# Almond Variety Development: 2016

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**Field crosses using mesh bags to exclude bees an so control crossing parents,**

## Introduction

Commercial almond production in California is dependent almost entirely on the variety *Nonpareil* and a relatively few closely-related pollenizers, most of which have *Nonpareil* and *Mission* as direct parents. A long-term emphasis of the UCD almond breeding program has been the identification and incorporation of new and diverse germplasm. Genetic solutions to emerging production challenges are now becoming available from this improved germplasm, including regionally-adapted selections expressing high productivity, self-fruitfulness, and increased insect, disease and environmental stress resistance. Improved breeding lines also offer opportunities to expand market demand by optimizing phytonutrients in new cultivars, such as the high heart-friendly oleic acid content in the recently released Sweetheart variety, while minimizing potential health and marketing risks including aflatoxins, allergens and salmonella.

A concurrent goal of this genetic improvement program is to develop California adapted germplasm possessing a broad range of genetic solutions to both immediate challenges as well as unanticipated future challenges such as resistance to new pests/diseases and compatibility with new cropping systems, and to make this germplasm generally available to both public and private California breeders. Tree crop improvement is particularly challenging because of the extensive requirements of land and time; thus high breeding efficiency is essential. Breeding efficiency has been achieved through the development of effective strategies for tree and data management to allow the large population sizes and rapid population cycling required for breeding progress. Breeding crosses in 2016 have resulted in over 16,000 seed, with approximately 10,000 seed targeted for field planting after initial greenhouse culling. Molecular marker methods are being utilized to improve our understanding of individual gene as well as larger-scale chromosome or haplotype inheritance. Ten UCD selections have been advanced to the Regional Variety Trials following extensive initial grower testing. An additional 22 UCD selections are currently being propagated for new grower testing in the different almond production areas. The variety *Kester* has been released providing the industry with a high quality, productive and late-flowering pollenizer producing pollen that is fully cross compatible with *Nonpareil* as well as all other major California cultivars.

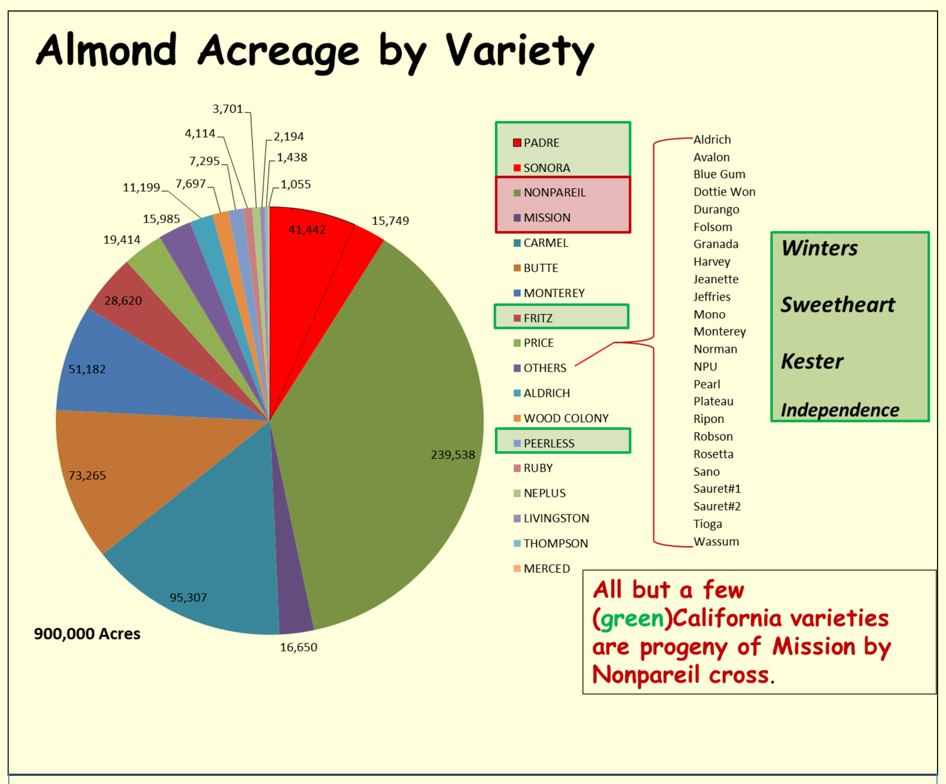



**Fig. 1.** The high genetic uniformity of current varieties results in higher vulnerabilities to pests/diseases and changing growing conditions.

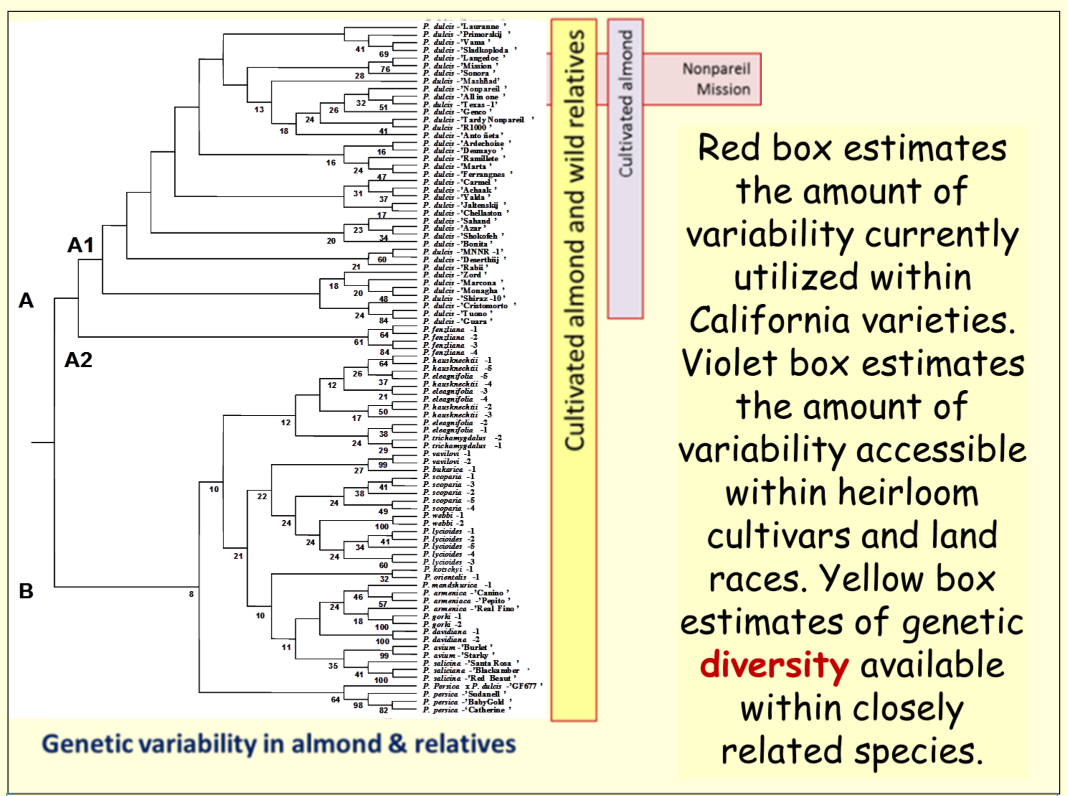



**Fig. 2.** Additional genetic diversity (and so possibility of new traits) available in Mediterranean and Asian varieties as well as related species.

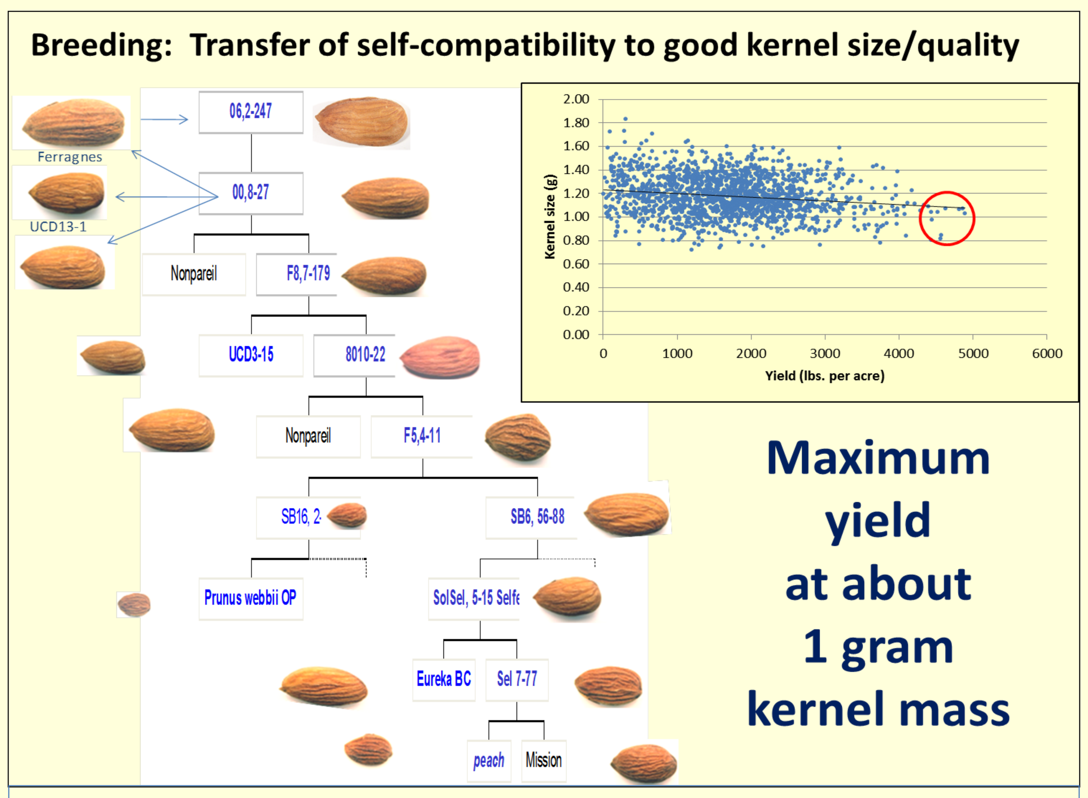



**Fig. 3.** The transfer of new traits such as self-cpmpatibility requires successive backcrosses to cultivated almond to recombine desired trait with good kernel size and kernel/tree quality. [Kennel mass target is ~1g/kernel to maximize yield].

| | 2015 | 2016 |
|---|---|---|
| Total crosses | ~30,000 | ~20,000 |
| Recovered seed | ~12,000 | ~2000++ |
| Transplanted seedlings | 1327 | |
| Greenhouse seedlings | 3568 | |
| Seed in stratification | ~3000 | |
| Seed in storage | ~3000 | |

**Table1.** Summary of breeding crosses and seed/seedling development from 2015 and 2016.

| Seed Parent | Kester Pollen | Self Pollen | S-genotype |
|---|---|---|---|
| Fritz | +++++ | - | S1S6 |
| Carmel | +++++ | - | S5S8 |
| Mission | +++++ | - | S1S5 |
| Butte | +++++ | - | S1S8 |
| Padre | +++++ | - | S1S18 |
| Price | +++++ | - | S1S7 |
| Thompson | +++++ | - | S5S7 |
| Sonora | +++++ | - | S8S13** |
| Monterey | +++++ | - | S1S8 |
| Winters | +++++ | - | S1S14 |
| Nonpareil* | +++++ | - | S7S8 |
| Kester | - | | S8S23** |

*-reciprocal cross also positive
** S-genotype not yet verified

**Table 2.** Cross-compatibility of the new UCD variety *Kester* with other commercial almond varieties representing major cross-incompatibility groups, based on 2016 test-crosses.

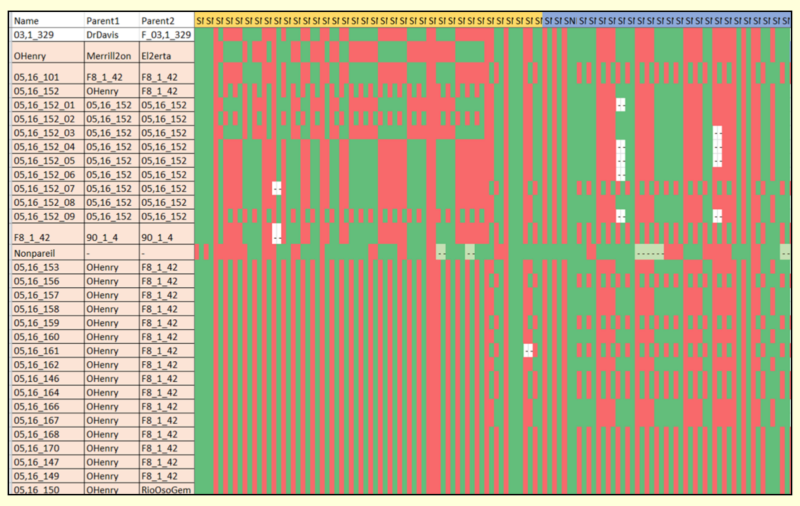


**Fig. 4.** The visualization of the inheritance patterns of different sets of molecular markers at different positions of chromosome 4 (top bar-gold color) and 5 (blue color) for *Nonpareil* almond and *O'Henry* peach as well as advanced breeding introgression of almond to peach showing how genes can e inherited in blocks following interspecies crosses.

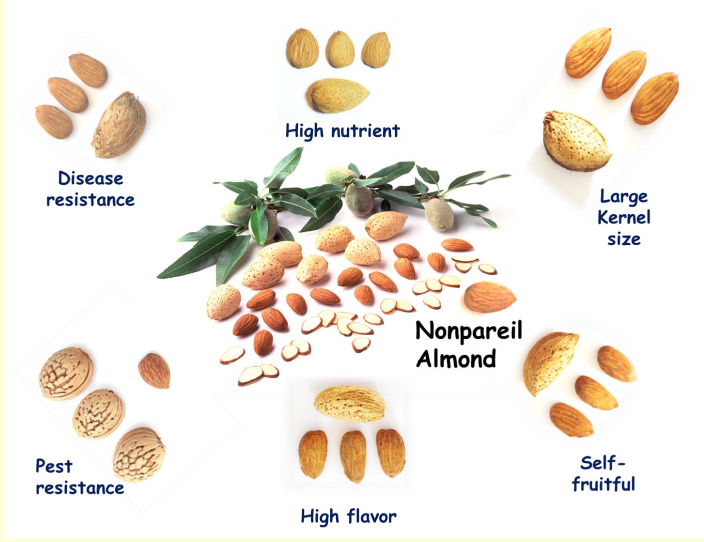
**Fig. 5.** Self-compatibility is controlled by a single gene which can be readily inherited (above). In contrast, self-pollination is more complicated and changes with development. Note the different relative position of the flower stigma (arrow) with pollen dehiscing anthers in the developing flowers at left.

## Breeding and Testing the next generation of California Almond Varieties

Because traditional almond varieties lack the characteristics needed for the next generation of California production (including self-fruitfulness, improve disease and pest resistance as well as improved resistance to drought stress and other consequences of climate change), new germplasm has been incorporated from European and Asian varieties as well as wild almonds and cultivated and wild peach. Through a process of cross-hybridization and recurrent selection, desired traits from this diverse germplasm have now been introgressed or incorporated into California-adapted breeding lines. The first generation of these adapted introgression lines were planted in 2014 in the new Regional Variety Trials (RVT-see accompanying poster). The second-generation of California-adapted introgression breeding lines target the consolidation of the most promising self-fruitful and resistance traits into productive almond varieties with good commercial qualities. A major challenge of this selection cycle will be anticipating the critical production/resistance needs of almond varieties destined for California planting 10 to 20 years from present.

| Selection | Bloom | Harv. | Self-fruitfulness | Origin |
|---|---|---|---|---|
| UCD3-40 | -5 | 11 | Partially Self-fruitful | P.fenzliana |
| Winters | -3 | 20 | Self-incompatible | Harriot |
| Sweetheart | -2 | 18 | Partially Self-fruitful | P. persica |
| UCD18-20 | 1 | 20 | Partially Self-fruitful | P. persica |
| UCD1-16 | 3 | 12 | Partially Self-fruitful | P.fenzliana |
| UCD8-27 | 4 | 12 | Self-fruitful | P. webbii |
| UCD8-160 | 4 | 15 | Self-fruitful | P. mira |
| UCD97,1-232 | 5 | 13 | Self-fruitful | P. mira |
| UCD1-271 | 5 | 14 | Self-fruitful | Tuono |
| UCD7-159 | 5 | 16 | Self-fruitful | P. webbii |
| UCD2-19E Kester | 6 | 10 | Self-incompatible | TardyNonp. * Arb. |
| UCD8-201 | 7 | 18 | Self-fruitful | P. mira |

**Table3.** Summary of UCD selections in advanced Regional Variety Trial testing (above; bloom and harvest times are relative to *Nonpareil).* (Below), Range in kernel quality types of advanced UCD selections now in grower testing.




| UCD Advanced Selection | Seed Parent | Pollen Lineage | Origin |
|---|---|---|---|
| UCD4-8-149 | Nonpareil | 25-75 * Winters | MF |
| UCD4-16-266 | Nonpareil | 25-75 * Winters | MF |
| UCD4-17-20 | Nonpareil | 25-75 * Winters | MF |
| UCD5-3-47 | Ferragnes | D3-4(Miss*WebF2) * Ferrag | F |
| UCD5-4-60 | UCD13-1 | 25-75 [Arb * 4-26]*[SB4, 4-2E] * F10D103-9wnt | M |
| UCD5-4-170 | UCD13-1 | 25-75 [Arb * 4-26]*[SB4, 4-2E] * F10D103-9wnt | M |
| UCD5-5-3 | UCD13-1 | 25-75 [Arb * 4-26]*[SB4, 4-2E] * F10D103-9wnt | M |
| UCD5-5-17 | UCD13-1 | 25-75 [Arb * 4-26]*[SB4, 4-2E] * F10D103-9wnt | M |
| UCD5-5-80 | UCD13-1 | 25-75 [Arb * 4-26]*[SB4, 4-2E] * F10D103-9wnt | M |
| UCD 5-5-367 | UCD13-1 | 25-75 [Arb * 4-26]*[SB4, 4-2E] * F10D103-9wnt | M |
| UCD 5-6-331 | UCD13-1 | 25-75 [Arb * 4-26]*[SB4, 4-2E] * F10D103-9wnt | M |
| UCD5-6-340 | UCD13-1 | 25-75 [Arb * 4-26]*[SB4, 4-2E] * F10D103-9wnt | M |
| UCD5-6-369 | UCD13-1 | 25-75 [Arb * 4-26]*[SB4, 4-2E] * F10D103-9wnt | M |
| UCD5-6-390 | UCD13-1 | 25-75 [Arb * 4-26]*[SB4, 4-2E] * F10D103-9wnt | M |
| UCD5-7-30 | UCD13-1 | 25-75 [Arb * 4-26]*[SB4, 4-2E] * F10D103-9wnt | M |
| UCD5-9-100 | UCD13-1 | D3-15 * D3-25 | WP |
| UCD5-9-358 | UCD13-1 | D3-15 * D3-25 | WP |
| UCD5-9-396 | UCD13-1 | D3-15 * D3-25 | WP |
| UCD6-1-254 | Nonpareil | D4-18'(P. webbii)* Sonora | W |
| UCD6-3-91 | Nonpareil | D3-25 * 25-75 | WM |
| UCD6-3-319 | Nonpareil | D3-25 * 25-75 | WM |
| UCD6-3-105 | Nonpareil | D3-25 * 25-75 | WM |

**Table 4.** Summary of UCD experimentals being propagated for 2017 regional grower trials. (Origin: *M -Prunus mira, F -P. fenzliana, P -P. persica, W -P. webbii).*

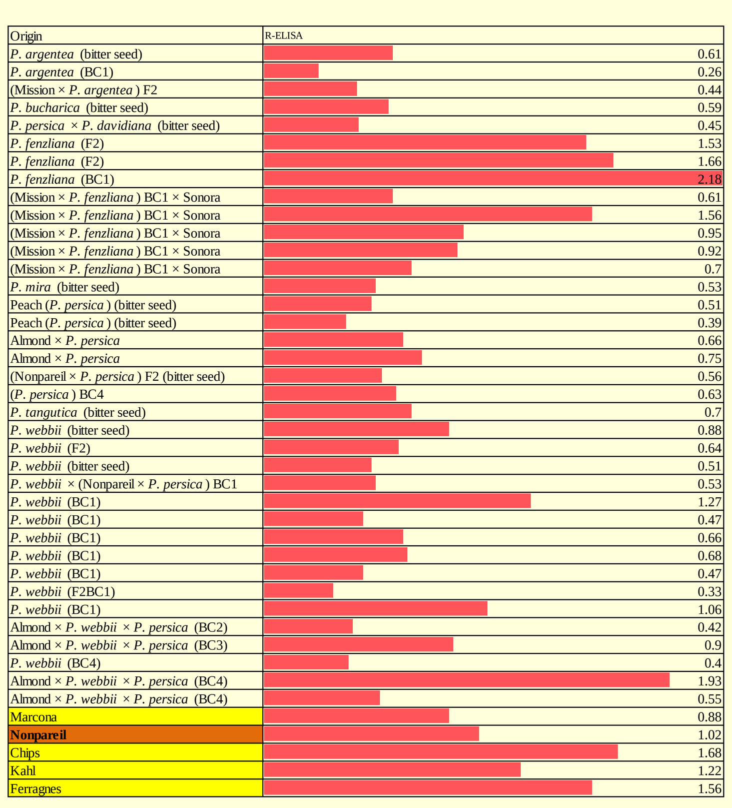
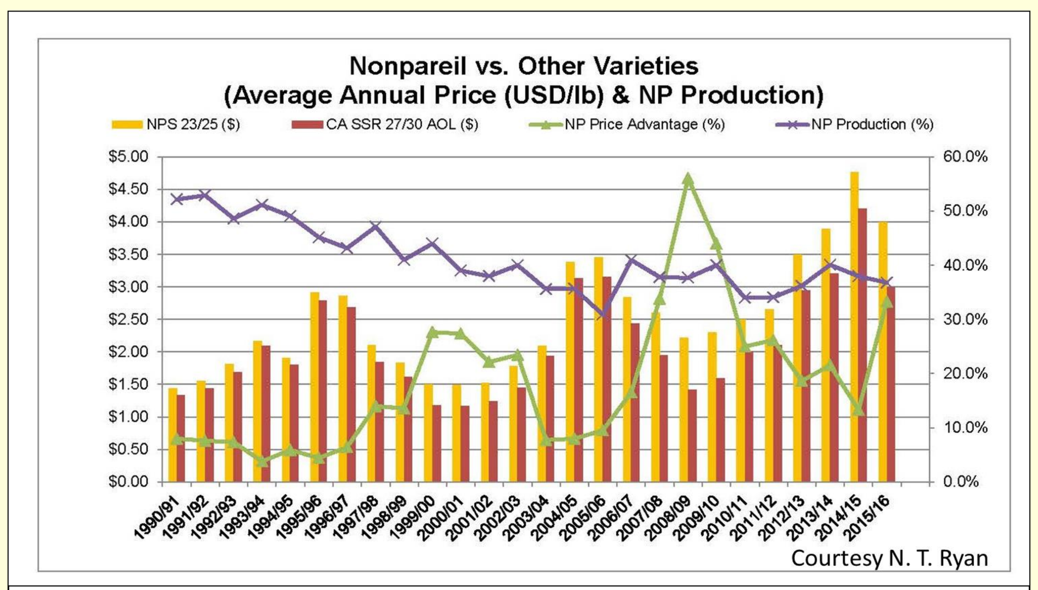


**Fig. 6.** Analysis of level of nut allergen reactivity for advanced breeding lines incorporating genes from related species showing opportunities to breed varieties with lower nut-allergy risk. (Cultivated almond is evolved from *P. fenzliana*).




**Summary**

The next generation of almond varieties will possess traits for improved disease/pest and climate stress resistance as well as improved nutritional and eating quality. Novel traits such as self-fertility will allow greater production consistency. As demonstrated by the production consistency of the *Nonpareil* variety (above), ultimate variety success will depend upon the presence of a large array of additional. essential traits where the poor performance of even one (bud-failure, alternate bearing, stick-tights, rootstock incompatibility, etc.) will result in eventual failure.