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Project No.: Field Evaluation of Almond Rootstocks (99-JC-02).

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Four Regional Rootstock Trials were established in Butte, Colusa, Kern, and San Joaquin counties. Rootstock effects to be evaluated in these ongoing trials will include rootstock influence on growth, height, bloom timing, harvest maturity, yield, and nut quality. Other continuing aspects of this project include evaluating interstocks that allow Nonpareil to grow on Marianna 2624 rootstock in trials in Colusa and Butte counties. Additional trials in Colusa county will evaluate Deep Purple plum as a rootstock for Nonpareil as well as the compatibility of newer varieties on Marianna 2624 plum.

Objectives:

1. Begin collection of data from Regional Rootstock Trials in Butte, Colusa, Kern, and San Joaquin counties. Complete replanting as necessary.

2. Continue obtaining information on growing Nonpareil on interstocks with Marianna 2624 plum rootstock from trials in Butte and Colusa Counties.

3. Evaluate the compatibility and field performance of Nonpareil on Deep Purple plum and the compatibility of newer almond varieties on Marianna 2624 plum in a Colusa county trial.

Results:

1. Regional Rootstock Trials

Rootstocks in Butte County:

Joseph H. Connell, Farm Advisor & Rick Buchner, Farm Advisor, Tehama Co.

Scions on all trial trees are Nonpareil and each rootstock has 10 replications of six trees each. The block is irrigated with solid set sprinklers. It replaced an older orchard that was removed in 1997 and it was not fumigated prior to planting. Beans were intercropped in the orchard in both the first and second growing seasons. This trial was planted out of cold storage in May 1998 due to a very wet spring. Significant tree losses occurred initially on Viking and Atlas. Viking replanted directly from the nursery in 1999 was successful and growth on all

stocks has been good since establishment.

Table 1. Tree losses at the 1998 planting in Butte county.

Rootstock	Loss/total trees	% Loss
Viking	35/60	58.3
Atlas	15/60	25.0
UC 1-82	1/30	3.3
Lovell	1/60	1.7
Nemaguard	0/60	0
Guardian	0/60	0
Hansen 536	0/60	0
Bright's hybrid	0/60	0

Table 2. Butte Co. Mean Trunk Circumference in centimeters*

	June 1998 (At Planting)	April 1999	October 1999
Bright's hybrid	4.01	9.62	20.44
Hansen 536 hybrid	4.18	11.43	24.89
UC I-82 hybrid	5.22	10.79	23.17
Viking	4.50	9.11	21.24
Atlas	4.33	10.06	21.98
Guardian	3.52	10.01	22.02
Nemaguard	3.74	10.79	23.17
Lovell	3.94	9.67	21.33

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

In Spring 2000, missing tree positions were filled in with replants in the Butte County plot. On February 3, twelve trees of Nonpareil on Atlas and one tree of Nonpareil on Viking were planted. This completes filling out the Butte rootstock plot assuming no further tree losses occur. This is the third growing season for the orchard and harvest is not anticipated this year.

Rootstocks in Colusa County:

John Edstrom, Farm Advisor

This trial was planted at a 22x24 foot spacing in March 1997 to evaluate 7 rootstocks on Nonpareil (1/2) with pollinizers of Carmel (1/6), Monterey (1/6) and Aldrich (1/6). The area was slip plowed and is irrigated with dual microsprinklers. Each combination was planted in 8 reps of 8 trees. Of the 64 trees of each combination planted, all trees on Nemaguard, Hansen 536, UC 1-82, and Atlas established successfully. One tree each on Lovell and Bright's hybrid were lost at planting, and two trees on Viking died. Trunk Circumference at 12 inches above ground level was measured in August 1999.

The Colusa regional rootstock evaluation is proceeding as expected and in general all stocks are performing similarly in terms of trunk size and survival with little if any differences showing at present. This uniformity may be partially due to the "evening out " affect that micro-irrigation often seems to have on new trees.

Trunk Circumference (cm), Colusa County, 1999.

	Rep									
Plot	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Total**	**Mean**
Atlas	34.0	31.5	32.1	31.1	31.7	33.0	34.6	31.5	*259.4*	**32.4**
Bright's	31.2	35.3	30.1	32.5	32.1	34.8	29.6	33.6	*259.2*	**32.4**
Viking	32.5	32.5	33.8	34.5	31.8	32.7	33.3	35.7	*266.9*	**33.4**
UC I-82	32.9	34.4	34.1	34.6	33.9	35.3	31.9	0.0	*237.1*	**33.9**
Hansen 536	34.9	34.2	34.5	35.8	34.6	35.8	34.9	35.9	*280.6*	**35.1**
Lovell	33.6	33.7	35.0	32.8	33.5	32.3	33.2	34.7	*268.7*	**33.6**
Nemaguard	32.3	32.3	34.8	32.8	34.3	33.1	33.7	34.9	*268.2*	**33.5**
Bright's (extra)	35.1	30.9	32.4	31.7	30.3	32.9	34.4	33.3	*260.9*	**32.6**

Rootstocks in Kern County:

Mario Viveros, Farm Advisor

Justification and Purpose:

Kern County almond orchards are sometimes victims of the wrath of "Santa Ana" winds which descend to the San Joaquin Valley from the Tehachapi Mountains during the dormant season. From time to time, this wind has blown over from a few trees to entire orchards. Repeated observations tell us that the most susceptible rootstock to these windstorms is Nemaguard while the most resistant is the peach-almond hybrid. There is currently no research-based information to support these observations.

In 1996, the first rootstock test plot was established in the Tejon Ranch area, a few miles north of the Tehachapi Mountains. Then, a year later (1997), a second rootstock plot was established seven miles east of the first test plot. Both plots are on very deep sandy soils and in the path of the "Santa Ana" winds. The first test plot has 66 trees per plot and the second has 30 trees per plot. The large plots are designed to evaluate the resistance of each rootstock to the "Santa Ana" wind. The 1996 test plot consists of the following rootstocks: Nemaguard, Bright's hybrid, Hansen 536, Hansen 2168, Atlas, and Viking.

In 1997, another rootstock experiment was planted in mid-February. It consisted of the following rootstocks: Nemaguard, Brights Hybrid, Viking Atlas, Hanson 536, Handson 2168 and P/A 1-82. All but P/A 1-82 were planted in 1997. The P/A 1-82 was planted in 1998. The experiment is a completely randomized block design with seven rootstocks each replicated six times with the exception of Nemaguard and Hanson 1-82 which are replicated five times and Hanson 2168 replicated three times. The scion variety on all these rootstocks is Butte.

Results:

There is no wind resistance data because the test plots are only third and fourth leaf.

Survival. During the first growing season, the mortality of the hybrid rootstocks has been very high in many commercial orchard plantings. Due to this fact many growers have decided not to plant the hybrid rootstocks. In Table 1, we can find the percent of trees that died during the first growing season. The highest percent of mortality was on Viking. The Brights Hybrid, Nemaguard and Hanson 2168 had similar mortality.

Table 1. Number of trees planted and percent of tree mortality during the first growing season of different rootstocks for almonds.

Rootstock	Number Planted	Percent Mortality
Nemaguard	142	6.0
Viking	180	13.0
Brights Hybrid	180	6.0
Atlas	180	0.0
Hanson 536	180	0.0
Hanson 2168	66	5.0

Growth. Peach almond hybrid tend to be large trees due to hybrid vigor. Tables 2 and 3 show trunk circumference and tree height respectively. There were significant differences between rootstocks at the time of planting (Table 2, Column 1997). The Atlas, Hanson 2168 and Hanson 536 were significantly larger than Brights Hybrid, Viking and Nemaguard. After one year in the ground, the rate of growth was significantly larger on Hanson 2168 and Hanson 536. However, there were no significant differences between these two rootstocks and Viking and Atlas. Nevertheless, the rate of trunk growth was significantly larger on Hanson 2168 and Hanson 536 than on Nemaguard and Brights Hybrid. There were no significant differences in trunk growth among any rootstocks by the third season (1999).

Table 2. Trunk circumference (mm) of different rootstocks from the time of planting (1997) to the third season (1999).

Rootstock	1996-1997	1997-1998	1998-1999
Nemaguard	55.75 a*	128.67 a	122.87 a
Viking	63.62 a	144.20 ab	122.31 a
Brights Hybrid	60.02 a	128.98 a	123.26 a
Atlas	76.31 b	137.25 ab	127.39 a
Hanson 536	75.61 b	150.28 b	141.13 a
Hanson 1-82	*	*	133.89 a
Hanson 2168	79.43 b	151.98 b	140.43 a

*Like letters indicate no significant difference between rootstocks.

Tree height measurements (Table 3) were made in Spring 2000 following the third growing season. They show that Hanson 536 is significantly larger than Nemaguard and Brights Hybrid but it is not significantly larger than Atlas, Hanson 2168 and Viking.

Table 3. Tree height (ft) on different rootstocks in spring, 2000.

Rootstock	Tree Height (ft)
Hanson 1-82	9.98
Nemaguard	12.18 b*
Bright Hybrid	12.43 b
Viking	12.55 bc
Hanson 2168	12.56 bc
Atlas	12.71 bc
Hanson 536	14.08 c

* Like letters indicate no significant differences among treatments.

Yield. Almond growers are always interested in yield. If a rootstock has good wind resistance but no production, then growers are not going to use the rootstock in their orchard. Growers are also interested in early production. A common belief is that hybrid rootstocks take longer to come into production. Table 4 shows weight per kernel (g), pounds per acre, and percent of open suture.

There were no significant differences between rootstocks on weight per kernel and on percent of open suture. The yields on Hanson 536 and Atlas were significantly greater than the yields on Nemaguard, Viking and Brights Hybrid. However, there were no significant differences between Hanson 536 and Atlas.

Table 4. Kernel weight (g), pounds per acre and percent of nuts with open suture from different rootstocks.

Rootstock	Weight/kernel (g)	Pounds/acre	Open sutures/100 nuts
Brights Hybrid	.96 a*	226 a	19 a
Viking	.95 a	264 a	15 a
Nemaguard	.97 a	330 ab	21 a
Hanson 536	.97 a	437 bc	21 a
Atlas	.98 a	527 c	18 a
Hanson 2168**	.96	484	12

* Like letters indicate no significant difference among rootstocks.
** This rootstock was not included in the statistical analysis because of two replications.

Discussion. This experiment has shown the following: 1) The mortality of trees in the first season was higher on the Viking than on any other rootstock. Also, the mortality of Hanson 2168 and Brights Hybrid is not any higher than Nemaguard. 2) There are significant differences in tree trunk circumference in the first two seasons, but they disappeared by the third season. However, tree height is significantly different between rootstocks in the third season. 3) A commercial crop was harvested in the third season (third leaf). The yield on Atlas was significantly higher than on Nemaguard.

Note: Data from the 1996 rootstock test plot is not included in this report. We are still in the process of summarizing and analyzing all data. April, 2000.

Rootstocks in San Joaquin County:

Roger Duncan & Paul Verdegaal, Farm Advisors in Stanislaus and San Joaquin Counties.

There are two main objectives in the San Joaquin County trial: 1) to document growth and yield characteristics of Nonpareil almond trees on eight rootstocks in a sandy soil and 2) to observe their relative tolerance to bacterial canker. In the year prior to trial establishment, a second generation peach orchard with severe bacterial canker was removed and the soil was solid fumigated (tarped) with 400 pounds of methyl bromide. On March 12, 1998, fifty trees on each of the eight rootstocks were planted in a commercial orchard with Carmel and Sonora as pollinators. Twenty-one of the fifty trees on Viking rootstock (42%) failed to leaf out and were replaced in 1999. All trees on the other seven rootstocks have grown well during the first two years of this trial. On October 15, 1999, tree height and trunk circumferences were recorded. Trees on Hansen 536 and the experimental UC 1-82 rootstocks are the largest as measured by trunk circumference. To date, no signs of bacterial canker are evident.

Tree height and trunk circumference of second leaf Nonpareil almond trees on various rootstocks. October 15, 1999.
Darpinian Almond Rootstock Trial, Escalon, CA

Rootstock	*Trunk Circumference (cm) @ 18"	*Tree Height (feet)
Hansen	29.0 A	11.2 AB (3.4 meters)
UC 182	28.9 A	11.6 A (3.5 m)
Lovell	26.4 B	10.9 BC (3.3 m)
Atlas	26.2 B	10.9 BC (3.3 m)
Bright's	25.7 B	10.2 D (3.1 m)
Viking	25.4 B	10.1 D (3.1 m)
Nemaguard	25.3 B	10.5 CD (3.2 m)
Guardian	25.2 B	10.7 BC (3.3 m)

*Measurements were not included for replant trees (Guardian, UC 182).
*Values followed by the same letters are not statistically different as measured by the least significant difference test at $P<0.05$.

2. Nonpareil / Interstock / Marianna 2624 trials:

J. Connell, J. Edstrom, W. Micke, J. Yeager, Nickels Estate, and CSUC Farm

To overcome the incompatibility of 'Nonpareil' on 'Marianna 2624' an interstock of 'Havens 2B' (*Prunus insititia* L.) that is compatible with both 'Nonpareil' and 'Marianna 2624' has been used. Such interstock trees have had variable performance. Observations indicate that differences in performance might be due to the length of the interstock, with trees having shorter interstocks doing poorly.

Two trials were established in 1989 to determine if longer interstocks (10 inches or scaffold budding) of 'Havens 2B' between 'Nonpareil' and 'Marianna 2624' would improve compatibility over shorter (4 inch) interstocks. A second objective was to determine if a long interstock (10 inches or scaffold budding) of a compatible almond cultivar would work as well or perhaps even better than 'Havens 2B' (previous reports on the use of compatible almond interstocks were conflicting). 'Mission' and 'Jordanolo' were used as the compatible almond cultivars in these trials.

One trial was conducted on a deep loam soil at California State University, Chico. In this trial scaffold budding of 'Jordanolo' 'Havens 2B' and 'Mission' and 10 inch interstocks of 'Jordanolo' have so far been the most vigorous of the combinations tested and have shown acceptable compatibility. Trees with 4 inch interstocks were less vigorous. Surprisingly, control trees of 'Nonpareil' directly on 'Marianna 2624' are growing fairly well on this deep soil after eleven years, even though this combination is considered generally incompatible.

The other trial at the Nickels Soil Laboratory, planted on 18-24 inches of gravelly loam soil over a heavy clay layer, has been subjected to greater stress. In this trial, all of the 'Havens 2B' interstocks have performed well with the longer interstocks producing more vigorous trees than the shorter ones. Scaffold budding of 'Jordanolo' has so far also performed fairly well and has produced more vigorous trees than the other compatible almond interstock treatments. On this shallow soil, trees of 'Nonpareil' directly on 'Marianna 2624' grew satisfactorily for a couple of years, but eventually the trees either died or performed poorly.

In summarizing these two trials, 10 inch interstocks and scaffold budding improved compatibility between 'Nonpareil' and 'Marianna 2624' compared to the use of shorter 4 inch interstocks. Thus, growers should benefit from using longer interstocks when planting 'Nonpareil' in an orchard requiring the use of 'Marianna 2624'

3. Deep Purple Plum as Rootstock for Nonpareil:

John Edstrom, Farm Advisor, & Stan Cutter, Nickels Soils Lab

The USDA Agricultural Research Service has identified a plum type rootstock, Deep Purple (DP) (*Prunus besseyi x p.salicina*) which has shown potential as a compatible rootstock for Nonpareil. DP has shown resistance to root knot and root lesion nematodes in USDA Field trials in Fresno. The tolerance of this rootstock to Oak Root Fungus is unknown.

The objective of this trial is to evaluate the compatibility and field performance of Nonpareil on DP rootstock as compared to Mission on Marianna 2624 plum (M2624). As a second objective, newly developed almond varieties will also be evaluated for their compatibility on M2624 as they become available.

All trees were planted as rootstocks out of cold storage on April 22, 1998, and budded to scion varieties in May. The following combinations were established in 4 replicates of 3 trees each: Nonpareil/DP, Nonpareil/M2624, Mission/DP, Mission/M2624.

Results:

The condition of much of the DP material out of cold storage was poor compared to the M2624 material. Trees on DP were small and many showed broken or cracked roots. Trees of Nonpareil on DP in particular started out at a disadvantage in this test. Growth this first season was poor.

During the second year (1999) overall tree growth improved, however major tree losses occurred on Nonpareil / DP. September 1999 ratings showed the following survival rates:

Nonpareil / Deep Purple	3/12	Mission / Deep Purple	5/11
Nonpareil / Marianna 2624	12/12	Mission / Marianna 2624	10/12

This initial effort at field evaluation of DP as rootstock for Nonpareil has been discouraging. The poor condition of the plant material provided out of cold storage, and the rather late planting date was certainly detrimental to this planting. Additional efforts are needed to fairly evaluate this rootstock.

Another attempt to evaluate the potential of Deep Purple is planned for 2000. This test will include two sources of Nonpariel (Burchell and FPMS) and Mission on Deep Purple and also other items that include Nonpareil on M2624 with an interstem of Padre, Nonpareil (Burchell Nursery) on M2624, Nonpareil (FPMS) on M2624, and Nonpareil on Hiawatha. Hiawatha is another plum selection similar to Deep Purple purported to show minimal suckering. It's compatibility with Nonpareil and resistance to Oak Root Fungus are unknown .

This trial will also test the compatibility of new almond varieties on Marianna plum, these include, Plateau, UC 13-1 and Avalon. Varieties planted for comparison will be Sonora, Mission, and Butte. Also planned for this test is the first UC evaluation of Nonpareil and Butte on the French peach almond hybrid rootstock, GF 677. Other items are the newly developed almond cultivars, Durango (Fowler) and Kochi (Sierra Gold) on Lovell.