Almond Variety Development

Project No.: **08-HORT1-Gradziel**

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Objectives:

Develop (1) improved pollenizers for *Nonpareil*, and ultimately, (2) varieties that possess self-fertility and improved market value and disease/insect resistance:

A. Expand field trials of new advanced almond selections and monitor performance of advanced selections now in regional/grower testing.
B. Continue to develop rapid selection/breeding techniques for Noninfectious Bud-failure, self-compatibility, and disease and pest (especially Navel Orangeworm [NOW] resistance).
C. Generate the next generation of almonds from controlled crosses and screen progeny trees for self-compatibility, tree productivity, kernel quality and resistance to key pests/diseases.

Interpretive Summary:

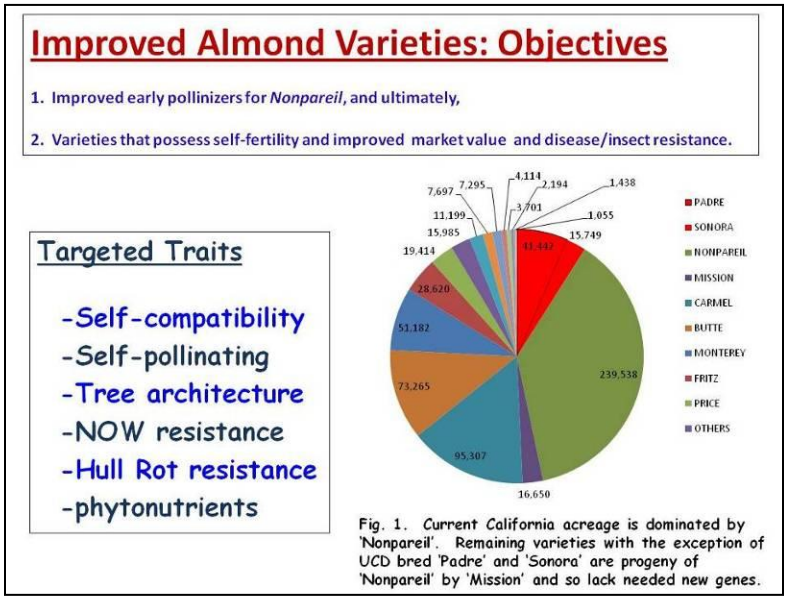
The objectives of the breeding program are the development of improved pollenizers for Nonpareil and eventually, varieties with improved production efficiency and market acceptance so as to offer alternatives to and possibly replacements for *Nonpareil*. The release of the *Winters* variety and more recently the *Sweetheart* variety provide productive, high-quality pollenizers for the crucial early *Nonpareil* bloom. Several lower priority late-bloom pollenizers are currently in the final stages of grower evaluations. New germplasm and breeding methods have been brought in to pursue improved market quality while simultaneously improving production efficiency (fertilizer and water use, etc.) and disease/pest resistance. The *Winters* and *Sweetheart* varieties represent initial products of these novel breeding efforts, demonstrating increased levels of self-compatibility and kernel quality, yet retaining high tree productivity. Advanced selections now in regional grower trials continue to show further improvements in these and other

characteristics including improved disease and pest resistance. This progress has been achieved through the incorporation of new germplasm possessing the required traits, the utilization of breeding methods capable of simultaneously manipulating the multitude of genes/traits required for commercial acceptance, and the implementation of molecular and horticultural strategies to allow the efficient generation and evaluation/selection of the very large progeny sizes required for success. In 2008 - 2009, over 14,000 new progeny trees were generated from over 40,000 crosses among 27 different crossing combinations. Over 20,000 bearing trees were evaluated for horticultural and market quality resulting in 4 additional advanced selections being propagated by 2010 regional grower testing, bringing the current number of advanced UC - Davis selections in various stages of grower testing to over 40.

In addition to making possible continuing improvements in production efficiency and market quality, the extensive diversity of often exotic germplasm incorporated into the breeding program in the last decades has also allowed the recovery of novel, unanticipated characteristics such as greatly improved kernel phytonutrient quality and broad-scale insect/pest resistance. Opportunities to fully exploit these and other novel tree and kernel traits to maximize production efficiency while minimizing the increasingly costly inputs including pesticides, fertilizers, water and labor, are being pursued in cooperation with University and private researchers, Farm Advisors, nurserymen, growers and processors.

Materials:

Breeding improved almond cultivars is somewhat like playing cards (though it may take 5 years or more before you can see how your hand has played out). In plant breeding, however, you can choose which deck of cards you draw from (your choice of parents for crossing). The trick is to select parents which have the specific traits you require yet which positively complement each other (from masking bad traits to synergistic complementation of good ones) for the multitude of other traits needed in a successful new cultivar. Nonpareil has dominated California almond production for over 100 years because of its good productivity and market qualities (**Figure 1**). Genetic fingerprinting research (see 2008 report by Dangl and Gradziel) has now verified that virtually all remaining California cultivars have Nonpareil and Mission as the sole parents, (with the notable exception of Padre and Sonora which were developed from controlled crosses at UC - Davis). Thus, the reason that most new cultivars have failed to show significant improvement over established cultivars such as Nonpareil is that we are essentially reshuffling the same old genes. To develop improved cultivars, particularly in the areas of productivity (primarily seed set efficiency and tree architecture/bearing habit), disease/pest resistance, and improved market (including phytonutrient) quality, new genetic material is required. California almonds are particularly vulnerable because they are self-sterile (requiring pollenizer varieties as well as honeybees to transfer the pollen) and flower during the winter storm season (reducing flower viability and honeybee cross-pollinations). Because self-fruitfulness is not present in almond, the UC - Davis genetic improvement program has been working over the last several decades to transfer this trait from related self-fruitful species including peach and wild almond relatives. The dramatically expanded genetic diversity brought in from this exotic germplasm also offers unprecedented opportunities to improve future California almond cultivars for other important traits ranging from productivity (fertilizer/sunlight/water use efficiency) to disease/pest resistance and kernel quality.



Improved Almond Varieties: Objectives

1. Improved early pollinizers for *Nonpareil*, and ultimately,
2. Varieties that possess self-fertility and improved market value and disease/insect resistance.

Targeted Traits

- -Self-compatibility
- -Self-pollinating
- -Tree architecture
- -NOW resistance
- -Hull Rot resistance
- -phytonutrients

Fig. 1. Current California acreage is dominated by 'Nonpareil'. Remaining varieties with the exception of UCD bred 'Padre' and 'Sonora' are progeny of 'Nonpareil' by 'Mission' and so lack needed new genes.

Figure 1. Current principal almond cultivars and future breeding objectives.

Methods:

Traditional plant breeding entails the making of controlled crosses between parents selected both for their specific traits and their mutual complementarity, and the subsequent careful evaluation and selection from their progeny for those recombinant individuals possessing the targeted desired traits as well as the range of other horticultural and market qualities required for a successful commercial variety. **Figure 2** shows UC - Davis seed parent trees on which branches and (in the background) an entire tree has been enclosed in screening to protect against uncontrolled insect pollinations in preparation for controlled crosses with selected pollen parents. To the left of these trees is part of a block of small seedling progeny trees which have been similarly mesh-bagged to test for self-fruitfulness. Because the probability of any individual progeny inheriting both self-compatibility as well as a flower structure facilitating self-pollination (inherited independently), as well as the full complement of other desired genes for horticultural/market acceptability, would be very rare, large progeny populations need to be developed and evaluated. In addition, for tree crops such as almond, it may take 5 years or more before the progeny can be effectively evaluated. Because UC - Davis has had extensive field resources and expertise, it was well suited to this type of research in the past. Current budget cuts, however, have dramatically reduced land availability and field expertise and have doubled or tripled field evaluation costs.

Figure 2. Enclosed branches and trees for controlled crosses.

An alternative method for gene transfer utilizes recently developed genetic engineering technologies to transfer targeted genes, in theory, from any organism to any organism. Research efforts in certain Mediterranean and Asian countries have attempted the development of self-fruitful almonds through the directed genetic engineering of the self-incompatibility gene to a self-compatible form. Multiple and sizable barriers exist, however, including ongoing technical difficulties in the genetic transformation/plant regeneration process, difficulties in engineering an effective self-compatible gene, difficulties in obtaining the required proprietary rights since most genetic transformation procedures are patented and protected, the unacceptability of transgenic products in key foreign markets. In important limitation of this approach is that it allows the transfer only a single major gene at a time. While self-compatibility (self-pollen is capable of fertilization when transferred from the flower anther to the same flower stigma) has been shown by our previous research to be a single major gene in almond, genes for self-pollination as well as 'modifier' genes optimizing self-compatibility expression also need to be transferred to be commercially functional. For example, Appendix A summarizes field data from breeding lines used as recent parents and the UC - Davis program. While all self fruitful cultivars possess the self-compatibility (Sf) gene, it can be seen that the selfing proportion (relative to open pollinated adjacent branches) can vary widely depending on the companion genes transferred. The only method to effectively transfer multiple genes remains the traditional method using controlled crosses. This approach has the added advantage in that other useful genes, including those for disease/pest resistance, greater production efficiency, and improved kernel quality, can be concurrently transferred from our more exotic germplasm to cultivated types. Because of our previous work in transferring self-compatibility from wild relatives has also resulted in a very rich and readily accessible new germplasm, the UC - Davis almond breeding program uses the more traditional but genetically more powerful controlled hybridization approach to cultivar improvement.

Since the goal of the UC - Davis almond breeding program is to both develop improved pollenizers for Nonpareil as well as developed the next generation replacement for Nonpareil and its pollenizers which possess improved production efficiency and kernel quality, multiple gene transfer through controlled crosses is being continued, but with two major changes to improve breeding efficiency. The first change entails the move towards high density plantings of progeny populations which has been made possible through the early rogueing-out of the less promising progeny (based on evaluation criteria developed from the previous 10 years of breeding program field evaluations). [While this early limitation of progeny population size will help keep the program within fiscal budgets, it will inevitably result in some rogueing of valuable germplasm]. The second major change to improve breeding efficiency involves our collaboration with Dr. Carlos Crisosto for using molecular-based markers to improve selection efficiency. Efficiency would be improved since the presence of the desired gene (for example self-compatibility) can be more accurately determined by the presence of the gene which encodes it rather than the often more variable field expression. In addition the presence of the gene could be determined at the seedling stage rather than waiting five years for the trees to come into production. [The relative high cost of molecular marker evaluation, however, currently precludes it large-scale use, limiting use to more advanced breeding selections]. Molecular markers currently being utilized by our program include single sequence repeat (SSR) markers adjacent to (and so tags for) genes of interest (**Figure 3**) as well as markers based on a specific gene sequence of the trait of interest. The self-incompatibility and self-compatibility designations summarized in Appendix A. are determined by the latter type of polymerase chain reaction PCR-based markers specific to the DNA differences of the self-incompatibility gene itself. [The breeding program use of molecular markers is discussed in greater detail in the 2006 and 2007 annual reports]. Biochemical and biological markers are also being used to screen seedlings prior to field transplanting.

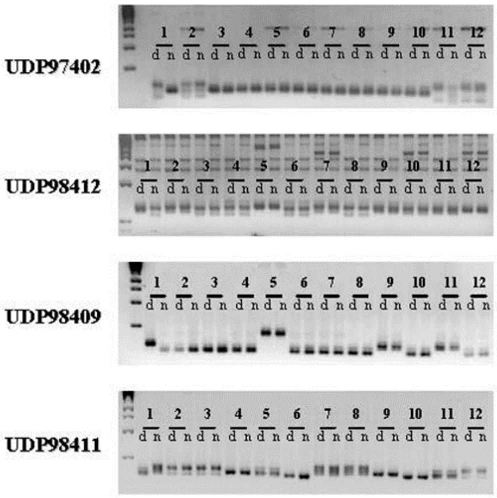


Figure 3. SSR markers used to precisely identify targeted genes from to improve efficiency.

Results:

Figure 4. Related species used as sources of new traits (top) and their hybrids with almond (bottom).

Leaf and nut morphologies representative of the original breeding germplasm (top) as well as their hybrids following the initial hybridization to almond (bottom) is shown in **Figure 4**. [Many of the interspecies hybrids are also being tested as potential rootstocks for almond]. The very wide morphological variability present, ranging from the pea-sized nuts of *Prunus scoparia* to the large, thick-shelled nuts of *Prunus persica* (peach) are also indicative of a wide genetic diversity for a range of horticultural and market traits. Similar extensive variability is also present in tree architecture, ranging from the small shrubby (and often leafless) cactus-type plants of *P. scoparia* as found in the high elevation deserts of Iran, to the large spreading *P. bucharica* trees as found at the border between northern China and western Mongolia. [The cultivated almond*, P. dulcis*, is believed to have been originally derived from crosses between *P. bucharica* and *P. fenzliana*, with possibly more recent hybridizations with *P. webbii, P. argentia* and others]. Because the native germplasm has evolved adaptations to a very wide range of ecosystems from the harsh high-altitude deserts of Iran (*P. scoparia*) to the humid subtropical conditions of Southeast China (peach), an extensive range of morphological and disease/pest resistance has also been observed in this germplasm (as documented in previous reports).

The rate of recovery of horticulturally desirable types is demonstrated in **Figure 5** where the transition of kernel type from peach and wild *Prunus webbii* (note the very small kernel sizes) to cultivated almond types is shown with increasing breeding generations. Typically, a recurrent backcross to Nonpareil or a Nonpareil-type almond is utilized to maximize the likelihood of recovering desired Nonpareil-type characteristics with concurrent strong selection in the progeny populations for the desired but rarer traits (self-fertility in this example). [Percentages in the enclosed boxes indicate the proportion of the final genome derived from Nonpareil]. The final selection in this sequence, '2000, 8-27' is self-compatible and shows good kernel (and tree) qualities, with approximately 95% of the genome derived from Nonpareil. As can be seen, a major obstacle to breeding progress is the small kernel size of most self-compatible parents utilized.

Because kernel size and shape is controlled by a number of genes, the kernel of progeny typically average-out or is intermediate to that of the parents making it less probable to recover selections having both good kernel size/shape and self-compatibility. Although selection 00, 8-27 shows good kernel size/shape combined with self-compatibility/tree productivity, it was one of only a few selections of over 2,000 progeny which made the grade. A relatively high proportion of up to 10% double kernels have been observed in young trees (**Appendix C, see: 2000,8-27**) of this selection, which may limit its ultimate commercial value. As shown in the diagram, further crosses of this selection have been made to the French variety Ferragnes (generating approx. 1,000 seedlings) for self-compatibility and improved size and disease resistance; to Nonpareil (approx. 2,000 seedlings) for self-compatibility and improved market type; and to Winters (UCD13-1, approx. 4,000 seedlings) for self-compatibility and improved productivity and kernel type. [**Table 1** summarizes other breeding line lineages.]

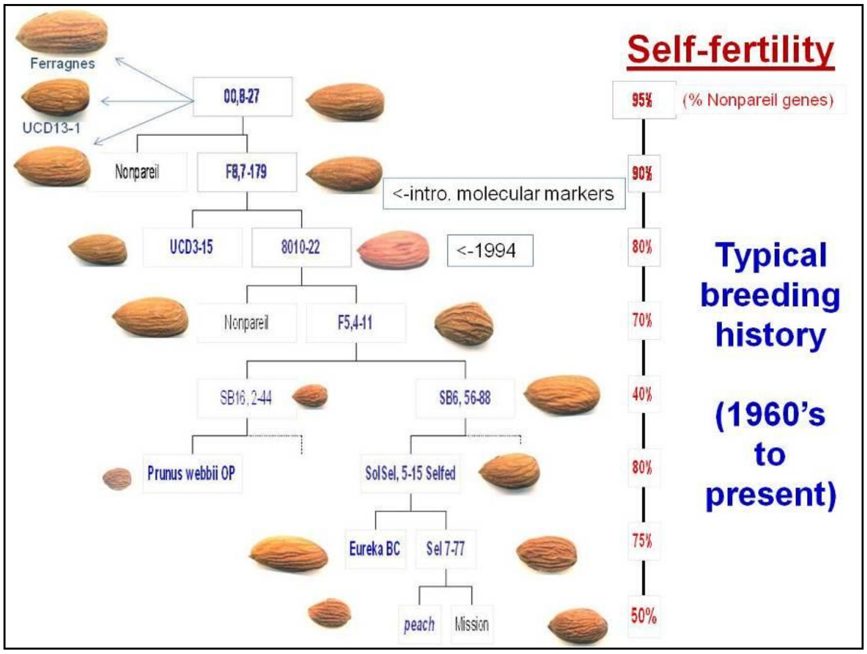


Figure 5. Sequence of controlled crosses for the transfer self-compatibility from page to almond.

In total, over 30,000 controlled crosses were made in 2008 with over 40,000 crosses made in 2009. Approximately 70,000 test-crosses (self-pollinations to test for self-compatibility) were also made each year. Over 14,000 seedlings were planted and evaluated in the greenhouse in 2008 with approximately 6,000 seedlings transplanted to the field in 2009 following greenhouse screening/rogueing of undesirable seedling types. In 2008, over 20,000 progeny trees at various stages of maturity were field evaluated with 30 individual genotypes selected to be used as parents in further crosses and and 4 additional genotypes selected for propagation for grower testing in 2009/2010. (Descriptions of these in previous selections are provided in **Appendix C**).

A sampling of the type of data collected is presented in **Table 2**, which summarizes 2008 field data for advanced selections used as crossing parents during the last breeding cycles. The species origin, specific lineage, and self-compatibility genotypes (S-alleles) are provided in **Table 1**. In addition to self-compatibility and kernel size/shape, multiple additional traits are also evaluated in progeny selections including tree structure (productivity), flower structure (self-pollination), nut quality (doubles, shriveled, etc.), and disease/pest resistance. For example, **Figure 6** shows several advanced partially self-compatible selections which also possess improved qualities in other traits. Although kernel size remains inferior to Nonpareil, the increased quality in other areas may lead to commercial acceptability for some of these selections and, for this reason, many marginal selections have been placed in regional grower testing (see **Appendix C**). [A second and often primary reason for field testing these selections is to evaluate their regional disease/pest resistance since (as in **Figure 5**) they continue to be used as parents in the recurrent backcross transfer target genes such as self-compatibility]. Regional testing is also crucial for identifying deficiencies in advanced breeding selections, many of which may not become apparent until well into the tree's maturity. A few of the basic requirements for commercial success is provided in **Figure 7**. Deficiencies in any of these areas (or a number of other areas such as double kernels, etc.) will significantly reduce the probability of commercial acceptance. Consequently, at this stage of the breeding program, the early identification of crucial deficiencies is as important, or even more important, than the identification/selection of novel desirable characteristics. For example selection UC - Davis, 25-75 possesses good kernel quality (**Figure 7**) as well as very high levels of self-compatibility and self-pollination. Tree architecture, however, was substandard as it retained some of the peach-like branching patterns of its peach great-great-grandparent. The most serious problem, however, did not express itself until trees were approximately 10 years old, at which time extensive trunk bark-cracking occurred leading to disease development, girdling, and in many cases tree death.

Figure 6. Selections showing improved self-compatibility/self fruitfulness but lower kernel quality (typically small size).

To reduce the risk of ultimately unproductive breeding lineages, a diversity of germplasm (based on species origins and specific lineage) is being actively maintained within advanced breeding material as shown in **Table 1** and **Appendix B & C**. For example, although the list of advanced highly self-compatible breeding lines in **Appendix B** is dominated by the WP (*P. webbii*/ peach) lineage, one of the most promising current selections is 2004, 8-160 (derived from the previously described UCD, 25-75) is ultimately derived from *Prunus mira*.

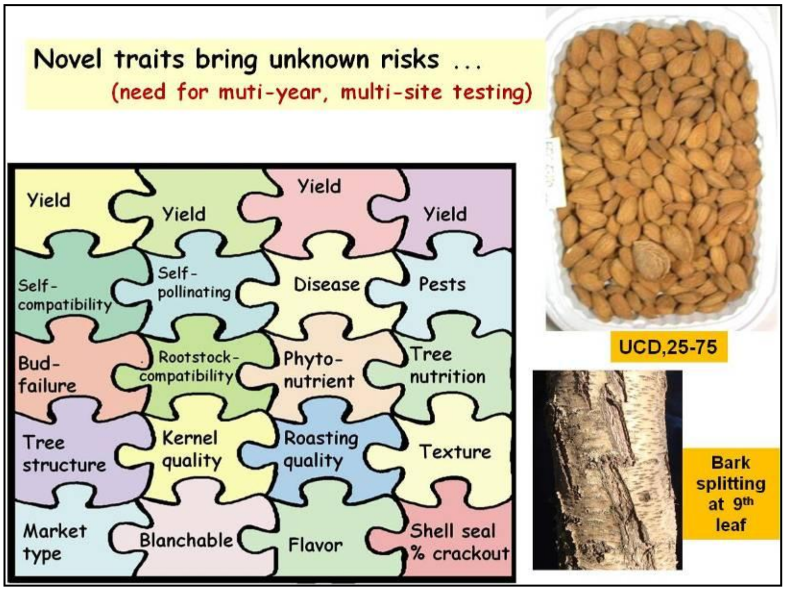


Figure 7. A small sampling of traits required for commercial success (left), the highly self-compatible/self-fruitful selection UCD, 25- 75, and bark cracking associated with this selection at

An example of the dangers of too great a focus on a specific germplasm can be seen in the emphasis of most European almond breeding programs on the use of the old Italian variety Tuono (self-compatibility derived *P. webbii*) as a sole source for self-compatibility. Advanced breeding selections, while demonstrating high levels of self-compatibility in the lab, have shown inferior field performance, possibly from inbreeding depression. (In inbreeding depression the recurrent reshuffling from a limited genetic base has exposed a number of the deleterious to lethal genes common in almond but typically masked by its outcrossing nature). The active maintenance of an extensive genetic diversity in advanced breeding lines has an advantage in that it also allows selection of synergistic interactions of genes from different origins. For example, while the *webbii* source of self-compatibility has been shown effective in both UC - Davis and European (i.e. Tuono) breeding programs, our highest levels of self-compatibility are found in breeding lines combining both the *webbii* and peach sources (**Table 2**). [Recent molecular studies based on this UC - Davis germplasm have shown that the self-compatibility mechanisms are different and so the combining of different self-compatibility genotypes may indeed be synergistic].

Maintaining a diverse germplasm in advanced breeding cycles is also desirable as it allows evaluation of the sometimes novel expressions of exotic genes when brought within a cultivated almond background. An example of this situation is presented in Figure 8 showing various levels of introgression of a high lignin shell trait from *P. webbii* to cultivated almond. The *P. webbii* shell (**Figures 4 and 8**) has a highly lignified inner shell and absence of any outer shell, being similar to peach in that the vascular channels are present in the outer shell rather than being sandwiched within the shell is occurs in cultivated almonds such as Mission in **Figure 8**. The *webbii* shell characteristic tends to be dominant (i.e. expressed and not masked) in progeny of crosses to cultivated almond making it readily transferred. In advanced breeding lines we have achieved selection of good kernel types with very thin yet highly lignified and well sealed shells resulting in a high shelling percentage (**Figure 8**).

Figure 8. Transfer of the web-shell trait from Prunus webbili (bottom left) to almond (Mission-left top, hybrid-left center). Advanced selection UCD 2-240 (center), high lignin, thick shelled Marcona almond (bottom right) and advanced selection 244 with highly lignified but thin shell (right top).

Shelling percentage is of great commercial importance since high shelling percentage (kernel mass/kernel plus shell mass) is associated with higher kernel yields while lower shelling percentage is associated with thicker shells (as in the variety Marcona in **Figures 8 and 9**) and so greater potential resistance to insect and aflatoxin damage. While the Mission shell is considerably thicker than a Nonpareil shell, both are considered soft shells since they lack the dominant (D-) gene which confers a very high lignification resulting in a thick and very durable shell as exemplified by the variety Peerless and the European variety Marcona. Our experience has shown that extensive crossing within the traditional California germplasm results in shelling percentages that are typically intermediate between the parents. Shelling percentages as high as 75-77%, however, have been recovered in good commercial quality, advanced breeding lines derived from *Prunus webbii* (see advanced selection 97,2-240 in **Appendix C**). The high shelling percentage results from more pronounced lignification of the inner shell wall and an absence of lignification in the typical outer wall (**Figures 8 and 9**). Previous research has shown that perturbations in the lignifications of the outer wall are an important cause of the subsequent shell fracturing and loss of shell seal integrity (and so vulnerability to navel orangeworm). The absence of cell lignifications in the outer wall of these advanced selections appears to avoid this vulnerability to shell fracturing, resulting in high proportion of resultant nuts having well-sealed shells. As discussed earlier, shell hardness is controlled by the D/d-locus where D- shells are hard and dd are soft. In addition to the final degree of lignifications, these genotypes also differ in their development time. D- genotypes become lignified at the beginning of Stage II while in dd genotypes (California types), lignification does not occur until after completion of Stage II, leaving these genotypes vulnerable to earlier insect feeding on the developing nuts. Within traditional germplasm, the timing of shell hardening has been positively correlated to the final shelling percentage. Consequently, the *P. webbii*-type endocarp, which appears to suppress outer shell layer development, may not only facilitate the breeding of high-sealed, high crack-out almond cultivars, but when paired with the high lignin D- allele, may promote earlier shell lignification and so greater resistance to insects such as lygus and leaf-footed bugs. Despite the high crack-out ratios, shell seal integrity can range from moderate to high depending on individual genotype. Thus, high shell seal integrity results from both the high lignin density found in fully developed shells as well a modified endocarp development pattern which appears to avoid internal structural stresses. We are currently continuing efforts to recombine the highly lignified *webbii* shell trait with the hard shell trait of European almonds to develop a thin, yet highly sealed shell adapted to California hulling/shelling equipment. In addition, because the hard-shelled nut types tend to be resistant to hull-rot (the greater lignification may prevent fungal spread from infected hulls to growing shoots), the *webbii* trait may allow development of thin-shelled, yet hull-rot resistant genotypes. Early selections showing more lignified versions of this trait result in durable, readily blanchable and attractive shells which may also offer alternatives to the increasingly problematic Peerless market type (**Figure 10**).

Figure 9. Premium quality *Marcona* almond (top) was premium quality *Marcona*-type Sweetheart variety (bottom).

Figure 10. Advanced selection showing web-trait in a high-lignin, thick shelled type as a possible replacement for Peerless.

Sweetheart almond variety

The recently released Sweetheart almond variety is a similar example of novel and so unpredictable traits which can be recovered when exotic genes are brought into a traditional almond genetic background. While the lineage of Sweetheart involves an early hybridization to peach (**Figure 11**) subsequent crosses have been selected towards a premium (Marcona-type) kernel roasting quality but without the highly lignified Marcona shell (**Figure 11**). [This was motivated, in part, by increasing domestic demand for Spanish-style roasted Marcona almonds (with store prices of $4/lb or higher common)]. Marcona, however, produces inconsistently in California and, with its highly lignified shell (30% kernel/nut crack-out ratio) was poorly compatible with California processing equipment. Sweetheart has very similar kernel characteristics as Marcona but with a thin (65% kernel/nut crack-out ratio), and relatively well sealed shell (**Figure 9**). The high roasting quality is the result of the very high levels of oleic acid within the kernels (**Figure 12**). Sweetheart has the highest proportion of oleic acid (75%) of any almond selection we've tested; in addition to conferring a high roasting quality, buttery texture and extended storage life, oleic acid is becoming increasingly recognized as an important phytonutrient [being a major marketing force in the recent expansion of (high-oleic acid) olive oil sales]. UC - Davis inheritance studies now support our preliminary conclusions that the high oleic acid content is result of a transfer from peach, a proposal which was originally contentious because peach is typically selected for fruit rather than kernel quality. [While the early Sweetheart lineage selections were for self-compatibility (the pollen parent 25-26 is a result of self-pollination while the seed great-grandparent {SolSel, 5-15} has been one of our most effective sources for selfcompatibility), Sweetheart shows only partial and inconsistent self-compatibility/self-fruitfulness.

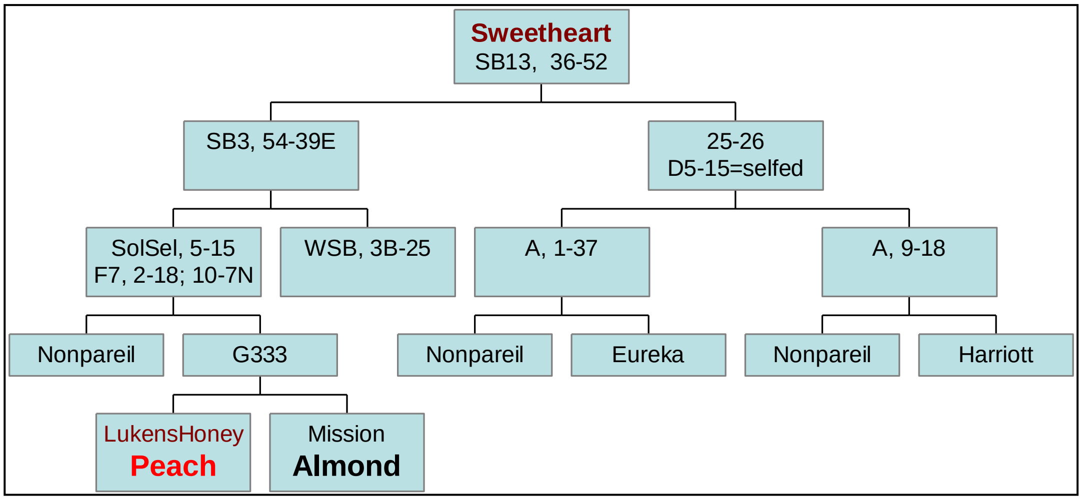


Figure 11. Breeding lineage of the Sweetheart variety.

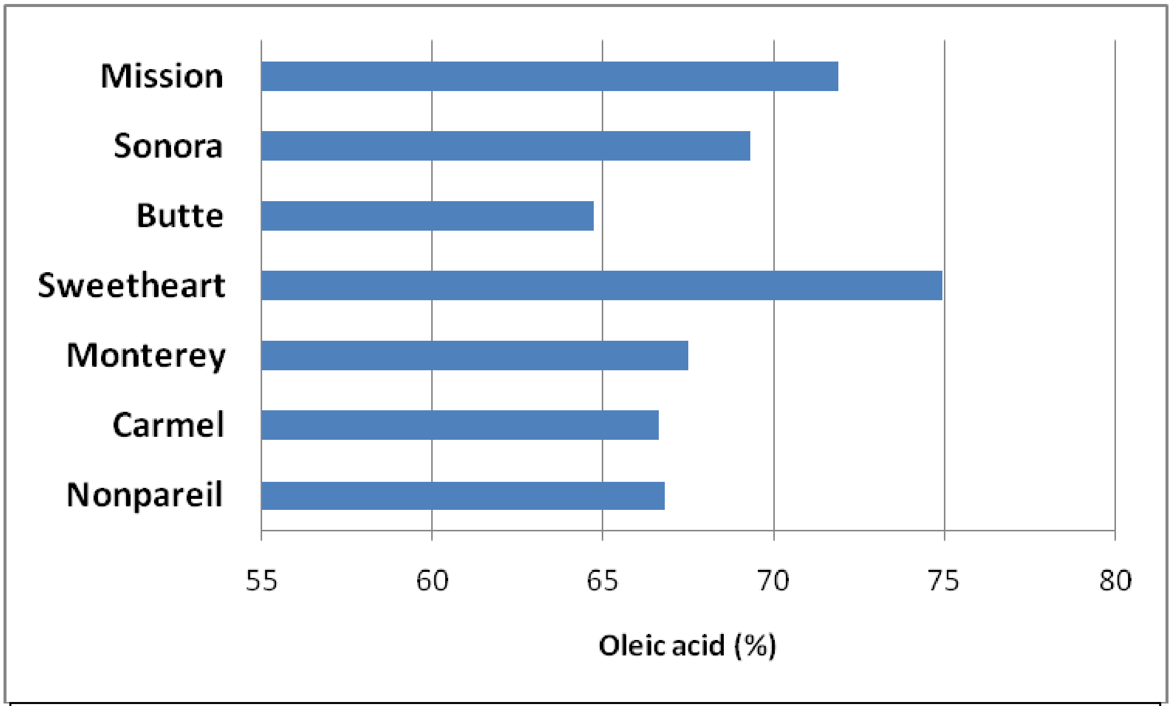


Figure 12. Oleic acid content of selected California almond varieties.

Prior to its release, Sweetheart has shown good productivity in limited regional trials over the past 10 years. Typically, longer and more extensive regional testing would be desired to reduce the possibility of releasing a new variety whose deficiency would only become apparent after sizable plantings had already taken place. However, given the good productivity of early trials and very high price for this type of Spanish-roasted almond (and so the increasing request from California growers for an alternative to Marcona), Sweetheart was released in 2007-08. Widespread plantings have taken place and these are being monitored. Very low tree productivity have been reported in 2 very young orchards (3 to 4 years) which have been traced back to a clonal source of Sweetheart (36-52x) which was propagated under test agreement prior to Sweetheart's official release and the official availability of foundation-tested stock for nursery propagation. Genetic identification (fingerprinting) recently completed [see Gradziel and Dangl 2008-2009 final research report] verify that clone source 36-52x is the Sweetheart variety. Concurrent tests at Foundation Plan Service (FPS) indicate that neither Sweetheart nor the clone source 36-52x are infected with *Prunus Necrotic Ring Spot Virus* (PNRV) or *Prune Dwarf Virus* (PDV) which sometimes result in low tree productivity. [Marcona plantings in California which were all derived from a single UC - Davis tree, however, have been shown positive (infected) for *Prunus Necrotic Ring Spot Virus* which has resulted in deteriorating growth and productivity for several recent California plantings. Low productivity has not been observed in the numerous commercial Sweetheart orchards propagated from official on FPS Foundation stock though these continue to be monitored and growers urged to contact us if concerns arise.

	PNRV	PDV	Genetic ID
Marcona	+	-	-
Sweetheart	-	-	+
Clone Source 36-52x	-	-	+

Figure 13. Molecular diagnostic comparisons of the Marcona and Sweetheart varieties and the suspect clone 36-52x.

Winters almond variety

The Winters variety (**Figure 14**) was developed as a pollenizer for the crucial early Nonpareil bloom. Because bloom time in almond is determined both by unique chilling requirements for flower buds to become active in January, as well as unique heat requirements for subsequent bud development to flowering, it has been very difficult to develop a variety which consistently flowers just prior to Nonpareil. Flowering 3 to 5 days ahead of Nonpareil provides the large quantity of pollen and nectar needed for bee hives to come up to strength for the critical Nonpareil bloom and fully compatible pollen to ensure successful cross-fertilization of the early Nonpareil bloom. The early Nonpareil bloom, because of its high fecundity, is very important to ultimate crop set and yields. In regional testing over the last 15 years, Winters has proven the most consistent variety for effectively covering early Nonpareil bloom (**Figure 15**). Winters has also proven to be highly productive despite the frequent absence of pollenizers for its early bloom (see previous annual reports). Like the UC - Davis almond varieties

Figure 14. Winters kernel and shell type.

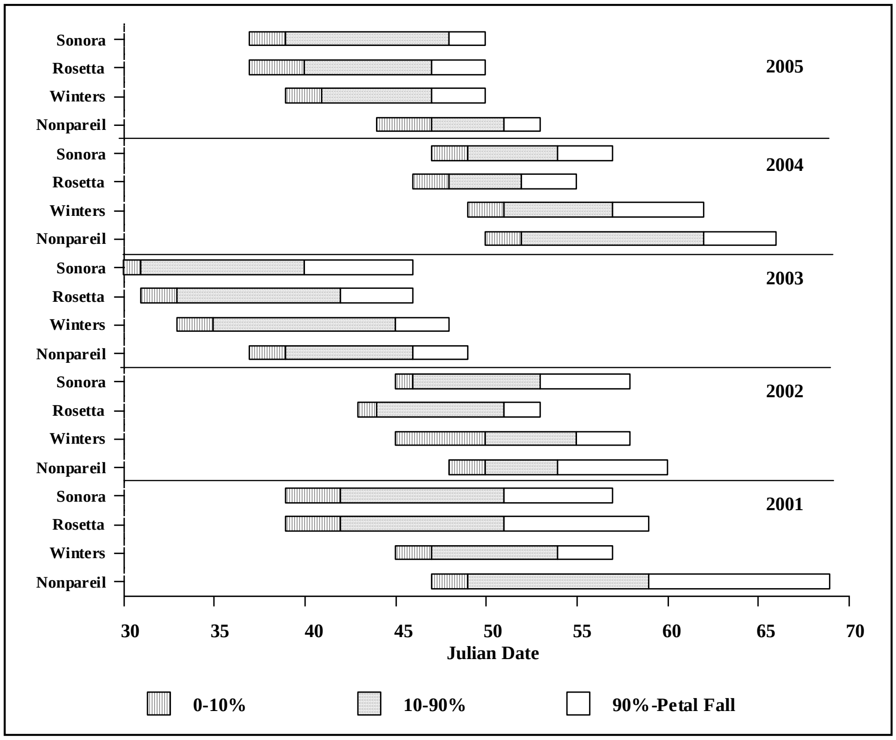


Figure 15. Bloom progression of 'Winters' relative to 'Nonpareil' and the widely planted early flowering cultivars 'Sonora' and 'Rosetta' from 2001 to 2005 at the North Sacramento Valley evaluation site [From 2006-07 Report].

Sonora and Padre before it, Winters parentage has benefited from contributions from a range of almond varieties besides Nonpareil and Mission (**Figure 16**). Unlike Sweetheart, however, the lineage of Winters includes only old, heirloom almond varieties. Two of these varieties, Jordanolo and Harriot, are notable for the high levels of Noninfectious Bud-Failure which ultimately contributed to their commercial demise. A 10 year evaluation of BF expression in progeny of a cross between Winters and the early flowering peach 40, A-17 have shown no evidence of BF. (Previous studies have shown that BF prone varieties when crossed to this tester line will show a high proportion of BF in progeny within five years of growth; the lack of BF-infected progeny in this cross supports a low probability of BF expression in Winters, despite its parentage). Winters is susceptible to several important diseases including anthracnose, alternaria leaf-spot, hull rot and navel orangeworm (the latter 3 exasperated by its high productivity). Winters is also notably unique in 2 other areas: a compact, lateral bearing-habit and relatively high native-levels of self-compatibility.

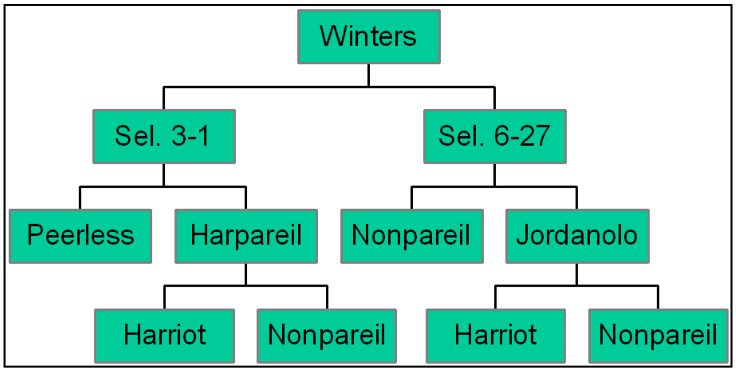


Figure 16. Breeding lineage of the Winters almond variety.

Self-compatibility

The ability of the Winters variety to set well even without a pollenizer for its crucial early bloom has suggested that it possesses inherently higher levels of self-compatibility. Higher levels of self-compatibility in Winters has been confirmed through controlled hand selfing (bagged branches) studies, and more recently molecular analysis of progeny from honeybee pollinated Winters trees. Molecular studies of Winters progeny resulting from pollinations by honeybees carrying both outcross and self pollen verify that up to 40% of the seed-set result of self-pollinations (**Figure 17**). While such relatively high levels of self-pollinations would contribute to Winters productivity in the situation where earlier pollenizers are not available, controlled self-pollination studies

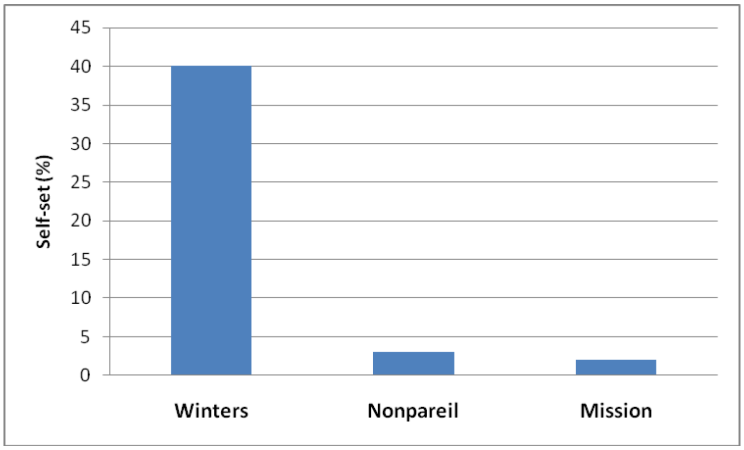


Figure 17. Seed-set following honeybee self/cross pollination on enclosed trees showing sizable capacity for self-compatibility for the Winters variety.

have shown that the levels of self-set vary from year to year and so may not be dependable in years of high pollination need. Self-compatibility in Winters, appears to be the consequence of a high level of modifier genes as it lacks the major gene for self-compatibility (**Appendix A**). As such, Winters has been an important parent for combining both the major self- compatibility gene (from exotic sources) with a synergistic genetic background (Winters modifier genes) allowing consistent and high levels of self-sets).

Experience over the past 10 years has shown that Winters also contributes high kernel quality and tree productivity to progeny, making it an important parent in our continuing breeding efforts.

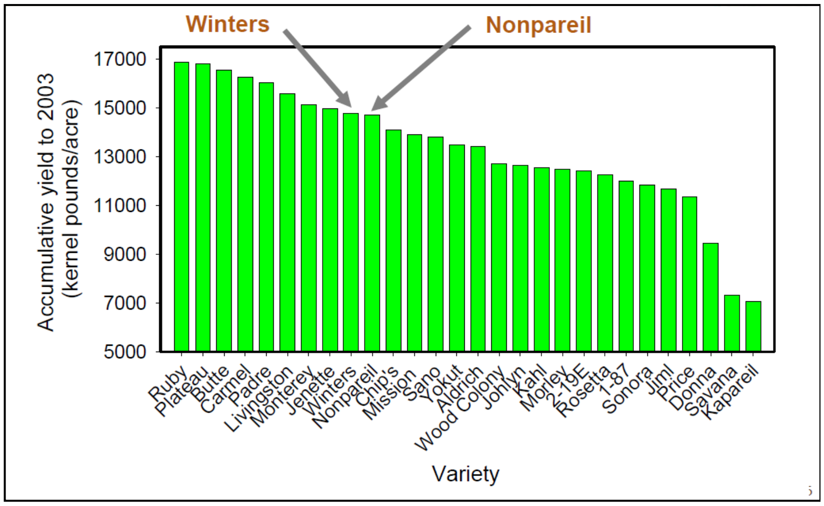


Figure 18. Accumulated yield of recent regional writing trial selections showing comparable yield of Winters and Nonpareil when averaged over different growing regions.

Compact bearing habit

The preponderance of short lateral shoots as well as spurs in Winters allows a more uniform productivity throughout the tree (and so less shading and greater light capture efficiency) and so a higher production efficiency per tree size. Recent field studies with Bruce Lampinen and cooperating Farm Advisors have shown that in the unusually wide tree spacings of the Butte Regional Trial (RVT) Winters can develop into a large and very productive tree (**Figure 19**). However, tree productivity is similar to Nonpareil when averaged over different RVT planting densities (**Figure 18**). Of particular interest, however, is the relatively high productivity of the Winters under the high density plantings more typical of commercial plantings, as in the Kern RVT (**Figure 19**). Of greater importance than the productivity of the Winters trees is its relatively small, compact size which while sufficient for good productivity on Winters allows even higher productivity on the adjacent (high-value) Nonpareil crop because the smaller trees intercept less of the sunlight ultimately captured by adjacent Nonpareil. [This study also documents the very high correlation of exposed tree leaf surface (sunlight capture) with final crop yields (given initial high levels of seed-set). Consequently to maximize orchard yields the compatibility of pollenizers to main crop variety need to take into account not just pollen cross-compatibility and orchard management (harvest, etc) considerations, but also a complementary rather than competitive interaction between varieties. Depending on use, then, there may be no ideal almond tree architecture and the knowledgeable integration of differing individual varietal architectures may allow sizable increases in final farm productivity. A legacy of basing current UC – Davis breeding efforts on an extensive diversity of exotic germplasm, is that unprecedented diversity in tree architectures and development patterns are now also available in a California adapted background. Over 40 advanced selections are now planted at different almond production environments to assess local and statewide productivity. Updated summaries of these UC - Davis advanced selections of various breeding lineages are provided in **Appendix C**.

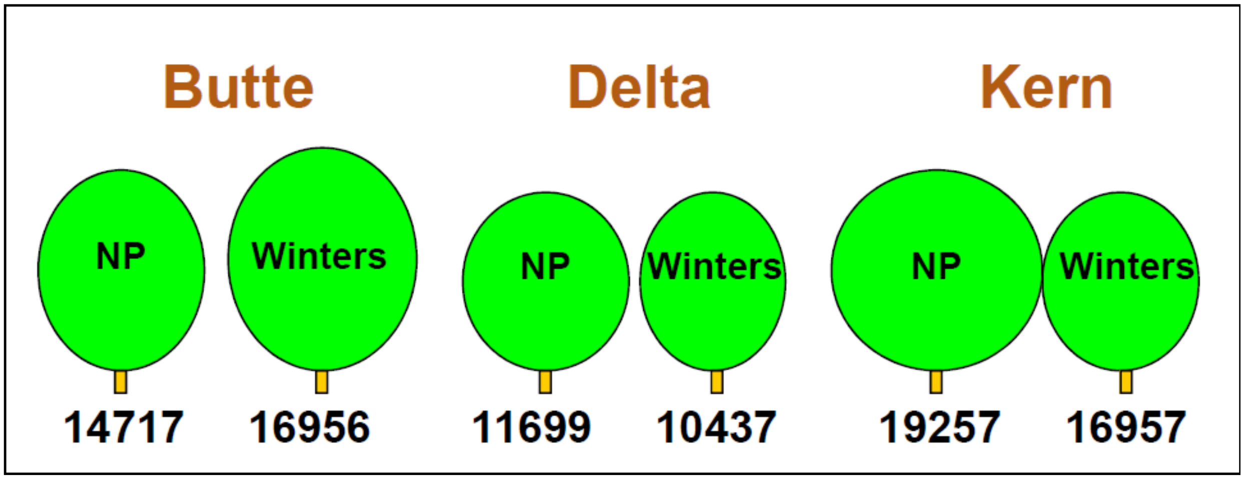


Figure. 19. Relation of Winters tree size at different planting densities and cumulative yields relative to almond showing Winters capacity for high productivity yet compact tree size (facilitating higher Nonpareil yields).

Recent Publications:

Martínez-Gómez P, K Majourhat,M Zeinalabedini, D. Erogu, M Khayam-Nekoui, V. Grigorian, A Hafidi, A Piqueras1 and TM Gradziel. 2007. Use of Biotechnology for Preserving Rare Fruit Germplasm. Bioremediation, Biodiversity and Bioavailability 31-40.

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Ogundiwin EA, Peace CP, Gradziel TM, Dandekar AM, Bliss FA, Crisosto CH (2007). Molecular genetic dissection of chilling injury in peach fruit. Acta Horticulturae 738:633-638 .

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Granell, A., C. Pons, C. Martí, T.M. Gradziel, C.P. Peace, J. Forment and C. Royo E. Ogundiwin and C.H. Crisosto. 2007. Genomic Approaches - Innovative Tools to Improve Quality of Fresh Cut Produce. Acta Horticulturae 746:203-211.

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Gradziel, T.M. 2008. Almond *(Prunus dulcis*). In: M. Priyadarshan and S.M. Jain (eds).Breeding of Plantation crops. Springer Science publishers. pg. 1-33

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Pere Arus, Thomas Gradziel, M. Margarida Oliveira, and Ryutaro Tao. Almonds. In; K.M. Folta, S.E. Gardiner (eds.), Genetics and Genomics of Rosaceae, C_ Springer Science. NY

Ogundiwin E.A., Martí, C., Forment, J., Pons, C., Granell, A., Gradziel, T.M., C.P. Peace, and C.H. Crisosto (2008). Development of ChillPeach genomic tools and identification of cold-responsive genes in peach fruit. Plant Molecular Biology (in press)

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Table 1. Breeding lines used as parents for self-compatibility and kernel quality. (Origin –related species used as initial source of self-fruitfullness; SC –has major gene for Self-compatibility).

Selection	ORIGIN	Traits	SC
91-18-174	*Mutation*	Self-compatible;	yes
96A,1-133	*PEACH*	Self-compatible;	yes
97,1-232	*PRUNUS MIRA*	Self-compatible;	yes
97,3-40	*PRUNUS FENZLIANA*		no
98,15-109	*PRNUS WEBBII*	Self-compatible;	yes
99,1-121	*P. WEBBII; PEACH*	Self-compatible;	yes
99,3-189	*PRUNUS MIRA*	Self-compatible;	yes
D3-25	*P. WEBBII; PEACH*	Amaretto flavor and shape for sugar coationg	yes
95,1-26	*Heritage germplasm*	Self-compatible;	yes
F7,1-1	*PEACH*	Self-compatible; Bacterial blast resistant	yes
F8,7-179	*P. WEBBII; PEACH*	Self-compatible;	yes
F8,7-180	*P. WEBBII; PEACH*	Large Nonpareil-type kernel	no
F8,8-160	*P. FENZLIANA; P. MIRA*	Self-compatible;	yes
F8,8-4	*P. WEBBII; PEACH*	Self-compatible;	yes
F8-8-161	*P. FENZLIANA; P. MIRA*	Self-compatible;	yes
2000,11-190	*Mutation*	Self-compatible;	yes
2000,1-180	*P. WEBBII; PEACH*	Self-compatible; Bud-failure?	yes
2000,13-162	*P.S WEBBII; PEACH*	Self-compatible; large Sonora-type kernel	yes
2000,16-81	*P. WEBBII; PEACH*	Self-compatible;	yes
2000,2-3	*P.S WEBBII; PEACH*	Self-compatible; Bud-failure?	yes
99,4-97	*P. WEBBII; PEACH*	Self-compatible;	yes
99,9-86	*P.S WEBBII; PEACH*	Self-compatible;	yes
2000,3-385	*P.S FENZLIANA; P. MIRA*	Self-compatible; self-pollinating; productive	yes
99,4-8	*PEACH*	Peerless-type shell; very productive	no
2000,8-27	*P. WEBBII; PEACH*	Self-compatible; Nonpareil-type kernel	yes
2002,1-271	*TUONO; ALMOND.*	Self-compatible;	yes
2002,8-119	*TUONO; ALMONDI;*	Self-compatible; Marcona-type kernel	yes
2004,14-158	*P FENZLIANA; PEACH*	Self-compatible;	yes
2004,14-31	*P. WEBBII;*	Self-compatible; Hard-thin & well-sealed shell	no
Ferragnes	*European cultivar*	Large kernel, semi-spft shell; disease resistant	no
LEGRAND	*PEACH*	Self-compatible; Stick-tight nuts	yes
LGOP	*PEACH*	Self-compatible; productive	yes
Sweetheart	*PEACH*	Marcona-type kernel; pollenizer for Nonpareil	no
UCD25-75	*P. MIRA*	Self-compatible; highly self-pollinating	yes
WINTERS	*Heirloom germplasm*	Partially Self-compatible; productive, pollenizer for early Nonpareil bloom	no
Tuono	*TUONO ALMONDI;*	Self-compatible;	yes
97,14-340	*PEACH*	Self-compatible;	yes

Table 2. 2008 field data selected breeding lines used as parents for self-compatibility and kernel quality. (Bloom – days before (-) or after (+) Nonpareil; Self-set refers to average self-set (bagged) compared to adjacent set on unbagged, insect pollinated branch.

Selection	Bloom vs. Nonp.	Kernel (g)	Shell-out (%)	Doubles (%)	Twins (%)	Crease (%)	Shrivel (%)	Length (mm)	Width (mm)	Thick (mm)	Self-set (%)
UCD2-19E	5	0.95	0.62	1	1	2	1	21	11.4	8.1	6
Sweetheart	0	0.95	0.51	0	1	7	0	19.6	13.2	8.7	12
LG-05	8	1.08	0.62	8	0	8	2	21.8	11.9	9.4	59
F8,8-4	1	1.36	0.60	9	2	15	7	25.7	12.9	9	76
F8,8-161	5	1.16	0.50	14	4	4	1	25.3	12	8.3	79
F8,8-160	5	1.29	0.62	0	9	18	4	27.1	11.9	8.3	88
F8,7-180	2	1.27	0.60	0	0	11	0	29.3	12.8	7.5	11
F8,7-179	2	1.08	0.62	3	0	2	1	27	12.2	8.5	73
F7,1-1	0	0.68	0.71	0	0	9	1	17.4	10.2	8.2	98
F10C,2-4	2	1.18	0.44	15	2	12	1	25.7	13.2	7.8	4
F10C,1-16	4	1.16	0.68	3	2	6	1	26.2	11.4	8.5	7
D3-26	5	1.22	0.63	1	1	5	0	25.3	12.9	8.5	12
D,1-6	2	1.45	0.73	18	9	6	5	26.1	13.5	8.2	8
D,1-25	5	0.74	0.40	1	0	11	0	24.4	11.6	6.9	79
C,1-10	3	1.22	0.69	2	0	12	9	27.1	14.3	7.5	5
99,9-86	0	1.33	0.51	0	0	4	0	25.6	13.8	8.9	81
99,4-8	6	1.51	0.27	0	0	5	0	26.2	16.8	8.5	4
99,3-79	4	1.30	0.42	12	0	7	0	21.3	13.3	10.5	7
98,3-53	-1	1.72	0.75	0	5	4	0	29.6	15	8.7	65
98,2-305	5	1.06	0.52	0	0	6	0	24.9	13.3	7.5	4
97,3-40	-5	1.77	0.45	1	3	17	0	32.3	14.5	9.3	7
97,2-240	3	1.19	0.65	3	0	4	1	22.6	13.1	9.4	3
97,15-109	3	1.22	0.66	3	2	18	1	27.2	13	8	67
95,1-26	1	1.80	0.56	2	0	9	0	29.1	14.2	9.6	63
2004,8-160	3	1.85	0.65	0	2	20	0	30.4	15.4	8.5	96
2004,14-158	0	1.48	0.39	0	4	0	0	25.9	14.2	8.8	62
2000,8-27	3	1.07	0.51	10	2	2	6	24.1	11.7	8.4	92
2000,2-3	1	1.17	0.57	3	0	12	2	24.4	12	9.1	90

Appendix A

Cross-incompatibility grouping (CIG) of California almond varieties showing S-allele genotype. Bolded varieties indicate previously genotyped varieties. The varieties genotyped in 2006-08 are not bolded. Red indicates recent additions/updates. Blue indicates previous inconsistent designations. [Revised from 2007-08].

CIG	Almond Cultivars and Breeding Lines	S-allele Genotype
I	**Nonpareil, Tardy Nonpareil**, Grace, West Steyn, UCD F8:7-180, Galaxy, IXL, Long IXL, Riedenhoure, Golden State	S^7S^8
II	**Mission,** All in One (S7S8)	S^5S^1
III	**Thompson, Sauret #2, Mono, Wood Colony**, Durango, Le Grand, Wassum, Granada, Mono, Harvey, Robson	S^5S^7
IV	**Merced, Ne Plus Ultra, Rosetta, Price cluster**, Aldrich, Pearl, Jeanette, Sano, Ripon (S5S17)	S^1S^7
V	**Carmel, Sauret # 1, Livingston,** Tioga	S^5S^8
VI	**Monterey**, Dottie Won, Plateau, Avalon, Folsom, Blue Gum, **Butte (S1S6?)**	S^1S^8
	Ferragnes	S1S3
	Languedoc	S1S5
VIII	Fritz, Ruby, Peerless (S6S16/*S1*)	S^1S^6
	Ripon, Norman (S5S8)	S1S7
	Le Grand, Northland (S6S8), Grace (S6S8)	S1S8
X	Winters	S^1S^{14}
	UCD 36-52 (Sweetheart)	S^1S^{14x}
IX	Padre	S^1S^{18}
VII	Arbuckle	$S^5S^?$
XVIII	Carrion	S^5S^{14}
XI	Tokyo	S^6S^7
	Drake, Smith XL	S6S8
XVII	Harriet	S^6S^{14}
	Jeffries	S7AS8
XII	Milo	S^7S^{13}
XIII	Jordanolo, Harpareil,	S^7S^{14}
	Pearl,	S7S6/*S1*
	Milow (S7S19)	S7S19
XIV	Kochi	S^8S^6
	Yosemite	S8S10
XV	Solano, Sonora, Vesta, Kapareil, Eureka, Wawona	$S^8S^{13/19}$
	Jubilee, Reams (S1S3)	S8S15
XVI	Bigelow , Kutsch , Rivers Nonpareil	S8S6/*S1*
	Titan	S8S14?
	UCD 25-75	$S^8S^?$
	UCD D3-25, UCD F8:7-179,	
	UCD F8:8-160, UCD F8:7-161,	
XIX	Jeffries, UCD 3-6, Johlyn	S^8
XX	Tuono, Supernova,	S^f
	Vesta (S8S13)	S10Sx
	Marcona	S11S12
	UCD 54P455 (peach)	$S^?$

Appendix B

Cross-incompatibility summary of California almond breeding lines and putative S-allele genotype. Color identifies different putative self-incompatibility alleles and their sources where known. ORIGIN code: *A*-Prunus argentia; *E*-European source; *F*-P. germplasm; *M*-P. mira; *P*-P. persica (peach); *S*-Supernova mutation; *T*-Tuono. [Revised from 2007-08].

Selection	**Origin**	**Parentage**	**S-alleles**
91-18-174	*S*	Supernova OP	Sc Ss ?
96A,1-133	*P*	F7,2-9 (Sel5-15 slf) op	Sb S14
97,1-232	*M*	25-75 [Arb * 4-26]*[SB4, 4-2E] * WINTERS	S1 Sd?
97,3-40	*F*	D4-18 (Mis * [P.fenzliana *Alm])** 13-1	S14
98,15-109	*WA*	D2-4 SB20,1-19 (Miss*Web)*Sonora) * SB20,1-28 (Miss*Arg)*Sonora	Sd S14
99,1-121	*WP*	D4-26 (F5,4-6[{W*W}*{SolSel, 5-15*24-6}])*LG	Sb S8
99,3-189	*M*	F56-22 * 25-75	Sd?
D3-25	*WP*	NP * F5,4-11 [W*W][SEL5-15SLF])	Sb S8
95,1-26	*H*	D5-4 (USDA CP33) * 13-1	S1 S14
F7,1-1	*P*	(Sel5-15[NP*LukensHoneyXMis]*WSB3b25)	Sb S8
F8,7-179	*WP*	D3-15 (NP*F5,4-43[W*W][SEL5-15SLF])) * D3-25	Sb S8
F8,7-180	*WP*	D3-15 (NP*F5,4-43[W*W][SEL5-15SLF])) * D3-25	S7 S8
F8,8-160	*FM*	D4-18 (Mis * [P.fenzliana *Alm])* Sonora * 25-75	S6 Sd
F8,8-4	*WP*	D3-15 (NP*F5,4-43[W*W][SEL5-15SLF])) * D3-25	Sb S8
F8-8-161	*FM*	D4-18 (Mis * [P.fenzliana *Alm])* Sonora * 25-75	Sd S13
2000,11-190	*S*	F7,1-1 * 91,18-174 (Sopernova OP)	Sb? Ss ?
2000,1-180	*WP*	D3-15 (NP*F5,4-43[W*W][SEL5-15SLF])) * D3-25	Sb S8
2000,13-162	*WP*	F7,1-1 * F8,7-179	Sb
2000,16-81	*WP*	F7,1-12 * 91,18-174	Ss ?
2000,2-3	*WP*	D3-15 * D3-25	Sb
99,4-97	*WP*	USDA CP33 * D3-25	Sb
99,9-86	*WP*	Mission * D3-25(NP*F5,4-11[W*W][SEL5-15SLF])	Sb
2000,3-385	*FM*	D4-18 (Mis * [P.fenzliana *Alm])* Sonora * 25-75	Sd?
99,4-8	*P*	Ferragnes * LGOP	Sb?
2000,8-27	*WP*	NP *F8,7-179	Sb S7
2002,1-271	*T*	F10 D, 3-11 * Tuono1-1	S1 S8
2002,8-119	*T*	Mission * Tuono1-1	Sf?
2004,14-158	*FP*	99,4-8 (Ferragnes * LGOP) * 97,3-40	Sb?
2004,14-31	*W*	99,4-1 (Ferragnes * LGOP) * 97,2-240 (Ferragnes * D3-6)	Sb?
Ferragnes	*E*		S1 S3
LEGRAND	*P*		Sb S8
LGOP	*P*	LeGrand OP	Sb S8?
Sweetheart	*P*	F7,1-1 (Sel5-15=[NP*LukensHoneyXMis]*WSB3b25) * USDA 25-26{SF?Harriot?}	S1 S14
UCD25-75	*M*	[Arb * 4-26]*[SB4, 4-2E]	SiSd
WINTERS	*H*		S1 S14
Tuono	*T*		S1 Sf
97,14-340	*P*	Sonora * LGOP	Sb S8

Appendix C

Advanced UCD Self-compatible Almond Selections in Regional Grower Evaluations

These breeding selections represent a very wide genetic variability due to their often interspecific origins. In addition to self-compatibility, novel genetic options for disease and insect resistance have been incorporated in this material. By establishing evaluation plots for these selections in different areas of the Sacramento and San Joaquin valleys, we hope to more thoroughly evaluate the value for further resistance breeding, as well as their potential and deficiencies as possible cultivar releases.

UCD2-19E. Lineage: Tardy Nonpareil X Arbuckle. This selection is one of the highest producing varieties at the Kern RVT plot with an accumulated (1996-2005) yield of 26,112 pounds per acre following an exceptionally high crop of 4890 pounds per acre in 2003 and continues to be among the highest producers through 2008 in Kern Co. plots. UCD2-19E shows a strong alternate bearing habit where years of high crop yield are followed by low crops. It is believed that on years of very high crop, insufficient nutrients are available to the overloaded fruiting spurs to initiate the number of flowers needed to maintain the crop, and in some cases to maintain the very viability of the spur into the next season. An alternate bearing habit is undesirable for California production, and usually breeding selections showing this behavior would be discarded. However, many Kern County growers have been successful in maximizing year-to-year production in other strongly alternate bearing varieties such as Price, by closely monitoring current season crop yield and providing increases in both irrigation water and fertilizer nutrients as needed. In addition to its very high crop, 2-19E shows good kernel quality, a late bloom ~7d after Nonpareil, and resistance to flower blight. Low disease observed in all plots to 2008.

LG-O5. Lineage: LeGrand-Open-Pollinated. Kernels have a good quality, Padre-type shape though are somewhat larger. Shells are soft, moderate in thickness with good seals. Kernels show moderate levels of doubles (~8%) and creasing. The tree is more compact, like Carmel, but allowing good productivity because of a shorter internode distance between leaves and spurs. Most production in the mature trees is on spurs which are well distributed throughout the canopy. The level of self-compatibility appears consistent unlike the LeGrand parent. Trees have shown good productivity both at the Winters and southern San Joaquin evaluation plots. Bud-failure has been observed in progeny of LG-05 indicating an incr5eased BF-potential of the parent; trees show low disease levels. Bloom starts ~8 d after Nonpareil.

C,1-10. Lineage: Wood Colony X Fritz. The result of a cross between two traditional, commercial varieties, this selection combines a Nonpareil-type kernel and paper shell with a later flowering and later maturing tree. In regional trials, tree productivity has so far been unexceptional. This selection also seems more susceptible to foliar diseases than other advanced selections moderate hull rot and internal dead wood. Its similarity to Nonpareil, however, would make this a very useful variety if it performs well in regional trials. In Moderate levels of kernel crease (~12%) and an overly spreading tree architecture may also be problematic with the selection.

C,1-16. Lineage: F10D,3-67 = Nonpareil X D3-19 {(Mission X P.fenzliana) X Solano}. This selection is derived from a cross to P. fenzliana with the goal of transferring improved disease resistance and cropping architecture. Tree is productive in both Sacramento and San Joaquin Valley test plots and consistently yields uniform and good-quality Price-like kernels. Some blind wood observed in 2008 due possibly to hull rot. Shells are paper and relatively well sealed. Tree is upright to spreading and it appears to have improved levels of disease resistance. Bloom starts ~4 d after Nonpareil.

C,2-4. Nonpareil-BF X Monterrey. [Tested as selection F10D, 5-39 in some locations]. This selection resulted from a cross between a high bud-failure Nonpareil selection and a variety Monterey (to evaluate latent bud failure potential in the variety Monterey). Kernels show good-quality, and being intermediate to Carmel and Sonora in shape and size. Shells are paper in texture and moderately well sealed. Upright, heavily branched trees with low flower blight. Experience has shown that crosses to high bud-failure sources have in approximately 50% probability of inheriting the predisposition to noninfectious bud-failure. Bloom starts ~2 d after Nonpareil.

D,1-25. Lineage: (Mission X P.webbii) X Sonora. Kernels being relatively long, wide and flat and thus well tailored for the sugar coating or panning market. In addition, kernels possess a unique and desirable amaretto flavor. The combination of kernel shape and kernel flavor quality has made it of interest to specialty markets processors. There is some evidence bark cracking and in some cases bark deterioration (a occasional consequence from wide crosses). The selection is being released for regional testing for growers and processors interested in this particular niche market. It is not self-compatible and has not been noted as having promising disease resistance. It produces a more spreading tree approx. 30% smaller than Nonpareil. The tree blooms approximately 6 d after Nonpareil and harvests approx. 18 d after Nonpareil. Average kernel length/width/thickness is 2.3/1.2/0.8 cm. Ave. kernel weight is 0.9 g; kernel/kernel + shell crackout is 0.0.44. Shells are attractive and well-sealed.

D,1-6. Lineage: 90,14-124= (Jeffries X Nonpareil). D,1-6 was selected for its very good Nonpareil-type kernel and thin paper shell conferring a high crack out with an improved barrier to insect pests. Shell seal is good at 96%. Trees appear only moderately productive in regional trials though with no evidence of reduced vigor or increased susceptibility to disease as is often associated with selfed or inbred genotypes. Double kernels kernels have been observed at high (18%) proportions. Other deficiencies to be watched for in this selection may be an increase susceptibility to stem canker which is frequently seen in this lineage. (Sample Nonpareil (left) and Carmel (right) kernels shown inside grey circle).

D3-25. Lineage: Nonpareil X F5,4-11 {P.webbii *(SEL5-15Selfed)). This relatively early breeding selection combines genes from P. mira (a wild peach), P. webbii (a wild almond) and P. dulcis (cultivated almond). The selection combines Nonpareil-type kernel quality with semi-upright tree architecture and good levels of self-compatibility. Both tree productivity and bearing wood renewal have declined with age and older trees tend to become more bushy & weepy. This selection is also associated with greater susceptibility to flower blight and possibly Bud-failure (BF). Crops in regional trials have been moderate. Shell seal is poor at ~8%.

D3-26. Lineage: F5,4-6 {P.webbii X P.webbii} X Solano. [Labeled as F10D, 3 -216 in some plots]. Tree is large with upright-spreading branches and moderately productive. Nuts are ovate, similar to Peerless, and like Peerless have a semihard shell resulting in good resistance to insect damage but moderate crack out ratios. Some evidence for alternate bearing has been observed in the parent trees, but trees in initial regional trials continued to show good growth and productivity. In addition to alternate bearing, the selection is being watched for consistency of bearing wood regeneration and susceptibility to peach twig borer damage and Noninfectious Bud-failure.

F8,7-179. Lineage: D3-15 (Nonpareil X F5,4-43 {P.webbii X P.webbii}{SEL5-15Selfed})) X D3-25 [(Nonpareil X F5,4-11{P.webbii X P.webbii}{SEL5-15Selfed})]. Combining multiple and distinct sources of self-compatibility (from both peach and P. webbii), this selection has shown consistently good levels of self compatibility even in seasons were spring storms have suppressed flower development. Improved levels of both foliar (including Alternaria leafspot) and blossom diseases have also been observed though moderate susceptibility to hull rot has also been observed. Kernels show good Carmel-like quality and are of uniform size and shape with some doubles. The shells are paper, though only 50% sealed. Early productivity in regional trials has been moderate to high. Regional trials are being watched closely for disease susceptibility and bearing wood renewal. Bloom starts ~3 d after Nonpareil.

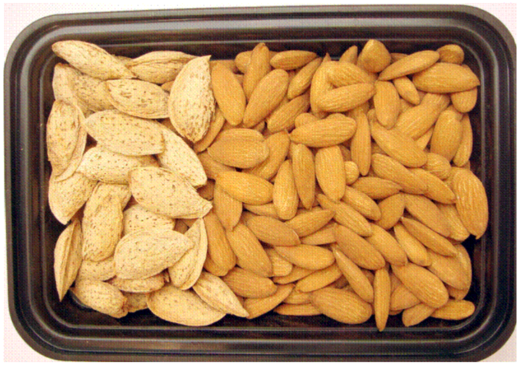
F7,1-1. Lineage: (Sel5-15{Nonpareil X LukensHoney X Mission} X WSB3b25). Breeding selection Sel5-15, has proven to be one of our most effective sources for both self-compatibility and improved disease resistance and has been derived from peach and more exotic almond germplasm. F7,1-1 combines a high levels of self-compatibility with high tree productivity and good disease resistance. The Butte-type kernel is a medium to small in size, and uniform in its good appearance and freedom from defects. It has a paper shell with 74% seal. This selection has been a consistent and dependable performer in terms of both self-compatibility, foliar disease resistance and tree productivity. The small kernel size is its most apparent handicap, though its consistent productivity and disease resistance may lead to commercial profitability. Tree has an

upright to upright -spreading tree which can be similar to 10% larger than Nonpareil. Bloom occurs 7 to 10 d after Nonpareil. Flower densities and levels of self compatibility are high, resulting in a high yield potential. Harvest occurs approximately 28 days after Nonpareil. Nuts are small and teardrop-shaped which appear desirable to the confectionery industry. Average kernel length/width/thickness is 1.8/1.1/0.8 cm. Ave. kernel weight is 0.8 g; kernel/kernel + shell crackout is 0.68 F7,1-1 has been one of the most resistant selections in Dr. Adaskaveg's UCD almond disease evaluation block with demonstrated resistance to bacterial blast and Monilinia flower blight.

F8,8-160. Lineage: D4-18 [(Mission X {P.fenzliana X Alm}) X Sonora] x 25-75. This and the following selection have incorporated genes from the wild almond species *P. fenzliana* into a cultivated almond background. F8,8-160 was selected for its consistent level of self-compatibility and its high-quality Carmel-type kernel. Shells are paper, and poorly (70%) sealed. Trees have shown good productivity both at the Winters, California and southern San Joaquin evaluation plots. Kernels are uniformly elliptical and relatively thick resulting in good kernel weights and so improved yield potential. In regional test plantings, trees are upright-spreading to bushy with moderate to good crop distribution primarily on spur bearing wood resulting in a tree size similar to Plateau or Carmel. Bloom occurs approximately 6 d after Nonpareil and can be profuse. Harvest occurs approximately 6 weeks after Nonpareil. Average kernel length/width/thickness is 2.2/1.2/0.9 cm. Ave. kernel weight is 1.0 g; kernel/kernel + shell crackout is 0.57.

F8,8-161. Lineage: D4-18 [(Mission X {P.fenzliana X Alm}) X Sonora] x 2575. Like F8,8-160, F8,8-161 was selected for its consistent level of self-compatibility and its high-quality Carmel-type kernel. Shells are comparable to, to slightly thicker than Carmel, having good (98%) seals. Trees have shown good productivity both at the Winters, California and southern San Joaquin evaluation plots. Trees are upright-spreading with an open architecture and good crop distribution, primarily on spur bearing wood. Doubled nuts (two nuts developing on a unique T-shape spur) are often observed and may contribute to the higher yield potential this selection. Pollen is fully cross compatible with Nonpareil and most major commercial almond varieties. Tree is upright and similar in size and vigor to Fritz. Bloom occurs approximately 10 d after Nonpareil and is also profuse. Harvest occurs approximately 28 d after Nonpareil. Shells are medium and thickness and are moderately well sealed. Kernels are medium in size

and of good quality. Average kernel length/width/thickness is 2.3/1.2/0.8 cm. Ave. kernel weight is 1.2 g; kernel/kernel + shell crackout is 0.63. Doubles (~14%) may be a problem and Monilinia flower blight has been observed in San Joaquin valley plantings.



F8,7-180. Lineage: D3-15 (Nonpareil X F5,4-43{P.webbii X P.webbii}{SEL5-15Selfed})) X D3-25 [(Nonpareil X F5,4-11{P.webbii X P.webbii}{SEL5-15Selfed})]. Although a sister line to F8,7-179, the selection is self-incompatible, having inherited none of the self-compatibility factors from the parents. Kernels are of good quality being similar to Nonpareil though larger. Shells are thin, paper consistency and only moderately well sealed. This selection has shown only moderate productivity at Winters, and southern San Joaquin test sites. Trees show problems in bearing wood renewal leading, eventually to lower yields. Trees flower just after Nonpareil and pollen is fully cross compatible with Nonpareil and Carmel. Flower blight observed in older trees.

F8,8-4. Lineage: D3-15 (Nonpareil X F5,4-43{P.webbii X P.webbii}{SEL5-15Selfed})) X D3-25(Nonpareil X F5,4-11{P.webbii X P.webbii}{SEL5-15Selfed}). This complex interspecies cross, combines genes from P. mira (a wild peach), P. webbii (a wild almond) and P. dulcis (cultivated almond). Kernels are of good quality, ovate in shape, and with good thickness resulting in good individual kernel mass. Shells have a medium thickness and are generally well sealed but but can show moderate (~60%) seal with heavy crops. Doubled-nuts have been observed in this selection but at relatively low numbers. Nuts are borne primarily in spurs but also at current shoot terminals, particularly in younger trees. Kernel quality problems, particularly double kernels, need to be watched with this selection. The tree is upright and approx. 10-20% smaller than Nonpareil. Flowering occurs 1-2 d after Nonpareil. Flowering has been profuse (high flower density) making it a good pollenizer for the later Nonpareil bloom. Harvest occurs approx. 30 d after Nonpareil. Average kernel length/width/thickness is 2.1/1.2/1.0 cm. Ave. kernel weight is 1.1 g; kernel/kernel + shell crackout is 0.55. Kernels have good size, shape and texture

97,1-227. Lineage: 25-75 [{Arbuckle X 4-26} X {SB4, 4-2E}] X Winters. The seed parent 25-75 is highly self-fertile (derived from the peach species Prunus mira) and productive but suffers from poor tree structure. The Winters parent contributes a more upright-spreading tree structure as well as an improved kernel size and quality. Kernels are large and uniform with a desirable Nonpareil-type elliptical shape. Shells have a medium thickness and are well sealed with good resistance to NOW and and damage. Self-compatibility in this election is rated as good, meaning that 50% or more of viable flowers will set seed when selfed under artificial (mesh bag limbs, limited controlled pollinations, etc.) conditions. The tree is upright to spreading and productive. Blooms approx. 5 d after Nonpareil and harvest approx. 21 d after Nonpareil. Average kernel length/width/thickness is 2.6/1.5/0.8 cm. Ave. kernel weight is 1.5 g; kernel/kernel + shell crackout is 0.42. Shells are easily cracked yet have good seals

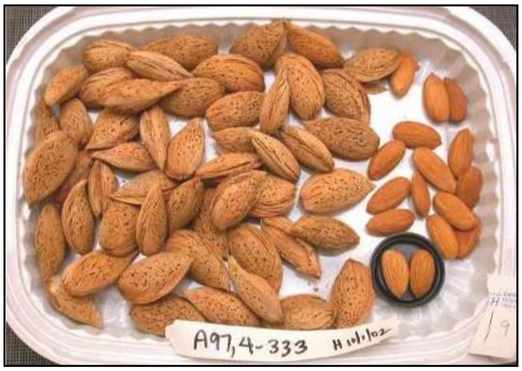
97,1-232. Lineage: 25-75 [{Arbuckle X 4-26} X {SB4, 4-2E}] X Winters. A sister line to 97, 1-227, resulting in good levels of self-compatibility and tree productivity. Nuts are large and ovate, being similar to Monterrey. Kernel shells are thinner than 97, 1-227 resulting in greater crack out but greater susceptibility to insect damage. The tree is productive and more spreading the 97, 1-227. Flower self-compatibility is rated as good, being slightly better than its sister line when compared over several years. Potential deficiencies include a possible predisposition to shriveled kernels and kernel gumming and a tree architecture that may develop to be overly spreading. The tree is approx. 20% smaller Nonpareil. The tree blooms approximately 5 d after Nonpareil and harvests approx. 21 d after Nonpareil. Average kernel length/width/thickness is 2.3/1.4/0.8 cm. Ave. kernel weight is 1.2 g; kernel/kernel + shell crackout is 0.40.

97,2-240. Lineage: D3-4 {(Mission X P.webbii) X (Mission X P.webbii)} X Ferragnes. The seed parent is a backcross from the cross between Mission and P. webbii, a wild bushy almond species with small but well sealed nuts. The French variety *Ferragnes* was used as the pollen parent to increase kernel size and quality and contribute a more upright architecture to the tree. Kernels are Carmel-type in size and appearance with few doubles. [For reference, a Nonpareil kernel (left) and Carmel kernel (right) are placed within a black disk within the sample tray]. The kernel shell has been reduced to a very thin but very durable inner shell resulting in crack outs exceeding 70%, combined with

very high shell seals and so low vulnerability to insect damage and aflatoxin contamination. Trees are medium in height and productive, though the spreading architecture results in a higher incidence of early limb splitting and possible tree loss if early orchard trees are not managed properly. Hull rot with shoot die-back is also common in southern sites. The possible excessive spreading nature of this tree remains its most serious potential deficiency. Flowers are self-incompatible but our cross-compatible with all major California cultivars. (Sample Nonpareil (left) and Carmel (right) kernels shown inside grey circle).

97,3-40. Lineage: D4-18 [(Mission X {P.fenzliana X Alm})] X Winters. The seed parent is a backcross of Mission and the wild almond species *P. fenzliana. P. fenzliana* was selected to bring in early flowering, good shell seal, a more upright tree productivity, and disease resistance. Winters was selected as the pollen parent to contribute better kernel quality and to maximize tree productivity through its tendency to produce consistently productive lateral branching. This selection exhibits very large Sonora-type kernels in a Peerless-type well-sealed shell. Twin kernels (2 embryos within the same seed-coat) have been observed but do not apper to be a problem. Flowering time is very early, occurring with Sonora or before. Despite its early flowering, the selection has been very productive in our southern San Joaquin test site. Flowers are self-incompatible but compatible with all commercial California almonds because of its unique S-allele genotype. The large, high-quality kernel combined with its attractive, durable shell make this selection a possible replacement for Peerless. Potential deficiencies include its very early flowering and possible susceptibility to leafspot.

97,4-333. Lineage: Nonpareil X F7,1-1 [(Sel5-15={Nonpareil X LukensHoney X Mission} X WSB3b25) X 25-26. The seed parent is Nonpareil crossed with the very productive, self-compatible and disease resistant selection F7,1-1. The self-compatibility from the pollen parent is derived from peach but was not transferred to this selection, which is self-incompatible. The kernel possesses good quality and is Carmel-like in appearance but typically not as as thick. Nuts have a paper shell which is only moderately sealed. Tree productivity appears mediocre with moderate foliage and excessive internal shoot die-back. Medium yields and the relative flatness of the kernels remain potential deficiencies of concern. (Sample Nonpareil (left) and Carmel (right) kernels shown inside grey circle).



98,11-77. Lineage: Nonpareil (F5,3-12) X 90,13-59 (Jeffries X Nonpareil). This selection was chosen for its high-quality Nonpareil-type kernels combined with a good sealed shell and disease resistance. The semi-hard shell confers greater insect resistance but results in lower crack out ratios. Potential concerns with this selection include possible deterioration in tree architecture due to its large, bushy shape and reduced yields as trees age. (Sample Nonpareil (left) and Carmel (right) kernels shown inside grey circle).

98,14-340. Lineage: Sonora X LeGrand-OP. LeGrand-OP is a selection from crossing the partially self-compatible variety LeGrand with Sonora. Flower self-compatibility is rated as good. Kernels are medium large and somewhat resemble the Sonora parent though slightly shorter. Shriveled and creased kernels were apparent in initial harvests but these were from essentially dry land farmed trees with better kernel quality observed in irrigated orchards. Kernel eating quality is very good. Trees are upright-spreading and productive. Trees tend to be more compact with dense, somewhat willowy dense-foliage though low disease.

98,15-109. Lineage: D2-4 SB20,1-19 (Missions X P.webbii) X Sonora) X D3-3 SB20,1-28 (Missions X P.argentia) X Sonora. The result of a complex interspecies cross involving cultivated almond (P. dulcis), and the wild almond species P. webbii and P. argentia, this selection combines good levels of self-compatibility, and a more spreading tree architecture. Erratic (cross-over) branching have been observed, however, with some, mainly internal, branch die-back, possibly from flower blight. Kernels are medium quality, with slightly beaked kernels and shells. Some kernel creasing and doubling were apparent in Winters, California seedling blocks, though this could have been the consequence of the near dry land farming methods used for this and related selections. Kernel quality remains a concern in ongoing evaluations as is the possibility that the tree habit may be overly spreading.

98,2-305. Lineage: Nonpareil X F7,3-11/D3-3 (SB13,28-21 X P.webbii hybrid). The result of a cross between Nonpareil and F7, 3-11, a self-compatible and aflatoxin resistant selection. Tree is large, upright and appears to be only moderately productive. Both shell and kernel are of medium quality as they are somewhat flat and elongated. Kernels consistently express the distinct and desirable amaretto flavor which combined with their elongated and relatively flat structure may make this a useful variety for panning or sugar coating. Potential deficiencies being examined in regional testing include inconsistency of amaretto flavor, kernel shape, and productivity and susceptibility to hull rot.

98,3-53. Lineage: D3-11 (=F8S,53-60) X F7,1-1 [(Sel5-15{Nonpareil X LukensHoney X Mission} X WSB3b25)]. The seed parent, D3-11, was selected for its very good kernel quality, potential disease resistance and tree productivity. Tree architecture, however, was excessively spreading, and in particular, the terminals and laterals bearing the crop were too weepy or feathery for consistent mechanical harvest. The pollen parent, F7, 1-1, was selected for its high disease resistance, high productivity, and good spur production. Hull rot is common however in this selection. Kernels tend to be small and Ruby-like though with occasional blank nuts. The resultant selection has combined the better attributes of both parents with good-quality Sonora-type kernels within an upright and productive tree. Very thin shells confer high crack out ratios but the poor seal (8%) result in increased vulnerability to insect damage.

99,1-121. Lineage: D3-26 (F5,4-6{{P.webbii X P.webbii} X {SolSel, 5-15 X 24-6}}) X LeGrand. A cross between D3-26 with its good tree, kernel and shelf characteristics (described previously) and the variety LeGrand to incorporate improved bearing habit and self-compatibility. The tree is upright and productive. Flowers show good levels of self compatibility and kernels show consistent high-quality. Kernels and shells are somewhat similar to Monterey in appearance with a slight but distinct beaking. The tree is very upright, and approx. 20% smaller than Nonpareil. Bloom occurs approximately 6 d after Nonpareil, while harvest occurs approx. 28d after Nonpareil. Kernels show good-quality but double-kernels may be a problem. Average kernel length/width/thickness is 2.4/1.4/0.9 cm. Ave. kernel weight is 1.3g; kernel/kernel

+ shell crackout is 0.30. The shell is similar to the variety Mission, having a very good shell-seal and so low worm damage. Bud-failure has been observed in 2008 on siblings of this cross and so a higher potential for it eventually showing bud-failure need to be considered.

99,4-8. Lineage: Ferragnes X LeGrand-OP (LGOP). (Sometimes listed in regional trials as 99,4-2). Combining the upright tree architecture and large kernel size of Ferragnes with the productivity and self-compatibility of LGOP, this selection has proven only partially self-compatible (i.e. between 25 to 50% of all viable flowers artificially selfed pollinated will set seed). Kernels are of good quality, being somewhat similar to Solano. Shells are hard, with a very good seal and insect resistance but moderate crack out ratios. The tree is upright-spreading and productive. The shell is durable, attractive, and bleachable. Because of its high productivity, and high-quality kernel and shell, the selection is being considered as replacement for the Peerless variety. Blooms approx. 1 week after Nonpareil.

1999,3-189. Lineage: D5-24 (SB20,1-5 (Mission x Hybrid-A[fenz]) x Sonora)* UCD25-75.
Tree is vigorous and upright spreading. Bloom occurs approximately 3 days after Nonpareil with harvest approximately 1 week after Nonpareil. Flowers are fully self-compatible and productive. Kernels are well sealed but showing a tendency to double. Production has been moderate to high at all locations.

1999,3-79. Lineage: Mission * D,3-6 (F5,4-10 {SB16, 2-44[Prwebbii*Prwebbii]*SB6, 56-88[SolSel, 5-15*Slf]) *Solano). Tree is upright-spreading and moderately productive. Bloom occurs approximately 4 days after Nonpareil. Flowers are self-incompatible. Kernels are uniform with moderate to good quality and moderate to good shell seal. Produced some double kernels (~12%) t in 2008. Shell is thick and well-sealed with only 42% Kernel/nut crack-out.

1999,4-97. Lineage: CP,5-33 * D3-25.
Tree is upright and productive. Nuts are uniform and of good quality. Bloom occurs with Nonpareil and harvest is approximately 2 weeks after Nonpareil. Flowers are fully self-compatible with production primarily on spurs. Shells are thin but withmoderate to good seal. Appears to have some resistance to flower blight.

1999,9-86. Lineage: Mission * D3-25 [(Nonpareil X F5,4-11{P.webbii X P.webbii}[{SEL5-15Selfed})]. Tree is upright-spreading and productive but with some tendency to alternate bear. Bloom occurs approximately with Nonpareil with harvest approximately 3 weeks after Nonpareil. Kernels are of very high quality and uniform with a slightly darker pellicle color. Flowers are self-compatible.

2000,11-190. Lineage: F1-1 * 91,18-174 (Supernova op). Tree is upright to upright-spreading and productive. Bloom occurs approximately 5 days before Nonpareil with harvest occurring approximately with Nonpareil. Flowers are fully self-compatible. Kernels are uniform with moderate to good quality and moderate to good shell seal. May produce some double kernels and some scab was evident in 2008.

2000,13-162. Lineage: F7,1-1 * F7,7-179. Tree is more compact, similar to Carmel, but somewhat more spreading. Blooms approximately 10 days after Nonpareil and harvest approximately 1 week after Nonpareil. Flowers are fully self-compatible. Kernels are elongated, being somewhat similar to Sonora and of good eating quality. Some double kernels are produced with some shot -hole evident in 2008.

2000,16-81. F7,1-12 * 91,18-174 (Supernova op). Trees are upright and productive producing well sealed kernels. Kernel size is moderately large occasionally showing shriveling. Bloom is approximately with Nonpareil and harvest is approximately 2 weeks after Nonpareil. Flowers are fully self-compatible and appear more resistant to flower blight. Some shot-hole was observed in 2008.

2000,3-385. Lineage: D3-18 * UCD25-75.
tree is a bright-spreading to spreading and very productive though prone to alternate bearing if under fertilized. Bloom is approximately 7d after Nonpareil. Flowers are fully self compatible and self-fruitful. Production is on high density spurs which can produce very high crops but a tendency to alternate bear. Kernels are Sonora-like in shape the somewhat smaller. Nuts are well sealed and of high quality.

2002,1-271. Lineage: D3-11 * Touno1-1. Tree is upright-spreading with a more open architecture. Flowers are fully self-compatible. Kernels are large and have a tendency to crease. Bloom occurs approximately 5 days after Nonpareil with harvest occurring approximately 2 weeks after Nonpareil. Flowers appear more resistant to flower blight. Nuts are well sealed with high crack out ratios.

2002,8-119. Lineage: Mission * Tuono1-1.
Tree is upright to upright-spreading. Bloom occurs approximately 1 week after Nonpareil with harvest approximately with Nonpareil. Flowers are fully self-compatible. Kernels are large and broad a similar to Sweetheart and Marcona with well sealed shells but moderate crack out ratios. Some kernel creasing has been observed at levels similar to Marcona. Leaves appear more resistant to leaf-blight in 2008.

2000,2-3. Lineage: D3-15 (Nonpareil X F5,4-43{P.webbii X P.webbii}{SEL5-15Selfed})) X D3-25 [(Nonpareil X F5,4-11{P.webbii X P.webbii}[{SEL5-15Selfed})]. A relatively recent selection, 2000,2-3 represents an advancement of the previously described D3-25 selection by incorporating improved tree structure disease resistance and productivity. Self-compatibility and a Nonpareil-type kernel were derived from the D3-25 parent. The D3-15 parent contributed a more upright-spreading tree structure, a more uniform, spur based productivity, and a more durable and well-sealed shell. Tree structure is upright to upright-spreading with a very high productivity resulting from a uniform and high nut distribution. The original tree also shows evidence of improved foliar disease resistance**.** The tree is semi-upright with radial branching. Anticipated size will be 10% narrower than Nonpareil but similar height. Expected bloom is approximately 6 d after Nonpareil with harvest approx. 21d after Nonpareil. Kernel quality is good.. Average kernel length/width/thickness is 2.4/1.2/0.9 cm. Ave. kernel weight is 1.2 g; kernel/kernel + shell crackout is 0.55. Shell-seal is moderate with approximately 70% of the nuts showing complete seals. This selection resulted from a complex series of crosses involving *Prunus persica* (peach) and *Prunus webbii* in its lineage. Preliminary evidence of BF observed in 2008 in 10 year old trees.

2000,8-27. Lineage: Nonpareil X F8,7-179. As with selection 2000,2-3, (above), this selection represents the next breeding generation derived from selection F8,7-179 (described below). The backcross to Nonpareil has resulted in an improved Nonpareil-type kernel quality and improved shell seal. High levels of self-compatibility have also been recovered as have good tree architecture and uniform crop distribution, primarily on spur bearing wood. The tree also exhibits improved levels of foliar disease resistance when compared to both parents. Kernel uniformity is very high with low levels of doubled or damaged kernels. The tree is upright-spreading and approx. 20% smaller than Nonpareil. The bearing-habit is similar in terms of the ratio of spur to shoot flower buds. The selection blooms approximately 4 d after Nonpareil and harvest approx. 18 d after Nonpareil. Average kernel length/width/thickness is 2.2/1.2/0.9 cm. Ave. kernel weight is 1.2 g; kernel/kernel + shell crackout is 0.64. The paper shells give good crack out but have poor seals (60%) though the worm infestation has not been a problem to date. Kernels show good-quality though double kernels (~10%) may be a problem.

2004,14-158. Lineage: 99,4-8 (Ferragnes * LGOP) * 97, 3-40 (P. webbii * Winters). Tree his upright-spreading to spreading. Bloom occurs approximately 2 days before Nonpareil. Harvest is approximately 3 weeks after Nonpareil. Flowers are self-compatible but not consistently so. Kernels are large and of uniform, with good quality and with moderately thin but well sealed shells. Branches are very productive leading to some breakage of seedling trees.

UC95,1-26. Lineage: USDA Selection CP33 * Winters. Tree is upright-spreading and productive with large, attractive nuts. Shell-seal is good as is the shell integrity. Tree shows high levels of self-compatibility in some years, but is more erratic in others. Flowering time is late, approx 10 d after Nonpareil. No disease problems observed to 2008.

2004,8-160. Lineage: NP * 97,1-232[25-75 [Arb * 4-26]*[SB4, 4-2E] * Winters /97,3-40[D4-18 (Mis * [P.fenzliana *Alm])** Winters]. Tree is upright-spreading to spreading. Production of large attractive nuts on high density spurs resulting in consistently high production. Good shell seal and kernel quality though some kernel creasing is common due to the larger size.Tree is highly self-compatible and appears self-fruitful (self-pollinating). Flowers approx. 6 d after Nonpareil.

2004,8-201. Lineage: NP * 97,1-232[25-75 [Arb * 4-26]*[SB4, 4-2E] * Winters /97,3-40[D4-18 (Mis * [P.fenzliana *Alm])** Winters]. [Sister line to 2004,8-160]. Tree is upright and productive. Bloom time is approx. 9 d after Nonpareil. . Nuts are of good quality and well-sealed. Kernels are large and somewhat flat. Branches show high density of spur production and show no disease despite the consistently high crops. No kernel defects observed to 2008.