogen (less than 2.2%). Levels of all other nutrients are more than adequate for all rootstocks. Zinc leaf nutrient data are not shown due to contamination of leaves from in-season zinc sprays.

There were significant differences between rootstocks for most nutrients. With a few exceptions, differences in leaf nutrient content fell into groups along the three rootstock species parentage lines. Trees on peach rootstocks (Nemaguard, Lovell & Guardian) have the highest leaf nitrogen, sodium and chloride levels and lowest levels of calcium and manganese. Peach / almond hybrid rootstocks (Hansen, Nickels & Bright's) tended to be lowest in nitrogen, potassium, sulfur, boron, sodium and chloride with the exception of Bright's which had the highest level of sodium. Bright's had the highest sodium leaf levels in 2004 also. The interspecific hybrids (Atlas & Viking) had the highest potassium values but generally fell in between for most other nutrients. As in 2004, Atlas had the highest boron and sulfur levels. Viking stands out for having the lowest magnesium leaf levels, also similar to the 2004 results.

Lower nitrogen levels of trees on peach / almond hybrid rootstocks, coupled with high ring nematode numbers, may help explain why these trees are more susceptible to bacterial canker. In addition, less accumulation of chloride in some peach / almond hybrid and interspecific hybrid rootstocks reinforces field experiences where these trees often perform better than peach rootstocks in areas where excess salt is a problem. Viking should be evaluated further for performance in high magnesium soils.

Table 2. Comparison of Leaf Nutrient Content of Nonpareil Almond on Eight Rootstocks. July, 2005.¹

	N (%)	K (%)	S (ppm)	B (ppm)	Ca (%)	Mg (%)	Mn (ppm)	Na (ppm)	Cl (ppm)
Lovell	2.13 a	3.19 ab	1802 ab	67.2 ab	3.2 f	0.62 c	84 c	127 ab	0.06 b
Nemaguard	2.10 a	3.16 ab	1794 b	69.0 ab	3.5 de	0.61 c	82 c	133 a	0.07 a
Guardian	2.06 ab	2.96 bc	1762 bc	66.2 bc	3.4 ef	0.69 ab	79 c	123 ab	0.07 a
Atlas	2.07 ab	3.31 a	1892 a	74.5 a	3.7 cd	0.62 c	88 c	125 ab	0.04 c
Viking	2.02 abc	3.25 a	1700 bc	69.6 ab	3.9 bc	0.47 d	107 b	121 ab	0.04 c
Nickels	1.91 c	2.77 c	1716 bc	58.6 c	4.0 b	0.66 bc	112 ab	114 b	0.04 cd
Brights'	1.93 c	2.95 bc	1756 bc	62.8 bc	4.0 b	0.63 c	109 b	133 a	0.03 d
Hansen	1.96 bc	2.49 d	1662 c	62.4 bc	4.5 a	0.71 a	126 a	97 c	0.04 cd

¹ Data followed by the same letters are not significantly different as measured by the Duncan's Multiple Range Test ($P \leq 0.05$)

Yield and kernel quality.

Bacterial canker (bc) disease has had a profound impact on yield in this trial (Table 3). Peach / almond hybrid rootstocks, especially Hansen, have been severely impaired by bc and have the lowest yields. Nemaguard is moderately affected by bc and has intermediate yields. In previous years, Atlas had the largest cumulative yield. However, Atlas yields fell off in 2005 as some of these trees were affected by bacterial canker. Guardian, Lovell and Viking have shown no signs of bacterial canker disease to date and had the highest yields this year. Direct comparison for cumulative yield for Viking is misleading because 42% of these trees are one year younger than other rootstocks due to high mortality of Viking at planting. As in previous years, overall yield suffered from a fairly high percentage of shriveled kernels in this orchard. As in 2004, Lovell had the highest number of shriveled nuts, but similar to the other rootstocks with the exceptions of Nemaguard, Guardian and Nickels. Rootstock has had no effect on double kernels in this trial.

Table 3. Yield and Kernel Quality of Nonpareil Almond Trees on Various Rootstocks.¹ Escalon, CA. 2005.

Rootstock	2005 Yield (meat lb. / acre)²	Kernel Weight (g)	Shriveled Kernels (%)	Double Kernels (%)	Cumulative Yield / Acre (4th – 8th leaf)³
Guardian	2102 a	1.29 a	4.2 d	1.4 a	10,272
Lovell	1816 ab	1.18 cd	8.8 a	1.6 a	9,033
Viking ³	1806 ab	1.16 d	7.4 abc	0.8 a	8,761
Nemaguard	1541 bc	1.27 ab	4.8 cd	0.6 a	9,448
Atlas	1305 c	1.25 ab	7.6 ab	1.0 a	9,640
Bright's	1285 c	1.22 bc	7.2 abc	1.6 a	8,723
Nickels	1255 c	1.23 abc	5.4 bcd	0.8 a	6,471
Hansen 536	465 d	1.14 d	8.0 ab	1.0 a	6,385

¹ Data followed by the same letters are not significantly different as measured by the Duncan's Multiple Range Test ($P \leq 0.05$).

² Per acre yields calculated by multiplying pounds per tree by 138 trees per acre.

³ Due to the high mortality rate of Viking at planting, data for Viking include many trees one year younger than trees of other rootstocks.

2. Alternative Rootstocks: evaluate the compatibility and field performance of ‘Hiawatha’ and other plum rootstocks for almond; study the compatibility of newer almond varieties on ‘Marianna 2624’ plum; and, evaluate other new European rootstocks.

The USDA Agricultural Research Service has identified various plum type rootstocks, which show varying degrees of compatibility with Nonpareil. One of these, ‘Hiawatha’ (*Prunus besseyi* x *p. salicina*) has shown resistance to root knot and root lesion nematodes in field trials. Researchers in France (INRA) have developed numerous peach/almond hybrid rootstocks with desirable characteristics, such as tolerance to drought, high pH soils and nematodes, and which also impart vigor to the scion. The most successful one of these, ‘GF 677’, is planted widely in Europe. Many newer almond varieties have not been fully evaluated on ‘Marianna 2624’.

Objectives

A) Evaluate the compatibility and performance of almond varieties on various rootstocks. (J. Edstrom, Stan Cutter, Nickels Estate).

‘Nonpareil’ grafted on ‘Marianna 2624’ and on ‘Padre’ inter-stem on ‘Marianna 2624’, and ‘Butte’ and ‘Nonpareil’ on ‘Hiawatha’ are being evaluated. Other almond varieties on ‘Marianna 2624’ include ‘Plateau’, ‘Winters’(13-1), and ‘Avalon’ with ‘Sonora’ and ‘Mission’ planted as standards. Evaluations of the newly developed cultivars, ‘Durango’ and ‘Kochi’ on ‘Lovell’ are also included. An additional evaluation of ‘Nonpareil’ on several European rootstocks is also included.

B) Evaluate variety compatibility and tolerance of alternative rootstocks to oak root fungus. (J. Connell, Jim Floyd - CSU Chico Farm, G&N Creekside Farms, Sam Lewis & Son Orchards)

Fowler nursery provided ‘Nonpareil’ and ‘Carmel’ on ‘Ishtara’ in 2002 to evaluate compatibility and oak root fungus resistance at the CSUC Farm. Additional alternative rootstock trees were planted in this and other oak root fungus spots in Butte County in spring 2003. These included ‘Nonpareil’, ‘Sonora’, and ‘Carmel’ on ‘Hiawatha’, ‘Nonpareil’ on ‘Tetra’, and some additional ‘Nonpareil’ trees on ‘Ishtara’. In spring 2004 additional ‘Nonpareil’ trees were planted in oak root fungus spots on the ‘Empyrean 101’ rootstock.

Results

A) Nickels- Plum Type, Alternative, and European Rootstocks for Almonds

After six years in the field, ‘Hiawatha’ continues to show promise as a compatible plum rootstock for ‘Nonpareil’ and ‘Butte’, however, vigor is moderate. The use of an inter-stem of ‘Padre’ between ‘Nonpareil’ scion and ‘M2624’ rootstock also looks very promising producing the largest trunk size in this ‘M2624’ rootstock test. However, the canopy size and vigor are about average for a ‘M2624’ rooted tree. The European peach-almond hybrid rootstock, ‘GF677’, is performing similarly to ‘Hansen 536’ when combined with ‘Nonpareil’ or ‘Butte’. As expected, ‘Nonpareil’ and ‘Butte’ trees on both PA hybrid roots (‘Hansen’ & ‘GF677’) are noticeably larger than ‘Lovell’ rooted trees. Both new almond varieties, ‘Kochi’ and ‘Durango’, are developing well on ‘Lovell’ with growth rates and yields similar to ‘Nonpareil’. ‘Kochi’ was

the only variety to show hull rot symptoms in this planting this season. 'Avalon' currently shows the best compatibility with 'M2624' of the combinations tested, while 'Sonora' is growing satisfactorily on 'M2624'. However, 'Winters' on 'M2624', while growing well in past years, was disappointing this season with substandard growth under only a moderate crop load. 'Plateau' trees are noticeably smaller and lower yielding and appear weak if not incompatible with 'M2624' plum rootstock. As reported earlier, all trees on 'Deep Purple' plum have died or are unacceptable.

Tree Size: Trunk Circumference in Centimeters

<u>Plum Type Rootstocks</u>	<u>Mean</u>	<u>Alternative Rootstocks</u>	<u>Mean</u>
Non (F) - M2624	27.7	Non - GF677	37.2
Avalon - M2624	36.6	Non - Hansen 536	39.2
Sonora - M2624	36.3	Non - Lovell	34.5
Mission - M-2624	35.6	Butte - GF677	41.2
Plateau - M2624	32.5	Butte - Hansen 536	42.6
Winters (13-1) - M2624	35.3	Butte - Lovell	37.9
Non - Padre/M2624	37.8	Durango - Lovell	35.5
Non (B) - Deep Purple	Dead	Kochi - Lovell	36.2
Non (F) - Deep Purple	Dead		
Mission - Deep Purple	20.9		
Non (F) - Hiawatha	33.7		
Butte - Hiawatha	36.3		

Now in its second season, our evaluation of 'Nonpareil' grafted onto new European rootstocks has shown mixed results. All trees died on two of the candidates, 'AC952UC1' and 'Pumiselect'. Trees on 'Penta CM7', and 'Jaspi' showed weak growth while trees on 'Cadaman', 'Kuban 86', and 'Julior' were quite vigorous. 'Ishtara' and 'Hiawatha' showed moderate, but acceptable, vigor. A new planting will be established in 2006 to test as solid rows these combinations: 'Nonpareil'/'Ishtara', 'Nonpareil'/'Kuban', 'Nonpareil'/'Empryeen', and 'Nonpareil'/'Padre'/'M40 plum'.

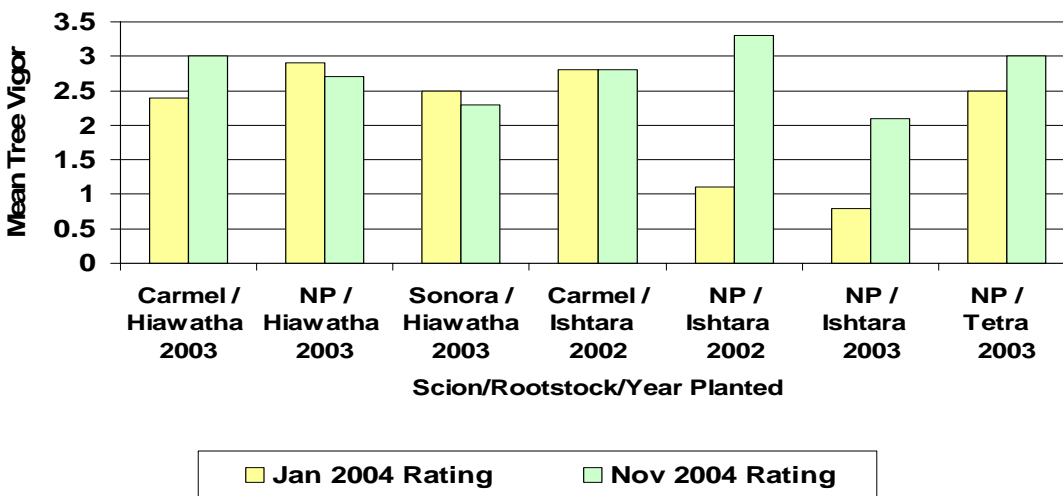
Nonpareil on European Rootstocks.

	<u>Mean</u>	<u>Vigor Rating at Nickels Soil Lab</u>
Cadaman	4	0 = dead
AC 952UC	dead	1 = extremely stunted
Hiawatha	3.66	2 = poor growth
Ishtara	3	3 = fair growth, commercially acceptable
Jaspi	2.87	4 = good growth
Kuban 86	4	5 = exceptional growth
(Krymsk 86)	--	
Pumiselect	dead	
Penta CM7	3	
Julior	4	

B) CSU Chico Farm & Butte County

The ‘Nonpareil’ and ‘Carmel’ trees planted on ‘Ishtara’ in spring 2002 grew well that year but growth weakened on the ‘Nonpareil’ through the 2003 season but improved in 2004. ‘Carmel’ on ‘Ishtara’ continued to look good through 2004. ‘Nonpareil’ planted on ‘Ishtara’ in 2003 started out as small trees and made weak growth in 2003 but improved in 2004. ‘Nonpareil’, ‘Carmel’ and ‘Sonora’ trees planted on ‘Hiawatha’ in spring 2003 all grew well the first two years. ‘Nonpareil’ trees planted on ‘Tetra’ in 2003 are also growing well after two year’s growth (Figure 1).

**Figure 1. Tree Vigor on Alternative Rootstocks
CSUC Farm, Butte County**



Rating Scale

- 0 Almost no growth or dead
- 1 Very weak, about 1ft of growth
- 2 Moderate, about 2ft of growth
- 3 Good, about 3ft of growth or about 5ft tall
- 4 Very vigorous

In spring 2004 additional Nonpareil trees were planted on ‘Empyrean 101’ in three different oak root fungus spots. After two seasons these trees appear to be growing well. There is no indication yet whether any of these rootstocks will show resistance to oak root fungus.