Almond Board of California

Annual Report - 2000

Project Title: **Almond Variety Development**

Project Leader: Tom Gradziel

Cooperating Personnel: B. Lampinen, W. Micke, D.E. Kester, M.A. Thorpe, J. Adeskaveg, J. Connell and M. Viveros.

Location: Department of Pomology, University of California at Davis

Objectives:
Develop improved pollinizers for Nonpareil, and ultimately, replacement varieties for Nonpareil and its pollenizers that possess self-fertility, improved disease and insect resistance and a range of bloom times and maturities. Goals for 2000 include:

A. Release of the UCD developed *'Winters'* variety as a new pollinizer for the early *Nonpareil* bloom. Finish the characterization, foundation stock increase and release of the UCD *Nickels* rootstock, a peach x almond hybrid rootstock for almond with improved disease resistance.

B. Breed reduced input, yet productive almonds possessing self-compatibility and pest/disease resistance. Test field performance and genetic control for tree productivity and desired traits. Continue to evaluate advanced selections 2-19E and 1-87 for productivity and disease resistance.

C. Evaluate genetic alternatives to chemical control for insect pests, particularly Navelorange worm (NOW) and ants, and for almond diseases, including shot-hole, almond leaf scorch, aflatoxin causing *Aspergillus flavus*, anthracnose, *Monilinia* hull rots and flower blights, and Noninfectious Bud-failure.

Current trends in almond production practices will require future varieties to produce uniform and economically sustainable yields with reduced chemical inputs. Greater uniformity or year-to-year production consistency is being pursued through the improvement of initial crop-set at flowering as this has been shown to be the principal determinant of final crop yield. Short term goals to improve crop-set involve the development and release in 2000-2001 of the UCD variety *'Winters'*, an improved pollenizer for the principal California variety, *Nonpareil.* Reduced grower inputs are also being pursued through the development of varieties resistant to important insect pests and diseases and through the development of self-compatible *Nonpareil*-type varieties requiring fewer honeybee pollinators and amenable to single variety plantings.

A. Release of 'Winters' almond as a pollinizer for 'Nonpareil, and of 'Nickels' as an improved hybrid rootstock.

'Winters' almond variety

Origin. The University of California at Davis has maintained an almond breeding program since the early 1950s with the encouragement and financial support of the Almond Board of California. A major objective of the breeding program is the development of pollinizer varieties for the California almond variety 'Nonpareil'. Because of its high market quality, 'Nonpareil' has become the leading California almond variety with approximately 41 % of total California acreage in 1999. Like all commercial California almond varieties, 'Nonpareil' is self-sterile and requires pollen from cross compatible varieties for successful seed set. The early 'Nonpareil' bloom contains the highest proportion of viable flowers and so is crucial to maximum crop set. It is also the most vulnerable to poor cross-pollination since traditional pollenizers such as 'Ne Plus Ultra' and 'Solano' often bloom too early to have good overlap with 'Nonpareil'. Many thousands of seedlings of *Prunus dulcis* have been developed and evaluated and the new variety 'Winters', which was evaluated under the individual seedling designation number '13-1', is the product of this breeding effort.

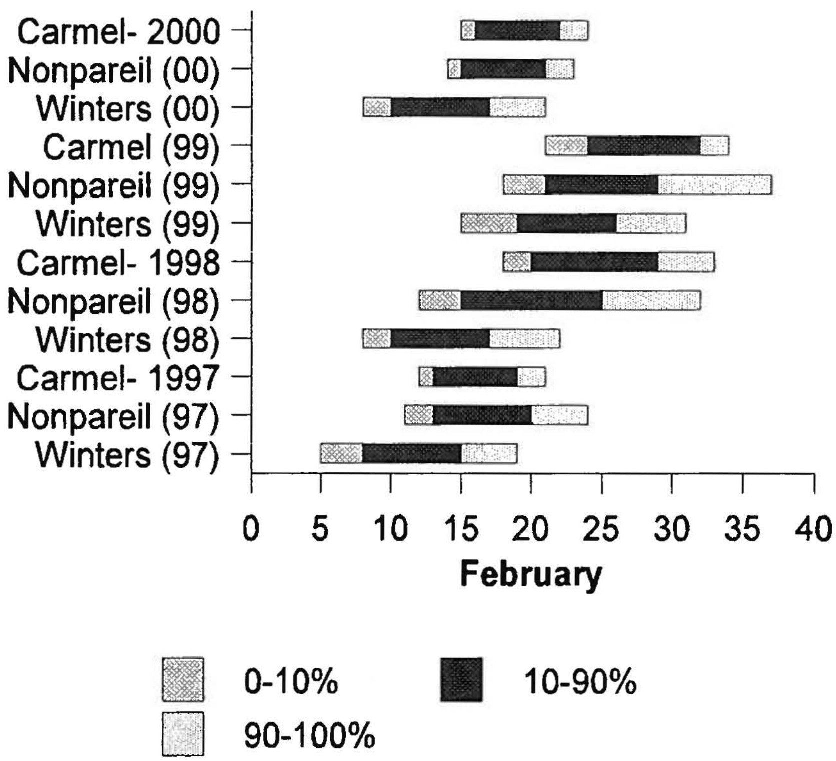

Figure 1. Bloom overlap of *Winters* vs. *Carmel* with *Nonpareil.*

The original almond seedling population from which this variety was selected was produced by routine crosses made in 1950 as part as the Calif. Expt. Stat. Proj. 739 -Almond Breeding Project carried out in the Dept. of Pomology. Nursery trees of the seedling population from this cross were initially planted in Field 8 at the Wolfskill Experimental Orchard (WEO) near Winters, CA. in the spring of 1952. The population was identified as 5001 (the first cross made in 1950) with the following pedigree: Selection 3-1 ['Peerless' x 'Harpareil' {'Harriot' x 'Nonpareil'}] x Selection 6-27 ['Nonpareil' x 'Jordanolo' {'Harriott' x 'Nonpareil'}]. The first observations of the 79 resultant trees of this population were made in 1955 and resulted in seventeen selections, which were further reduced to 8 in 1956 . Selection '13-1' refers to the Row and Tree location of the original seedling block.

Selection 13-1 trees were propagated at the Pomology nursery at Davis in 1970 and planted at the Almond Selection Block at Dept. of Pomology orchards at Davis and also at the Kearney Agriculture Field Station at Parlier, CA (Fresno Co.). Sel. 13-1 was submitted to the Foundation Plant Materials Service (FPMS) for virus indexing during the early 1970's. The selection was positive for *Prunus Ring Spot Virus* and so could not be included in Regional Variety Trials being established in Kern, Colusa, Butte, San Joaquin and Fresno from 1976 to 1981. Trees of '13-1' were submitted to thermotherapy treatment to eliminate viruses from living tissues. The treatments were successful and "clean" propagation material free of the *Prunus Ring Spot Virus* were resubmitted to FPMS for inclusion into the Foundation Block where they were designated by the Accession Number 3-27-1-77 (3 refers to almond, 27 to cultivar, 1 to source, and 77 to year). In 1992, selection 13-1 was included in a second generation of semi-commercial Regional Variety Trials, supported by the Almond Board of California, which included plots in Kern Co, Butte Co., and San Joaquin Co. Twenty six

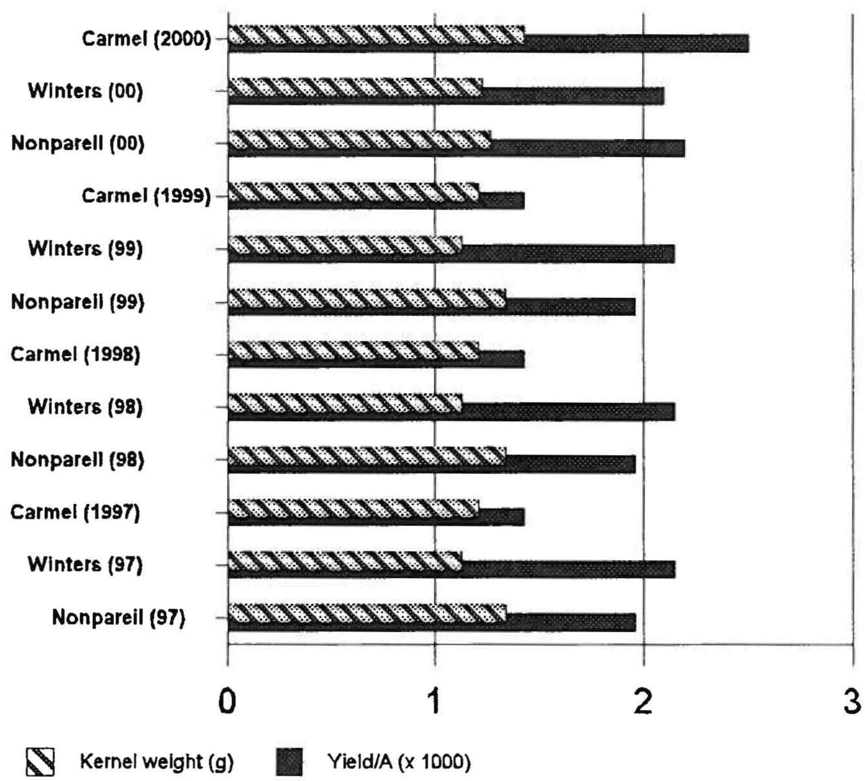

Figure 2. Performance of Winters, Nonpareil and Carmel at the Kern RVT (1997-2000)

trees of each selection were included in each plot. Smaller test plantings have also been established in the Sacramento and San Joaquin Valleys. Data on yield, insect and disease damage, and tree and nut characteristics have been obtained annually from 1995 to 2000. Based on its promising performance, particularly its consistent bloom overlap with the early bloom of Nonpareil (Fig. 1), it's cross compatibility with Nonpareil, and it's good tree and nut qualities (Fig. 2 and 3), selection 13-1 was selected in 1999-2000 as a candidate for patenting and release.

Description. The 'Winters' variety of almond demonstrates cross-compatibility with 'Nonpareil' along with good bloom overlap with the early 'Nonpareil' bloom (Fig. 1) and so is an effective pollenizers for this critical bloom period of 'Nonpareil'. Harvest of 'Winters' is 3-4 weeks after 'Nonpareil' and so does not interfere with this and other early harvested varieties. The 'Winters' tree is upright and vigorous. Fruit production occurs on a combination of spurs and terminal shoots, including a lateral bearing habit on abundant lateral shoots developed during the previous season. This unusual bearing habit results in a tree with a high productivity and tolerance to foliage and fruit loss from disease and insects. Kernel and shell qualities are good as compared to both *'Sonora'* and 'Aldrich' which are the principal early 'Nonpareil' bloom pollenizers at present (Fig. 2 and 3).

Performance. The early *Nonpareil* bloom contains the highest proportion of viable flowers and so is crucial to maximum crop set. It is also the most vulnerable to poor cross-pollination since traditional pollenizers such as Ne Plus Ultra and Solano often bloom too early. Bloom of mature trees in Regional Variety Trials consistently showed good overlap with early *Nonpareil* bloom (Fig. 1). *'Winters'* has been a productive variety in Butte in Kern (Fig. 2) County RVTs, with lower production at the Delta college RVT resulting from cultural rather than variety causes. Kernel and shell qualities are good as compared to both *Nonpareil* and *Carmel*. *'Winters'* is free of Noninfectious Bud-failure but is susceptible anthracnose and to a lesser degree to Alternaria. Thus, *'Winters'* is not presently recommended for planting in areas where these diseases are problems. *'Winters'* has been the highest yielder of all varieties at the Butte RVT over the previous five years (Fig. 2). [Yield in 2000 was 2446 pounds per acre with an accumulated yield for the first 5 years of production of 8467 pounds per acre, as compared to 1762 pounds per acre for *Nonpareil* in 2000 giving it an accumulated yield of 6762 pounds per acre, and 1934 pounds per acre for *Carmel* in 2000 for an accumulated yield of 6875 pounds per acre

Availability

'Winters' is available as a licensed (patent-pending) cultivar with licenses granted through the Office of Technology Transfer (OTT), University of California, Oakland, CA. Propagation material is distributed as registered virus tested sources through the Foundation Plant Materials Service, University of California, 1 Shields Ave, Davis, CA 95616.

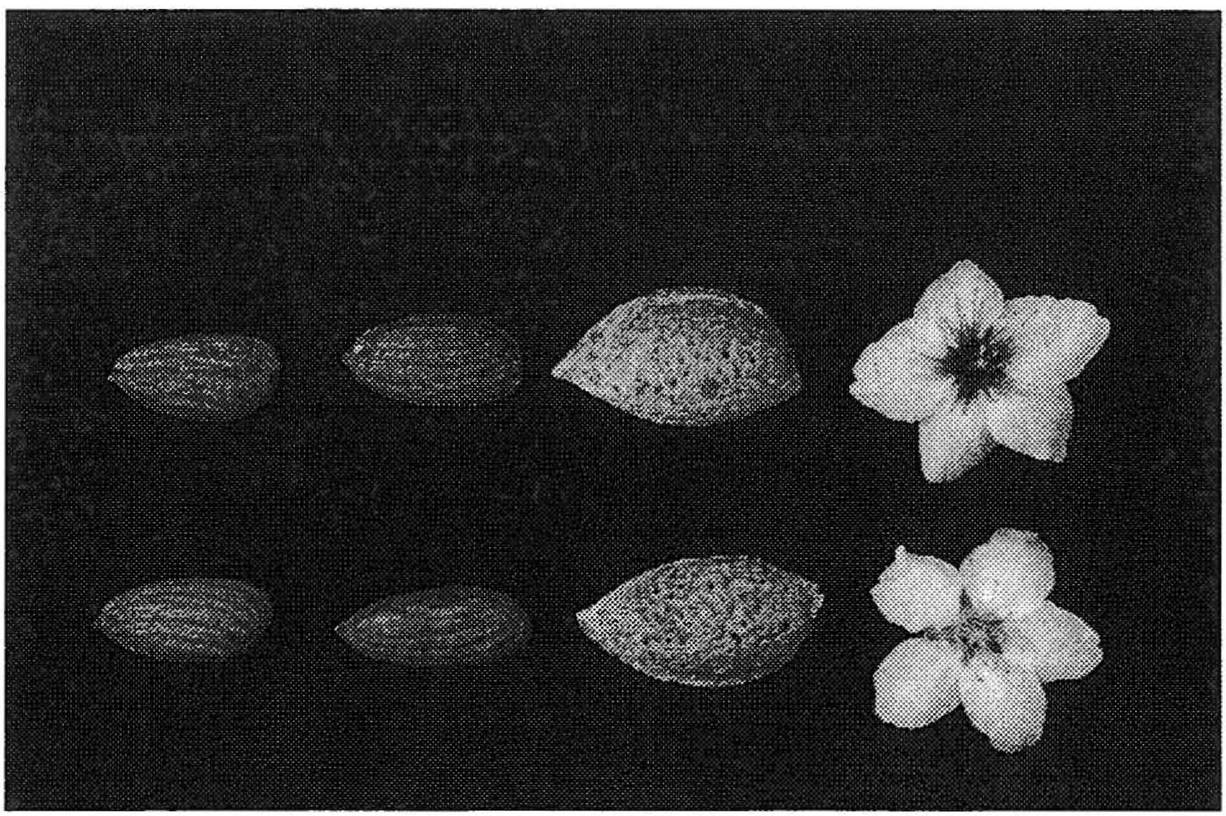

Fig. 1. Appearance of the nut, shell and flower for 'Winters' almond.

'Nickels' almond x peach hybrid clonal rootstock

'Nickels' is a vegetatively propagated almond rootstock clone originating as a hybrid seedling 'PA1-82' from the cross of 'UCD5-33' almond to 'Nemaguard' peach. Vegetative progeny are uniform, vigorous, highly compatible with almond cultivars, and relatively easy to propagate. Compared with the commercially important 'Hansen 536' rootstock, 'Nickels' is better adapted to current nursery propagation and storage practices as well as to a wider range of California almond production environments, possibly related to its greater winter chilling requirement. 'Nickels' also has a similar range of resistance to nematode species as does the parental 'Nemaguard', which is a widely used rootstock for *Prunus* tree crops in California. The hybrid vigor of this interspecific rootstock confers greater vigor to the almond scion, making it particularly useful for replant situations where adjacent trees are typically larger and so more competitive.

Origin

Four types of rootstock are currently used in California almond plantings. 'Lovell' peach rootstock is preferred by growers in the Sacramento Valley due to its general tolerance to heavier soils and its promotion of earlier bearing. 'Marianna 2624' plum rootstock is used on heavy wet soils and where oak-root fungus is a problem. 'Nemaguard' peach is the most widely planted rootstock, particularly in the San Joaquin Valley with its better drained and often sandy soils, due to its field resistance to root knot nematodes (*Meloidogyne* spp.). 'Nickels' belongs to the most recently developed class of almond rootstock which utilizes almond x peach hybrids to combine nematode and disease resistance with greater scion vigor and earlier bearing.

'Nickels' originated from a cross of 'UCD5-33' almond [*Prunus dulcis* (Mill.) D.A. Webb] to 'Nemaguard' peach [*Prunus persica* (L.) Batsch] made in 1959 as part of the almond breeding program at the California Agricultural Experiment Station, University of California, Davis, California. Prunus rootstock development was then pursued through two separate strategies. C.O. Hesse and C. J. Hansen identified peach germplasm resistant to root knot nematodes (*Meloidogyne javanica* and *M. incognita*). The second approach by D.E. Kester and C. J. Hansen sought to utilize the hybrid vigor of interspecific hybrids between almond x peach to provide vigorous uniform rootstocks for almond. The latter program also selected hybrid clones that could be readily propagated by hardwood cuttings. From the Hesse-Hansen program, two clonal almond x peach selections were introduced: 'Hansen 2168' and 'Hansen 536'. Only 'Hansen 536' became an important commercial rootstock for almonds in California and is often being referred to and sold as 'Hansen' rootstock. However, the short dormancy characteristic of the 'Hansen 536' rootstock is associated with higher levels of root-rot fungus infection of bare-root trees in nursery cold-storage, leading to higher tree losses in the orchard following transplanting. In addition, long-term orchard survival of 'Hansen 536' has been shorter than other rootstocks of this type, and a greater sensitivity to wet soils has limited its use primarily to the San Joaquin Valley in California where the annual rainfall is less than in the more northern parts of California.

'Nickels' was selected to overcome these limitations. It was first grown at the Department of Pomology orchards at Davis, under the field designation 'PA1-82'. Softwood cuttings were used to produce plants that were tested in greenhouse nematode control tanks maintained by Hesse and Hansen. Cuttings of 'Nickels' as well as 'Nemaguard' controls grown for 8 months in disease screening tanks maintained at temperatures below 25 °C containing *M. javanica* and *M. incognita* (race 3) isolated from San Joaquin Valley orchards were completely free of galls and so considered to be resistant to immune to these nematodes. However, gall development on susceptible cultivars (e.g. 'Lovell) indicated that nematode invasion took place under these conditions. Field trials in naturally infested as well as artificially inoculated soils concluded that 'Nickels' is not immune but possesses levels of field resistance comparable to 'Nemaguard' which is presently the most widely planted rootstock for control of *Meloidogyne* spp. damage in almond and peach. Propagation tests of 'Nickels' also showed rooting success of greater than 60% for hardwood cuttings when treated with rooting hormones and fungicides and planted directly into the nursery row in late fall, as is common practice.

Two long-term orchard plots were established in 1976, one at the Nickels Estate Research Farm (Colusa County, CA) in the Sacramento Valley of northern California and the other at the Kenneth Hench Regional Variety Trial (Kern County, CA) in the lower San Joaquin Valley of southern California. These included the important almond rootstocks at that time with emphasis on comparing a series of peach x almond hybrid clones, including 'Nickels'. Tree performance was evaluated over the life of the orchard with tree size and yield data collected in 1988 and 1989. Propagations for the evaluation of tree survivability following different nursery tree storage treatments were made in 1995, and data on transplant survival were collected in 1996 and 1997.

Description. As an unbudded plant, 'Nickels' is a large tree with a form intermediate between its parents 'Nemaguard' and almond selection 'UCD5-33'. Fruit bearing habit tends to be like the peach parent with long vigorous shoots which eventually develop shorter spurs. Flowers are borne laterally on long shoots, usually 2 to 3 at a node (Fig. 4). About 20% of buds are produced on short spurs. The overall flower size is greater than that of both parents.

Bloom and leafing-out period is in early to middle March in California, which is later than essentially all of the almond cultivars, and corresponds to about that of 'Nemaguard'. It is much later in bloom than 'Hansen 536' and 'Hansen 2136', due probably to its higher winter chilling requirement. The tree becomes dormant in late October to November, being earlier than that of other almond cultivars and the 'Hansen 536' and 'Hansen 2136' rootstocks.

The bark, buds and shoots have a rose brown over green coloration which also gives it a reddish look as compared to 'Hansen 536' and 'Hansen 2136'. The flower buds also have a red coloration which extends to the sepals. Petals are dark rose-pink in the bud rather than the white petals typical of almond, and remain pink as they expand, then gradually fade to light pink and almost white by petal drop. Flower appearance is very showy and petals overlap with a rounded to oblong shape and an undulating margin. The endocarp is very hard and peach-like with a pronounced tip (Fig. 1). Leaves are dark green in color, and large and lanceolate in shape, tapering to the apex about 1/3 of the way from the apex. Glands are not prominent, often with 2 to 4 globose glands found on the petiole near the blade.

Performance

Almond trees evaluated on 'Nickels' rootstock demonstrated good performance over the 20-year evaluation period with no evidence of increased disease susceptibility or rootstock-scion graft-incompatibility when compared with 'Nemaguard' and almond *X* peach commercial rootstocks. The 'Nickels' hybrid rootstock conferred increased vigor over 'Nemaguard' as measured in tree trunk circumference or trunk cross-sectional area measured at 30 cm above the soil line (Table 1). This increased tree vigor has made 'Nickels' and other hybrid rootstocks useful for tree replant situations as the resultant tree is more able to compete with the older, and so larger, adjacent trees. Overall tree yield was not significantly different than on 'Nemaguard' (Table 1), however, yield efficiency was lower than on 'Nemaguard'. Additional field trials have also shown that 'Nickels' has greater resistance to replant-related tree failures. The higher survivability of 'Nickels' over 'Hansen 536' following both short term storage (with roots held in moist saw-dust at ambient temperatures typically ranging from 2-10

°C) as well as long-term cold-storage of bare rooted trees at 1-3 °C (Table 2) demonstrates a greater adaptability of this rootstock to these nursery practices and possibly a greater resistance to soil borne pathogens since root rot organisms appear to be the primary cause of this type of tree decline.

'Nickels' is currently being tested as a rootstock for peach and while long term performance evaluations are not complete, no rootstock-scion incompatibility have been observed with peach cultivars.

Advantages of the 'Nickels' rootstock over the 'Hansen' and similar hybrid rootstocks are longer tree survival in orchards, a wider adaptation to California almond growing areas including the wetter regions of northern California, better compatibility with nursery propagation/storage practices, and vegetative propagation rates comparable to the 'Hansen' rootstocks. The name 'Nickels' was conferred to recognize the contribution of the Nickels Estate Research Farm, which provided land and support for early rootstock test plantings.

Availability

'Nickels' is available as a licensed (patent-pending) cultivar with licenses granted through the Office of Technology Transfer (OTT), University of California, Oakland, CA. Propagation material is distributed as registered virus tested sources through the Foundation Plant Materials Service, University of California, 1 Shields Ave, Davis, CA 95616.

Fig. 4. Appearance of the flower and endocarp for 'Nickels' almond x peach hybrid rootstock.

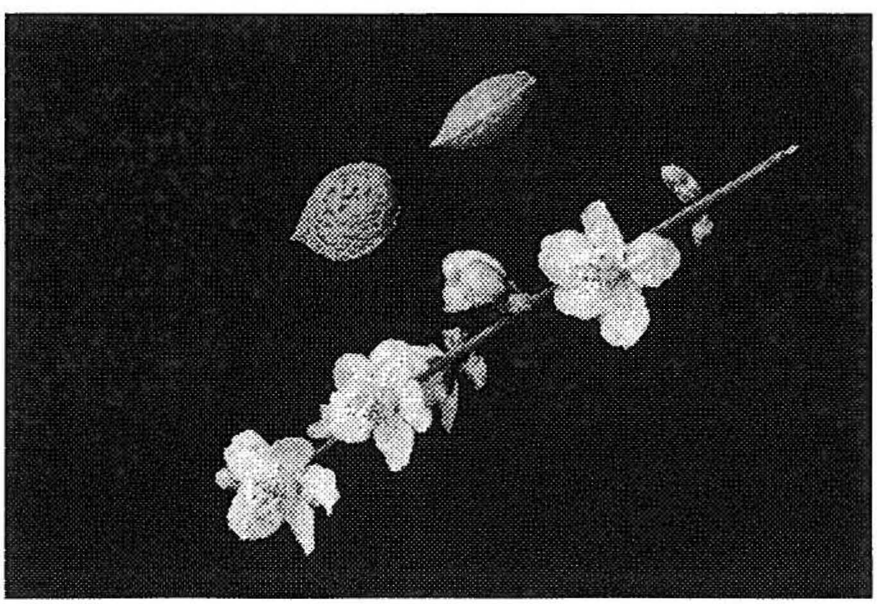

Table 1. Average 1988 and 1989 tree and nut performance for three commercially important California almond varieties on 'Nickels' and standard 'Nemaguard' rootstocks.

	'Nemaguard'	'Nickels'	Probability[z]
Mission			
Kernel yield (kg.)	19.8	20.2	N.D.
Ave. kernel mass (gm DW)	1.11	1.13	N.D.
Trunk circumference (cm)	77.8	87.3	<0.05
Trunk cross-section (cm^2)	487.6	612.9	<0.05
Yield per cross-section area	40.6	33.0	<0.05
Nonpareil			
Kernel yield (kg.)	23.2	23.5	N.D.
Ave. kernel mass (gm DW)	1.31	1.27	N.D.
Trunk circumference (cm)	87.3	96.3	<0.05
Trunk cross-section (cm^2)	612.1	749.3	<0.05
Yield per cross-section area	37.9	31.4	N.D.
Ne Plus Ultra			
Kernel yield (kg.)	16.7	18.1	N.D.
Ave. kernel mass (gm DW)	1.40	1.49	N.D.
Trunk circumference (cm)	77.63	88.56	<0.05
Trunk cross-section (cm^2)	486.2	631.2	<0.05
Yield per cross-section area	34.4	28.7	<0.05

[z] As determined by Student's T-test, n= 30; N.D. - No Difference.

Table 2. Survival of 'Nonpareil' trees budded in 1995 onto 'Hansen 536' and 'Nickels' rootstocks and planted at the same time but with different pre-transplant practices.

		Survival (%) after 2 seasons (1997)		
Treatment	Number of trees	'Hansen 536'	'Nickels'	Probability[z]
Direct planting	30	98	97	N.D.
Short term-storage[y]	50	8	43	<0.01
Long-term cold-storage[x]	30	16	90	<0.01

[z] As determined by Student's T-test, ; N.D. - No Difference.

[Y] Stored for less than 1 month with roots held in moist saw-dust at ambient temperatures ranging from 2-10 °C.

[X] Held as bare-rooted trees for greater than 1 month at 1-3 °C .

B. <u>Breed improved and productive almonds with reduced grower inputs.</u>

The lineage of most commercially important California almond varieties can be traced back to 2 parents: *Mission* and *Nonpareil*. While this germplasm has proven well adapted to California growing conditions, the self-incompatibility and general susceptibility to insects and diseases has required the widespread use of interplanted pollinizer varieties and of chemical pesticides. Self-compatibility and pest resistance are being pursued through the collection and characterization of new germplasm and its incorporation into new varieties. Genetic recombination has been achieved through traditional controlled crosses between selected parents as this strategy allows for the simultaneous selection for the multitude horticultural traits required for variety success. Recent advances in the new biotechnologies has been employed to develop molecular markers allowing the more efficient identification and so selection of genes controlling key traits such as self-compatibility. Although the almond breeding program is less than 10 years old, it has achieved consistent growth both in a number of progeny trees generated (Fig.5) and in the wealth to of new germplasm incorporated. Over 40 genotypes have been identified from field tests, which possessed levels of self-fruitfulness and 15 of the most promising selections combining both self-compatibility and improved horticultural quality have been selected and propagated for

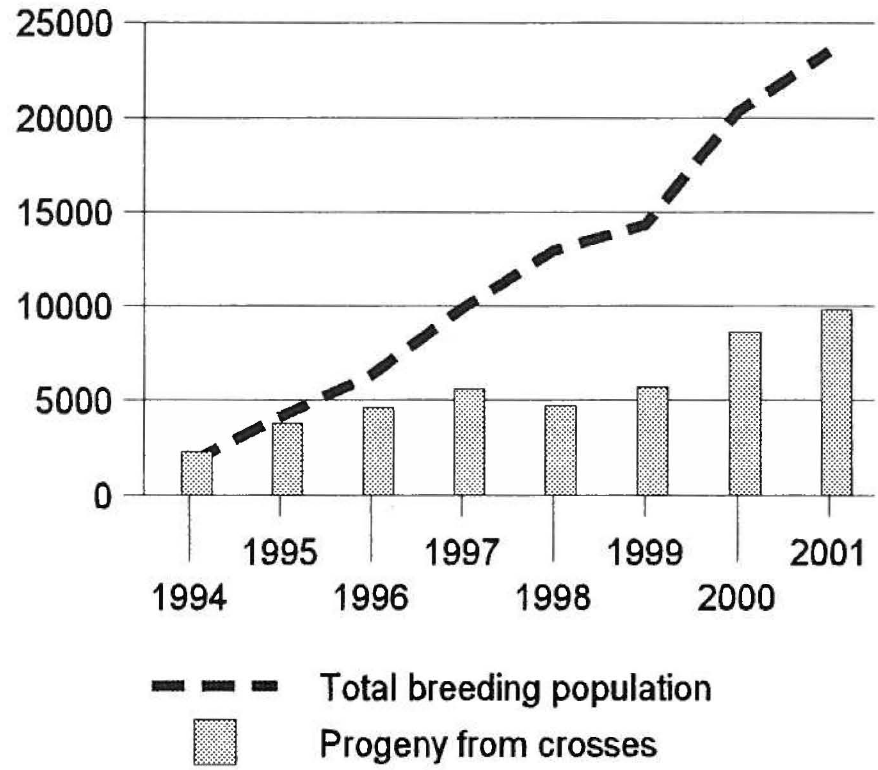

Figure 5. Summary of progeny number from yearly crosses as well as cumulative breeding population size.

further testing. Tests of advanced self-compatible lines have shown consistent set even in solid blocks (Fig. 6) or during inclement weather conditions with reduced honeybee pollenizers activity (Fig. 7). While kernel and shell characteristics of several of these selections presently approach commercial requirements, further breeding may be required to further improve both kernel size and tree architecture so as to be compatible with California orchard management systems.

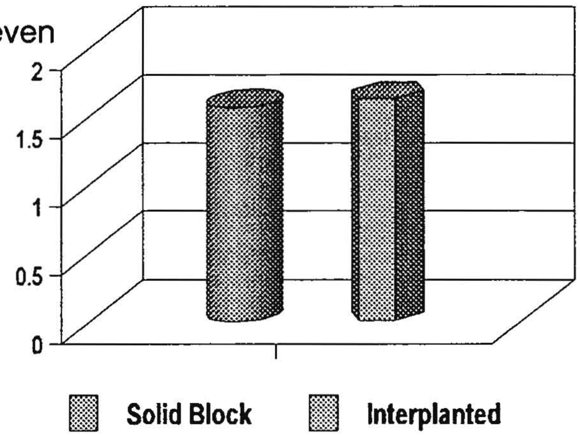

Figure 6. Comparison of 2000 yields for selfed vs. out-crossed SC lines. (#/A x 1000)

This germplasm is also being screened for resistance to the almond pests Navel orangeworm and ants, and the diseases anthracnose, *Alternaria*, almond leaf scorch, and *Monilinia* blights, and aflatoxin producing *Aspergillus* species. We are also examining the mode of action of resistance genes. For example, recent work has demonstrated that almond shell seal integrity is determined not only by the quantity of lignin but also by the process of lignification. Almond appears particularly vulnerable to shell breakdown adjacent and parallel to the suture seal which corresponds to the area of the vascular strands connecting fruit tissue with the developing seed. During early development almond has two ovules, though one usually aborts. Subsequent degradation of the vascular attachments feeding the aborted embryo appears associated with the most common point of shell break-down. This knowledge of the early stages of shell breakdown should allow more efficient screening for new varieties with relatively thin yet well sealed shells as well as cultural management options for minimizing shell splitting in current varieties.

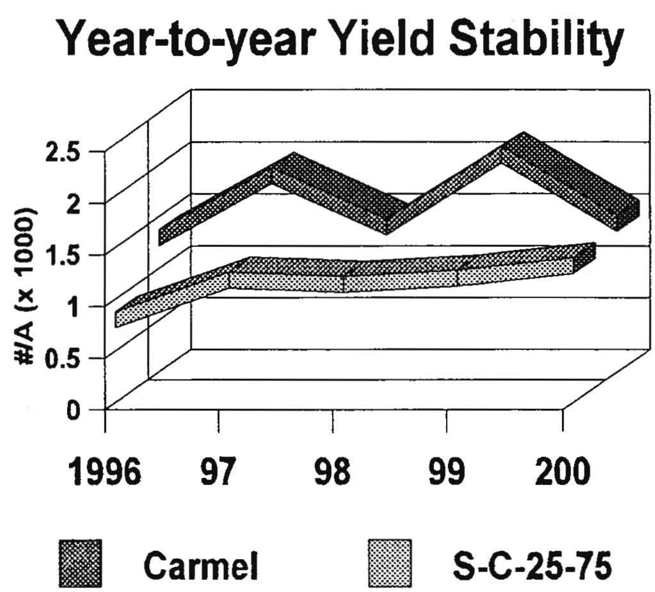

Figure 7. Cropping stability of self-compatible UC,25-75 almond.

C. **Low Bud-failure *Carmel* source.** Noninfectious Bud-failure is an economically important affliction of almond characterized by a recurrent failure of terminal shoot buds and the associated ' pushing' of more basal lateral buds. This results, over several years, in a' crazy-top' pattern of growth with associated losses in production. Noninfectious Bud-failure appears to result from the deterioration in a vital developmental process rather than from infectious agents or genetic mutations. The proper selection of clonal source has allowed the large-scale propagation of commercial trees with low potential for expressing Noninfectious Bud-failure for the strongly afflicted Nonpareil almond variety. Previous nursery budwood collection practices, based on the direct evaluation and selection from within the scion mother blocks, have proven unsuccessful in identifying Carmel source clones conferring low Noninfectious Bud-failure expression to their vegetative progeny trees (Table 3). Clonal sources conferring both a low incidence in the level of bud-failure, as well as a lower expression of bud-failure when it occurs, have been successfully identified following long-term field evaluation of vegetative progeny trees (Tables 3 and 4). Early indicators of the Noninfectious Bud-failure potential among different Carmel clonal sources appear to be the time to initial bud-failure expression in vegetative progeny populations, and more importantly, the rate of increase in Bud-failure incidence during the initial years of vegetative progeny growth. Long-term vegetative progeny tests have identified clonal sources of Carmel and other Noninfectious Bud-failure affected varieties, which have been successfully utilized for very a large-scale propagations of almond tree cultivars in California (Table 4).

Summary.

Breeding program achievements include the selection, testing, and release to the California industry of 1.) the *Winters* variety as a new productive and high quality pollinizer for Nonpareil, 2.) a low-Bud-Failure clonal source of the important *Nonpareil* pollenizer variety *Carmel,* and 3.)the *Nickels*, a hybrid rootstock for almond with improved disease resistance. Advanced self-compatible almond selections with good horticultural characteristics should be ready for initial grower testing within 5 years. A wide range of resistance sources for important almond diseases has been collected and is undergoing field testing. Rapid progress in breeding appropriate resistances into future varieties will depend on accurate grower and processor identification of the almond diseases where genetic resistance is essential (i.e. chemical/cultural control will not be economically viable in future California almond production practices).

Table 3. Percentage of trees showing bud-failure in different years for individual nursery Carmel sources evaluated from 1992-2001. Means followed by the same letter are not different at the 5% level of significance. [N0 designates the original 'Carmel' tree; while N1 designates the UCD selected low Bud-failure clonal source FPMS 3-56-1-90].

Nursery source	1992	1993	1994	1995	1996	1997	1998	Source mean
C4	49	61	84	94	95	98	99	83.0a
N3	22	27	45	74	69	86	93	59.4b
C6	20	23	38	68	64	81	85	54.0bc
C5	13	19	41	72	67	76	78	52.4bc
N4	3	10	36	69	67	80	86	50.1bc
C1	8	12	28	52	49	68	80	42.5cd
C2	9	12	28	50	47	68	83	42.5cd
C3	8	11	19	37	39	57	70	34.3d
N2	5	6	10	35	30	61	74	31.5d
NC5	5	6	12	18	18	32	44	19.3e
N1	0	0	2	2	2	3	9	2.2f
N0	0	0	0	0	0	3	10	1.8f
Year mean	11.8a	15.4a	28.5b	47.6c	45.5c	59.5d	67.6d	

Table 3. Progression of Noninfectious Bud-failure in selected FPMS Carmel sources showing bud-failure potentials in tested sources including FPMS# 3-56-1-90. [FPMS# 3-56-1-90 is the UCD selected low-Bud-failure Carmel clonal source presently being utilized by the majority of California almond nurseries].

FPMS#	Source ID	No. progeny	1997	1999	2001
3-56-1-90	D2	38	0	5	2
2	D7	40	2	47	85
6	Nursery	NOT TESTED			
7	Nursery	NOT TESTED			BF+
3-56-8-92	D4	10	0	0	10?
9	D8	10	0	0	40
10	VG 11-6	10	0	0	70
11	D21	14	42	85	92
12	VG 8-8	10	0	0	80
14	VG 8-12	10	40	80	90
15	VG 8-7	6	16	100	100
	VG 11-3	10	0	0	0?
	VG 8-13	10	0	30	60
	VG 8-14	10	0	10	60
	VG 8-18	10	0	0	40
	VG 8-23	10	0	10	40

Publications from 1999-2000 Research.

Kester, D.E. and T.M.Gradziel. 1999. The University of California Almond Breeding Project: I. Historical Aspect. Nucis: 34:322-325.

Gradziel, T.M. and S. A. Weinbaum. 1999. High Relative Humidity Reduces Anther Dehiscence in Apricot, Peach and Almond. HortScience 34:322-325.Gradziel T.M. and Kester, D.E., 1999. The University of California almond breeding programme: II. Breeding objectives and projects. Nucis-Newsletter 8: 10-14.

Tamura, M.K., K. Ushijima, H. Sassa, H. Hirano, R. Tao, T.M. Gradziel and A.M. Dandekar. 2000. Identification of self-incompatibility genotypes of almond by allele specific PCR analysis. Theor. Appl. Genet.101: 344-349.

Gradziel, T., N. Mahoney and A. Abdallah. 2000. Aflatoxin production among almond genotypes is unrelated to either kernel oil composition or *Aspergillus flavus* growth rate. HortScience 35:937-939.

Sathe, Shridhar K., Suzanne S. Teuber, Thomas M. Gradziel, and Kenneth H. Roux. 2001. Electrophoretic and immunological analyses of almond (*Prunus dulcis* L.) genotypes and hybrids. J. Agric. Food Chem. 49(4):2043-2052.

Martínez-Gómez P. and Gradziel T.M., 2001. *In-vivo* Micrograft in Almond and Their Applications in Breeding Programs. HortTechnology 11 (2): 181-183.

Ushijima, K, Sassa H., Tamura, K. Kusaba, Tao R., , Gradziel T.M., A.M. Dandekar and Hirano H. (In press). Characterization of the S-locus region of almond (Prunus dulcis): analysis of a somaclonal mutant and a cosmid contig for an S haplotype. Genetics.

Kester, D.E., R. N. Asay and T. M. Gradziel. (In press). 'Nickels' almond x peach hybrid clonal rootstock. HortScience.

Gradziel T.M., Martínez-Gómez P., Dicenta F. and Kester D.E., 2001. The utilization of related almond species for almond variety improvement. J. Amer. Pomolog. Soc. 55 (2). (in press).