Almond Variety Development

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

Project Leader: Tom Gradziel
Department of Plant Sciences
University of California, Davis
One Shields Ave.
Davis, CA 95616
(530) 752-1575
tmgradziel@ucdavis.edu

Project Cooperators: M.A. Thorpe, E. Ogundiwin, B. Lampinen, J. Adaskaveg, J. Connell, M. Viveros, J. Edstrom, S. Metcalf and P. Schrader

Objectives:

Develop (1) improved pollinizers for Nonpareil, and ultimately, (2) varieties that possess self-fertility and improved market value and disease/insect resistance. Objectives for 2008-09 include:

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 self-compatibility, and disease and pest 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:

A. Field trials of advanced breeding lines

Over 30 advanced breeding selections are now in regional grower trials for performance evaluation under different California growing conditions. Traits being evaluated include self-compatibility, disease and pest resistance, and tree productivity. Tree productivity is being evaluated as tree yield over the expected life of the orchard and includes such characteristics as tree architecture, spur bearing-habit, kernel size, and and flowering and seed-set potential. Because most of these desired traits, particularly self-compatibility and improved disease/pest resistance, have been transferred from outside the traditional California germplasm, kernel and tree quality of the first generations of breeding crosses were generally inferior to standard California cultivars. This is particularly true when wild almond and peach species were used as sources of exotic genes such as self-compatibility. The current, advanced breeding generations have overcome many of these deficiencies yet provide many novel opportunities to improve almond quality and productivity. For example, the 'Sweetheart' variety which was recently released an as alternative to the high roasting-quality European variety 'Marcona', possesses very high kernel oil quality which increases both its consumer phytonutrient value as well as roasting quality. Different tree and branch architectures are also being evaluated in Sacramento and San Joaquin County evaluation plots to determine whether different cultivar types are required to optimize performance in these different almond growing environments. Early results indicate that while differences in traits such as flowering and hull-split times are important, tree and bearing-habit architectures conferring the highest yields in the San Joaquin Valley also tend to show the best yields in the Sacramento Valley. Advanced UCD breeding lines continue to show some of the highest 2008 as well as cumulative yields in regional trials. Yields for UCD selection '2-19e' surpassed 3000 kernel pounds per acre in 4th leaf Kern County trials and, so far, show no evidence of an alternate bearing habit under the higher-input management strategies used (see summary of Field Evaluation of Almond Varieties in this volume, Project 08-HORT2-Lampinen, and in the report , Project 07-HORT2-Lampinen, on the 2007-08 Final Report CD). Kernel quality has also shown sizable improvement with increasing breeding generation, with many advanced self-compatible selections recently being classified into 'California', 'Carmel', and 'Nonpareil' marketing groups in ABC sponsored industry evaluations. Detailed descriptors of advanced breeding lines currently in field trials are presented in the 2007-08 Final Report CD, Project 07-HORT1-Gradziel. Samples of many advanced breeding selections will also be available for evaluation during this conference. Twelve new UCD breeding selections are currently being propagated for planting in grower test-plots in 2009.

B. Selection for self-compatibility, and disease /pest resistant.

The breeding program is utilizing multiple genetic sources, including wild and related species, for the development of self-compatibility and disease/pest resistance in order to identify the most effective genetic source as well as combine different genetic sources to maximize final performance. In addition to the traditional European 'Tuono' source for self-compatibility, we have also incorporated self-compatibility from peach and the related species, *Prunus mira* and *Prunus webbii*. In advanced breeding lines in which the self-compatibility genes have been transferred to a cultivated almond background, the peach and *P.mira* sources have provided the highest level of self-compatibility under field conditions, with even higher and more consistent levels achieved when combining self-compatibility genes from different sources. Preliminary molecular studies indicate that part of the reason for this increase is that the peach-derived genes optimized pollen performance while the almond-derived genes primarily affect pistil performance. To maximize tree self-fruitfulness, consistently high levels of self-pollination are also being incorporated using these genetically simpler self-compatible breeding lines. Similar results have been found in the disease/pest resistant programs, where a recombination of multiple resistance mechanisms provides the best field performance. Initially targeted diseases include flower blight, Alternaria leaf spot, and hull rot, with early results indicating improved resistance levels in advanced 'commercial quality' selections. Resistance is evaluated under field conditions in Sacramento and San Joaquin Valley plantings as well as under more controlled conditions at UCD research plots (in collaboration with Dr. Jim Adeskaveg). UCD selection F7,1-1, in particular, has shown high levels of resistance to flower blight, bacterial blast, and hull rot as well as being highly self-compatible and high-yielding, but suffers from a small kernel size. Advanced breeding selections combining the positive attributes of F7,1-1 with improved kernel quality are now beginning regional testing.

Resistance to Navel Orangeworm (NOW) is also being pursued through an improved shell-seal as well as biochemical-based resistance to NOW larvae development. Breeding line 97,2-240 possesses a thin but highly sealed shell conferring both good NOW resistance and a high kernel/nut crack-out ratio. Tree structure however tends to be too spreading resulting in excessive limb breakage. The high shell-seal trait is readily transferred in controlled crosses, however, and advanced breeding lines combining this high-seal NOW resistance with improved tree architectures are now being propagated for regional testing. The recently released 'Sweetheart' cultivar also shows improved resistance to post-harvest worm infestation, which appears to be biochemical-based. More recent studies, however, indicate that the resistance is primarily to hull-rot infection, the occurrence of which appears to greatly facilitate early-stage NOW survival. Detailed information on self-compatibility/resistance sources, including molecular markers being developed for their characterization is provided in the project report, 07-HORT1-Gradziel, on the 2007-08 Final Report CD.

C. <u>Generate large progeny populations required to recombine the wide diversity agronomic traits and disease and pest resistance needed.</u>

Final success of a cultivar will be determined not by the presence of desirable traits such as self-compatibility but by the absence of major deficiencies in any of the extensive requirements for consistent high yields and market quality. To effectively recombine the large number of required genes, very large breeding populations are needed. For the second consecutive year, favorable weather conditions during flowering has allowed the breeding program to surpass the targeted goal 8,000 seed from controlled crosses, with over 12,000 seed being processed to date. In addition to previously targeted traits, breeding efforts are being expanded to pursue higher kernel phytonutrient quality and resistances to other pests and diseases (including anthracnose and noninfectious bud-failure). The resulting high number of progeny trees in UCD trials (exceeding 40,000 trees in early 2008) has, however, taxed breeding program resources. Aggressive selection strategies (using morphological and molecular markers) are currently underway to eliminate approximately 75% of seedling trees by the end of 2008 (in anticipation of rapidly decreasing University support). Molecular markers have greatly facilitated source identification for self-compatibility, as well as disease identification in field studies. We are now pursuing molecular markers for disease resistance that can be used at the seedling stage and so reduce the need for the more expensive full tree evaluations. Studies are also underway to better characterize the determinants of final yield potential to allow earlier and more efficient selection strategies. Yield studies have benefited from the greater variability in tree architecture and bearing-habits generated by our early breeding efforts. Advanced California-adapted selections having different architectures and bearing habits are now being evaluated in regional trials using traditionally derived yield data combined with a more detailed characterization of tree light-capture and yield-efficiency from Bruce Lampinen's research. The goal is the development of selection criteria that predict not just individual tree yield potential, but total orchard yield, optimizing productivity of the high-value cultivars over the often lower-value pollenizers. Initial findings are available in the Field Evaluation of Almond Varieties, Project 07-HORT2-Lampinen report on the 07-08 Final Report CD.