Annual Report to the Almond Board of California **July 1, 2005**

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, height, bloom, harvest maturity, yield, and nut quality. 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 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.

Results:

1. Regional Rootstock Trials

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. Desirable rootstock characteristics will be evaluated in these ongoing trials as the trees mature. Observations will include influence on growth, size, yield, bloom timing, harvest maturity, nut quality, and tree survival as opportunities for evaluation occur. Information developed will be useful in adapting orchards to the diverse environments where California almonds are grown.

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.

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.

Due to a very wet spring, the Butte County trial was planted with dormant trees from cold storage in May 1998. 'Bright's', 'Hansen 536', 'Nickels', 'Atlas', 'Viking', 'Guardian', 'Nemaguard', and 'Lovell' rootstocks are included. The block is planted on a deep loam soil in a high rainfall area and 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.

The Colusa County trial was planted in March 1997. 'Bright's', 'Hansen 536', 'Nickels', 'Atlas', 'Viking', 'Nemaguard', and 'Lovell' rootstocks are included. The block is on shallow soil with a hardpan that was slip plowed prior to planting. It is irrigated with dual microsprinklers. Sixty-four trees of each rootstock were planted in 8 replications of 8 trees each.

The Kern County orchard was established in February 1997. It includes, 'Bright's', 'Hansen 536', 'Hansen 2168', 'Nickels', 'Viking', 'Atlas', and 'Nemaguard' rootstocks. 'Nickels' was planted a year later in 1998. The orchard is irrigated with solid set sprinklers. Large plots designed to evaluate the resistance of each rootstock to "Santa Ana" windstorms were planted 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 'Hanson 2168' replicated two times. Tree spacing is 24' x 24'.

Planted in March 1998, the San Joaquin County trial included: 'Bright's', 'Hansen 536', 'Nickels', 'Atlas', 'Viking', 'Guardian', 'Nemaguard', and 'Lovell' rootstocks. Designed to document relative rootstock tolerance to the bacterial canker complex, a second-generation peach orchard with severe bacterial canker was removed the year prior to trial establishment and the sandy soil was solid tarp fumigated with methyl bromide. Fifty trees of each rootstock were planted in a commercial orchard with 'Carmel' and 'Sonora' as pollinators.

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. Analyses of variance and mean separation was done by using either Duncan's multiple range test, the least significant difference test, or Fishers protected LSD.

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

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

Tree Size

In the Butte County trial, tree growth is documented annually through trunk circumference measurements. 'Bright's Hybrid' and 'Hansen 536' have the largest tree trunk circumference followed by 'Nemaguard' and 'Nickels' (Table 1).

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
Hansen 536	4.18 bc	11.43a	24.50a	41.32a	54.12a	61.53a	72.15a	73.17
Nickels Hybrid	5.22a	10.79ab	23.17 b	38.79 b	51.34 b	57.48 b	67.49 b	69.84
Viking	4.50 b	9.11 d	21.24 cd	36.35 c	47.82 de	54.73 c	63.07 de	69.46
Atlas	4.33 bcd	10.06 bc	21.98 c	36.16 c	46.33 e	53.36 c	60.99 e	67.24
Guardian	3.52 f	10.01 bc	22.02 c	36.42 c	47.01 de	53.81 c	61.79 e	62.58
Nemaguard	3.74 ef	10.79ab	23.17 b	38.45 b	49.76 c	57.15 b	65.37 bc	72.42
Lovell	3.94 de	9.67 cd	21.33 cd	35.86 c	46.58 de	53.45 c	61.12 e	67.95

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.

Influence of rootstock on leaf nutrient content

A comparative leaf analysis was performed in July 2004 which produced the results presented in Table 2. Values represent means of five replicated samples for each rootstock. Trees on peach-almond hybrid rootstocks were generally higher in calcium, zinc and manganese, and lower in chloride than were trees on peach rootstocks. 'Nemaguard' peach rooted trees were higher in potassium and lower in magnesium than were 'Lovell' peach rooted trees. Trees on 'Hansen 536' were lower in nitrogen than trees on other rootstocks.

Table 2. Leaf Tissue Analysis Nutrient Levels in Nonpareil Almond, Butte County, July 2004.

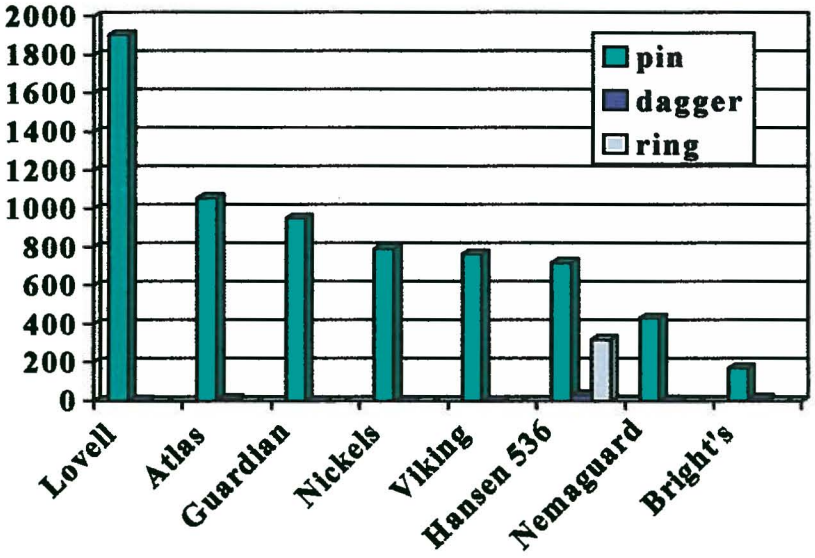
Rootstock	N (%)	K (%)	B (ppm)	Ca (%)	Mg (%)	Na (ppm)	Cl (%)	Zn (ppm)	Mn (ppm)
Bright's Hybrid	2.48ab	1.30ab	37 d	4.49 b	1.02 cd	231a	0.05 b	26a	38 b
Hansen 536	2.27 c	0.99 c	40ab	5.05a	1.32a	200a	0.05 b	25a	45a
Nickels Hybrid	2.38 bc	1.14 bc	38 bcd	4.91a	1.14 b	199a	0.05 b	23ab	39 b
Viking	2.52a	1.41a	39abcd	3.81 c	0.90 e	284a	0.07 b	20 c	31 c
Atlas	2.52a	1.39a	41a	3.78 c	1.05 c	213a	0.06 b	18 c	29 c
Guardian	2.51ab	1.12 bc	39abc	3.58 d	1.20 b	253a	0.10a	19 c	22 e
Nemaguard	2.57a	1.47a	40abc	3.53 d	0.96 de	194a	0.10a	18 c	24 de
Lovell	2.48ab	1.15 bc	37 cd	3.46 d	1.13 b	217a	0.10a	20 bc	27 cd

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.

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. 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

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

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

Yields in the Colusa County orchard (Table 1) were down a little last year. Kernel size was equal for all rootstocks. Peach-almond hybrid rootstock yields showed less variation between plots than yields on peach or on inter-specific hybrid rootstocks.

Table 1. Mean yield (pounds kernel/tree) in Colusa County.

	4th Season	5th Season	6th Season	7th Season
Rootstock	2000	2001	2002	2003
Bright's Hybrid	4.75 cd[z]	8.6 cd[z]	26.8	25.7
Hansen 536	5.94 ab	9.5 abc	27.9	30.1
Nickels (1-82)	5.65 bc	8.8 bcd	25.4	29.5
Viking	6.47 ab	9.8 abc	24.4	22.2
Atlas	6.96 a	10.2 ab	26.6	26.6
Nemaguard	4.55 cd	8.4 cd	25.9	24.5
Lovell	6.51 ab	10.3 a	24.7 ns	22.8

Values followed by the same letters are not statistically different as measured by:

[z] Fishers Protected LSD at $P < 0.05$.

Tree Size

Differences in tree size are apparent between the seven rootstocks in the Colusa trial (Table 2) with the 'Hansen 536' and 'Nickels' hybrids larger than the others.

Table 2. Colusa County mean trunk circumference in centimeters.

Following:	2nd Season	3rd Season	4th Season	5th Season	7th Season
Rootstock	August 1998	Fall 1999	Fall 2000	Fall 2001	April 2004
Bright's Hybrid	19.7	32.4	45.3 ab*	53.6 b	67.4
Hansen 536	21.2	35.1	47.9 a	56.2 a	71.5
Nickels Hybrid	20.4	33.9	44.6 b	52.6 bcd	76.9
Viking	20.7	33.4	42.8 b	51.7 bcd	65.8
Atlas	20	32.4	42.2 b	50.5 d	63.4
Nemaguard	19.9	33.5	42.2 b	52.0 bcd	64.5
Lovell	20.5 ns	33.6 ns	42.2 b	51.1 cd	64.0

* Values followed by the same letters are not statistically different as measured by Fishers Protected LSD at $P < 0.05$.
ns - Not significantly different

Influence of rootstock on leaf nutrient content

A comparative leaf analysis was performed in July 2004 which produced the results presented in Table 3. Values represent means of five replicated samples for each rootstock. Trees on peach-almond hybrid rootstocks were generally higher in calcium and manganese, and lower in nitrogen, chloride, and boron than were trees on peach rootstocks.

Table 3. Leaf Tissue Analysis Nutrient Levels in Nonpareil Almond, Colusa County, July 2004.

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

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

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

Yields were not significantly different in 2004 (Table 1), and 'Santa Ana' winds did not cause tree losses in this plot during 2004.

Table 1. Kern Co. mean yield (pounds kernel/tree) at various ages.

Rootstock	3rd Season 1999	4th Season 2000	6th Season 2002	7th Season 2003	8th Season 2004
Bright's Hybrid	2.99 a	7.64 ab	29.27 ab	30.51 abc	36.68
Hansen 536	5.78 bc	11.03 bc	31.52 b	34.15 bc	37.22
Hansen 2168 [xx]	6.41	11.95	27.95	22.25	26.73
Nickels Hybrid	yy	4.23 a	25.20 a	31.13 abc	33.31
Viking	3.50 a	9.34 b	25.30 a	28.42 ab	34.23
Atlas	6.97 c	14.45 c	31.30 b	36.17 c	33.66
Nemaguard	4.36 ab	10.04 b	26.07 ab	28.02 a	32.10 ns

Values followed by the same letters are not statistically different as measured by:

Duncans Multiple Range Test at $P < 0.05$.

[xx] not included in analysis, only two replicates.

[yy] not included in analysis, trees one year younger.

Yield data for 2001 is unavailable due to malfunctioning scales.

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 2) but by the fourth season there were no significant differences in trunk growth among any rootstocks. After the fifth season the 'Hansen 536' rooted trees were larger while the 'Bright's' and 'Nemaguard' rooted trees were smaller.

Table 2. Kern County mean trunk circumference in centimeters.

Following: Rootstock	1st Season Fall 1997	2nd Season Fall 1998	3rd Season Fall 1999	4th Season Fall 2000	5th Season Fall 2001	6th Season Fall 2002	7th Season Fall 2003
Bright's Hybrid	9.34 c*	22.24 b	34.57 d	48.91	54.1 b	62.43 ab	69.56 ab
Hansen 536	12.71 a	27.73 a	41.85 a	48.10	63.0 d	68.75 c	77.01 c
Hansen 2168	12.41 a	27.61 a	41.65 ab	51.41	61.8 cd	69.78 c	77.21 c
Nickels (1-82)	**	12.79 c	26.17 e	46.36	50.4 a	58.55 a	67.10 a
Viking	11.08 b	25.50 a	37.72 c	51.35	59.1 c	65.72 bc	73.35 bc
Atlas	12.38 a	26.11 a	38.85 bc	52.47	58.3 c	62.50 ab	69.97 ab
Nemaguard	8.95 c	21.81 b	34.10 d	48.01 ns	54.2 b	59.42 a	66.50 a

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

** This rootstock was planted in 1998, one year later than the others.

Tree height measurements (Table 3) 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 thereafter.

Table 3. Kern County Tree Height in meters.

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

Influence of rootstock on leaf nutrient content

Leaf analysis performed in July 2004 produced the results presented in Table 4. Trees on peach-almond hybrid rootstocks were generally lower in nitrogen and chloride, and, higher in calcium and zinc, than were trees on the 'Nemaguard' peach rootstock.

Table 4. Leaf Tissue Analysis Nutrient Levels in 'Butte' Almond, Kern County, July 2004.

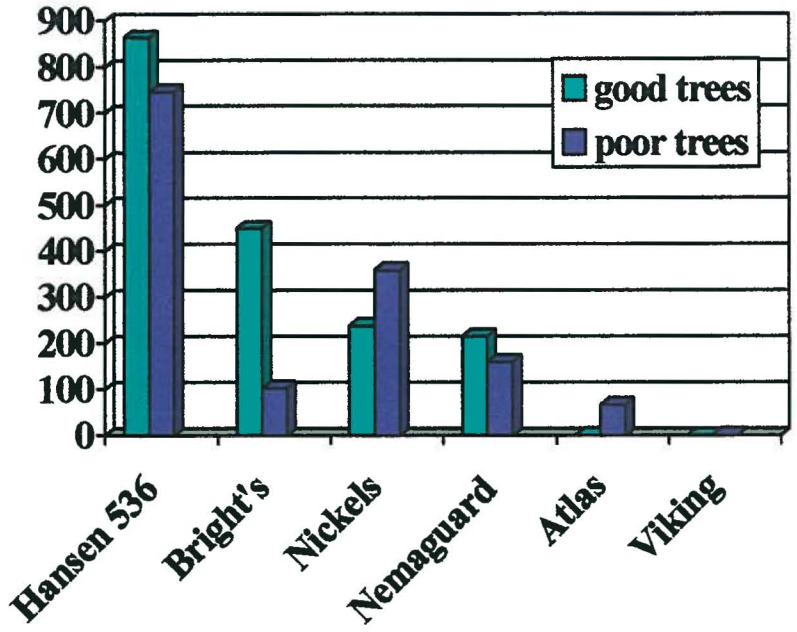
Rootstock	N (%)	K (%)	B (ppm)	Ca (%)	Mg (%)	Na (ppm)	Cl (%)	Zn (ppm)	Mn (ppm)
Bright's Hybrid	2.37 a	1.15 a	33 a	4.67 c	0.85 a b	2028 a	0.30 a	37 b	54 a
Hansen 536	2.29 a	1.05 a	34 a	5.07 d	0.98 c	1540 a	0.31 a	35 b	58 a
Nickels Hybrid	2.46 a b	1.01 a	32 a	4.92 c d	0.91 b c	1360 a	0.29 a	37 b	60 a
Viking	2.45 a b	1.00 b	33 a	4.12 b	0.83 a b	1786 a	0.41 b	24 a	60 a
Atlas	2.71 c	1.47 a	39 b	3.74 a	0.77 a	2008 a	0.45 b	28 a	47 a
Nemaguard	2.55 b c	1.03 a	35 a	3.81 a	0.83 a b	1980 a	0.65 c	24 a	41 a

Values followed by the same letters are not statistically different as measured by the least significant difference test at $P< 0.05$.

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 scion on eight rootstocks growing in a sandy, replant site.
2. To evaluate rootstock tolerance to the bacterial canker complex.

In the fall prior to trial establishment, a second generation peach orchard with a history of bacterial canker was removed and the soil was fumigated with a solid, 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. Presumably due to cold storage sensitivity, twenty-one of the fifty trees on Viking rootstock (42%) failed to grow and were replaced in February 1999. Replacement trees have grown well. We experienced no problems establishing trees on the other rootstocks.

Bacterial canker

Signs of bacterial canker became evident for the first time in spring 2002 (fifth-leaf) and have continued to progress through 2004. Bacterial canker is most severe in the three peach-almond hybrid rootstocks (Figure 1.). Forty-six percent, 23%, & 10% of 'Hansen', 'Nickels', and 'Bright's' hybrid trees showed moderate to severe symptoms, respectively. Two out of fifty trees (4%) on 'Nemaguard' were affected by bacterial canker in 2004. Through 2004, 34%, 15% and 2% of 'Hansen', 'Nickels' and 'Bright's' Hybrid, respectively, have been replaced due to severe

bacterial canker. It is interesting that preliminary soil tests show that these rootstocks also support the highest populations of ring nematode which is known to be associated with bacterial canker (Figure 2). All rootstocks harbored potentially damaging levels of root lesion nematode (*Pratylenchus vulnus*).

Fig. 1. Rootstock Susceptibility to Bacterial Canker
Escalon, CA

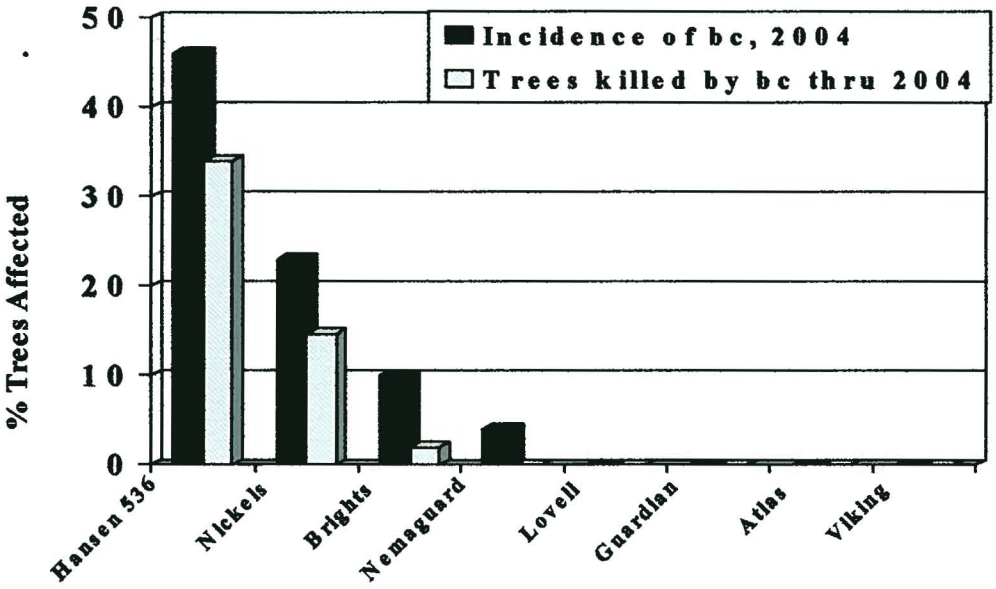
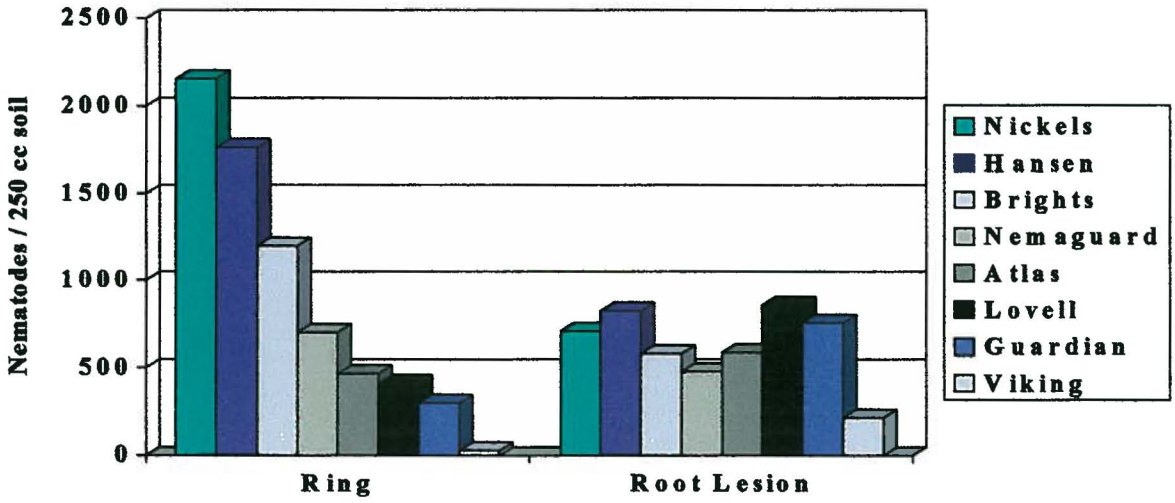


Fig. 2. Soil Numbers of Pathogenic Nematodes as Influenced by Rootstock
May, 2004

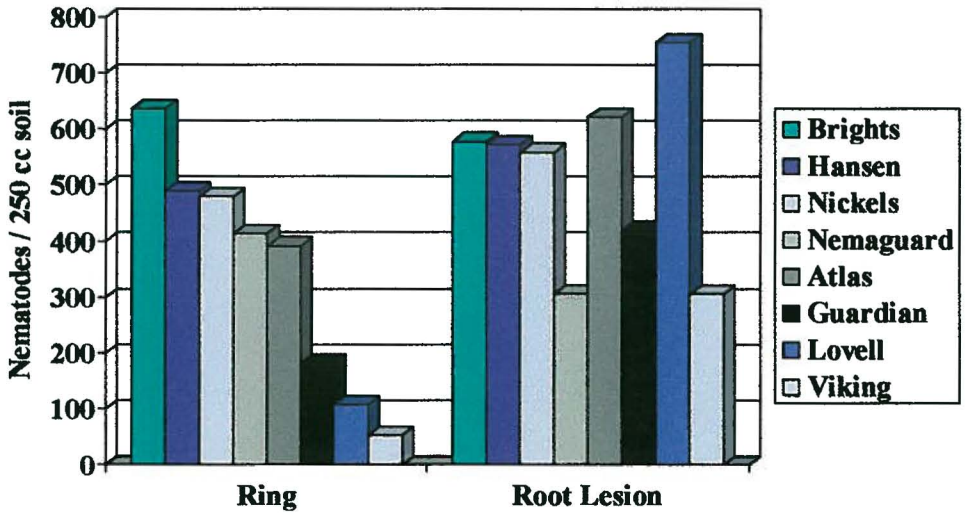


Nematodes by rootstock

Additional soil samples screened by Mike McKenry for nematodes in January 2005 (Figure 3) again showed that the peach almond hybrid rootstocks had the highest ring nematode population while Viking harbored the lowest population. Root lesion nematode populations were at potentially damaging levels on all rootstocks and numbers were similar to the May 2004 screening.

This site supported two nematode species including *P. vulnus* and *Mesocriconema xenoplax*. Where ring nematode populations were low the population levels of *P. vulnus* were high. These nematodes do compete for feeding sites but to date Bacterial Canker is still thought to be a disease predisposition caused by feeding of ring nematode not *P. vulnus*. In this site *P. vulnus* was hosted by Atlas and Viking rootstocks but these rootstocks did not host the *P. vulnus* population from Kearney Ag Center.

Fig. 3. Soil Numbers of Pathogenic Nematodes as Influenced by Rootstock. Escalon, January, 2005



Tree size

In May, 2004, tree size was compared for each rootstock by measuring trunk circumference. Trees on all rootstocks have grown well. Trees on 'Nickels' are the largest (Table 1). 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 above).

Table 1. Tree Size as Influenced by Rootstock. May, 2004	
Rootstock	**Trunk Circumference (cm)**
Nickels	65.0 a[1]
Bright's	62.2 b
Nemaguard	61.6 bc
Hansen	61.3 bc
Lovell	60.9 bc
Viking[2]	60.9 bc
Atlas	59.6 c
Guardian	59.6 c

[1] Data followed by the same letters are not significantly different as measured by the Duncan's Multiple Range Test (P≤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.

Influence of Rootstock on Leaf Tissue Nutrient Content

In July, 2004, leaves were sampled from all ten replications of each rootstock and sent to the DANR lab at UC Davis for nutrient analysis. Results are shown in Table 2 below. There were significant differences between rootstocks for most elements. Rootstocks of similar parentage tended to have similar leaf nutrient levels. Peach rootstocks ('Nemaguard', 'Lovell', and 'Guardian') had significantly higher leaf chloride levels than other rootstocks and tended to have the lowest calcium and manganese. The peach-almond hybrid rootstocks ('Hansen 536', 'Nickels' and 'Bright's') had significantly lower leaf nitrogen than other rootstocks and were actually deficient, according to University of California guidelines. P/A hybrids also tended to have the lowest levels of potassium and boron and the highest calcium and magnesium. It is not

Table 2. Leaf Tissue Nutrient Levels of Nonpareil Almond on Eight Different Rootstocks. July, 2004. Escalon CA									
	N (%)	K (%)	B (ppm)	Ca (%)	Mg (%)	Na (ppm)	Cl (%)	Zn[2] (ppm)	Mn (ppm)
Nemaguard	2.30 a[1]	2.76 abc	47 a	3.84 de	0.61 d	74 abc	0.09 a	101 a	64 cd
Lovell	2.28 a	2.92 ab	47 a	3.56 e	0.61 d	75 ab	0.08 b	112 a	69 cd
Guardian	2.32 a	2.57 cd	47 a	3.73 e	0.70 b	69 bcde	0.08 b	96 a	57 d
Atlas	2.27 a	2.70 bc	49 a	4.23 bc	0.67 bc	66 cde	0.04 c	100 a	77 c
Viking	2.26 a	2.99 a	45 ab	4.11 cd	0.47 e	73 abcd	0.04 c	106 a	94 b
Nickels	2.13 b	2.27 e	42 bc	4.78 a	0.69 b	65 de	0.03 c	108 a	102 b
Bright's	2.09 b	2.40 de	42 bc	4.44 b	0.64 cd	80 a	0.03 c	114 a	102 b
Hansen	2.08 b	2.00 f	40 c	5.03 a	0.75 a	61 e	0.03 c	112 a	132 a

[1] Data followed by the same letters are not significantly different as measured by the Duncan's Multiple Range Test (P≤0.05).
[2]Data reflect in-season foliar sprays containing zinc and do not represent actual leaf zinc levels.

clear why 'Bright's' Hybrid had significantly higher levels of sodium than the other peach-almond hybrid rootstocks. The inter-specific hybrids ('Atlas' and 'Viking'), with almond, peach, plum and apricot parentage, tended to have leaf levels between the peach and peach-almond hybrid rootstocks for most elements.

The Influence of Rootstock on Hull Boron Levels at Harvest.

Darpinian Rootstock Trial, Fall 2004

	Hull B ppm		Leaf B ppm	
Atlas	49.2	A	49	A
Nemaguard	46.8	A	47	A
Guardian	42.8	B	47	A
Lovell	42.6	B	47	A
Bright's	40.2	BC	42	BC
Viking	39.0	C	45	AB
Hansen	36.2	D	40	C
Nickels	34.6	D	42	BC

Boron levels in almond hulls followed a pattern similar to levels found previously in leaf tissue with regards to the influence of rootstock on mineral nutrition. Atlas and Nemaguard had the highest hull boron while the Peach Almond hybrid rootstocks Hansen and Nickels had the lowest levels of boron in the hulls. The hull analysis provided a greater spread than did the leaf analysis between the lowest boron level on Nickels rootstock and the highest boron level on the Atlas rootstock.

These differences in tree nutrition may help explain observations in commercial plantings. Lower nitrogen levels in trees on peach-almond hybrid rootstocks may help explain why these trees are more susceptible to bacterial canker. In addition, less accumulation of chloride in peach-almond hybrid and inter-specific hybrid rootstocks reinforces field experiences where these trees often perform better than peach rootstocks in areas where excess salt is a problem.

Yield and kernel quality

As in years past, per tree yields are statistically similar among most rootstocks (Table 3). Yield for 'Hansen' was significantly lower than all other rootstocks in this trial. The low yield for 'Hansen' is a result of a combination of poor bloom density (see 2003 report) and the decline of many trees from bacterial canker. Despite being moderately affected by bacterial canker, 'Nickels' and 'Bright's' hybrid had yields similar to other rootstocks. Cumulative yield for 'Viking' is misleading because many of these trees are one year younger than other rootstocks due to high mortality of 'Viking' at planting. 'Bright's' hybrid had the largest kernel size while 'Viking' had the lowest.

Once again, overall yield suffered from a fairly large amount of shriveled kernels in this orchard, presumably due to water stress during critical stages of kernel development. There tended to be fewer shriveled nuts from trees on peach-almond hybrid rootstocks.

Table 3. Yield and quality of Nonpareil almonds on various rootstocks. Escalon, CA.

Rootstock	2004 Yield (meat lb. / tree)	Kernel Weight (g)	Shriveled Kernels (%)	Cumulative Yield / Tree (4^{th} - 7^{th} leaf)	Cumulative Yield / Acre (4^{th} - 7^{th} leaf)[3]
Atlas	18.3 a[1]	1.08 bcd	7.4 ab	60.4	8335
Guardian	17.3 a	1.14 ab	4.4 cd	59.2	8170
Nickels	17.1 a	1.12 abcd	3.0 d	37.8	5216
Viking[2]	17.0 a	1.07 d	4.8 bcd	50.4	6955
Bright's	17.0 a	1.16 a	3.4 d	53.9	7438
Nemaguard	15.9 a	1.14 abc	6.6 abc	57.3	7907
Lovell	14.8 a	1.08 cd	9.2 a	52.3	7217
Hansen 536	8.5 b	1.09 bcd	3.8 cd	42.9	5920

[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.

[3]Per acre yields calculated by multiplying pounds per tree by 138 trees per acre.

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 of almond varieties on 'Marianna 2624' and 'Hiawatha' plum rootstocks, and the performance of European rootstocks; 'GF 677', 'AC952UC1', 'Pumiselect', 'Penta', 'CM7', 'Jaspi', 'Cadaman', 'Ishtara', 'Kuban 86', and 'Julior'.

(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. Additional evaluations of the newly developed cultivars, 'Durango' and 'Kochi' on 'Lovell' are 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

After four years in the field, 'Hiawatha' continues to show promise as a compatible plum rootstock for 'Nonpareil' and 'Butte'. The use of an inter-stem of 'Padre' between 'Nonpareil' scion and 'M2624' rootstock also looks very promising producing the largest tree size of any almond combination on 'M2624' rootstock. The European peach-almond hybrid rootstock, 'GF677' is performing similarly to 'Hansen 536' when combined with 'Nonpareil' or 'Butte'. Both new almond varieties, 'Kochi' and 'Durango' have similar growth rates to 'Nonpareil' when planted on 'Lovell'. 'Winters', 'Avalon' and 'Sonora' are all growing well on 'M2624' while 'Plateau' trees are noticeably smaller and may not be compatible. As expected, most 'Nonpareil' on 'M2624' defoliate prematurely and grow very poorly with many dead (Table 1).

Table 1. New almond rootstocks, Nickels Soils Lab, Colusa Co.
Trunk circumference in cm., March 2004

	Rep				
Plum Type Rootstocks	**I**	**II**	**III**		**Mean**
Non (F) - M2624	d	26.4	29.0		27.7
Avalon - M2624	33.1	39.4	37.4		36.6
Sonora - M2624	37.1	35.4	36.3		36.3
Mission - M-2624	34.0	36.9	35.9		35.6
Plateau - M2624	37.1	31.2	29.2		32.5
Winters (13-1) - M2624	37.1	33.3	35.5		35.3
Non - Padre/M2624	38.4	38.7	36.4		37.8
Non (B) - Deep Purple	d	d	d		
Non (F) - Deep Purple	d	d	d		
Mission - Deep Purple	16.4	d	25.5		20.9
Non (F) - Hiawatha	36.6	33.1	31.4		33.7
Butte - Hiawatha	37.4	35.1	36.5		36.3

Alternative Rootstocks	**I**	**II**	**III**		**Mean**
Non - GF677	35.5	38.8	37.4		37.2
Non - Hansen 536	40.5	36.7	40.3		39.2
Non - Lovell	36.5	32.2	34.8		34.5
Butte - GF677	41.9	39.1	42.6		41.2
Butte - Hansen 536	42.0	43.3	42.5		42.6
Butte - Lovell	40.8	36.0	36.9		37.9
Durango - Lovell	34.9	35.4	36.3		35.5
Kochi - Lovell	34.6	36.2	37.9		36.2

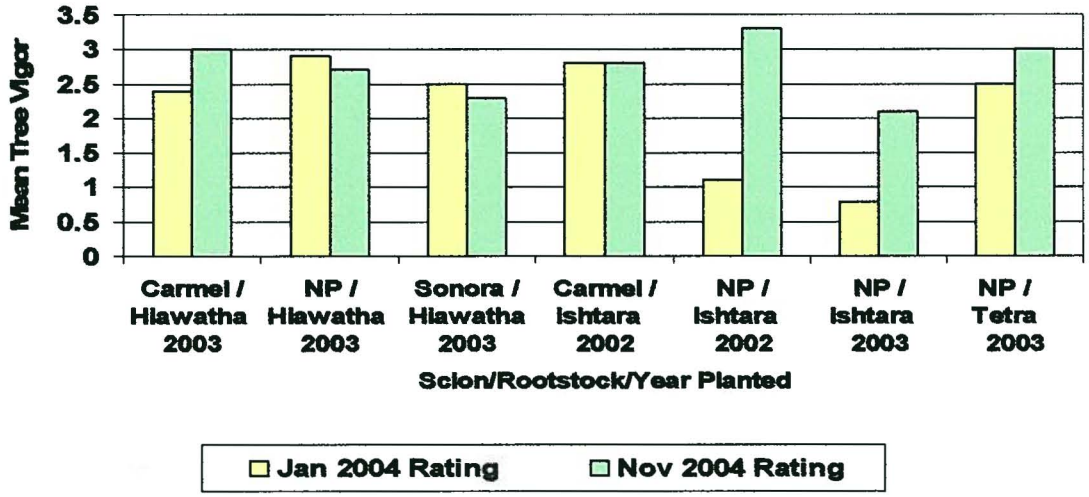
d= dead, not used in size averages

Our new evaluation of European rootstocks showed 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' and 'Hiawatha' were quite vigorous. 'Ishtara', 'Kuban 86' and 'Julior' showed moderate vigor.

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 one season these trees appear to be growing well. There is no indication yet whether any of these rootstocks will show resistance to oak root fungus.

Acknowledgement

The principal investigators in each of these trials wish to thank the Almond Board of California for their continued support. Industry steadfastness is appreciated since it takes considerable time to begin to show differences between rootstocks as environmental conditions favoring one rootstock over another occur sporadically and at uncertain intervals. Observations on other limited rootstock tests are also reported here when opportunities for their evaluation occur.