

RosBREED

Enabling marker-assisted breeding in Rosaceae



www.rosbreed.org

Dedicated to the genetic improvement of U.S. rosaceous crops

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Volume 1 Issue 3

RosBREED holds its first PBA Workshop at Michigan State University, June 2010



RosBREED participants at the workshop.



Eric van de Weg (PBA Team Leader; PRI, Netherlands) and Yingzhu Guan (Project Associate; Washington State University).



RosBREED participants working hard at the PBA workshop.



Phil Stewart (Driscoll's Strawberry Associates, CA) and RosBREED's BIMS programmer Jerry Hill (Washington State University).

RosBREED uses PediMap and soon FlexQTL™ software programs for data analysis and management. To provide hands-on training for PediMap, data quality management, and the basics of FlexQTL™, RosBREED's Pedigree-Based Analysis (PBA) Team organized and conducted a successful two-day workshop at Michigan State University, East Lansing, MI on June 15-16. This workshop was attended by 30 participants (see pages 4-5 for more information on the workshop and the PBA Team). While Eric van de Weg (Plant Research International, Netherlands) conducted all the sessions of this workshop, two of RosBREED's Demonstration Breeders at Michigan State University, Jim Hancock (strawberry) and Amy Iezzoni (tart cherry), took participants on a field tour of their breeding programs immediately following the workshop.

Inside this Issue

<i>RosBREED by the numbers</i>	2
<i>Community Breeders' Page</i>	3
<i>RosBREED's PBA Team</i>	4
<i>Who's Who in the PBA Team</i>	6
<i>Who are our Breeding Trainees?</i>	7
<i>Advisory Panel Member profiles</i>	8
<i>Breeder profile: Tom Gradziel</i>	9
<i>Jewels in the genome</i>	11
<i>Calendar of events</i>	12





- ★ **RosBREED II** The RosBREED Executive Committee is planning RB II, which will be held in East Lansing, Michigan March 8-9, 2011 followed by two and a half days of PBA Training (March 10-12). Prior to the East Lansing meeting, the RosBREED Executive Committee, the Socio-Economics Team, and any interested participants will meet with RosBREED Advisory Panel Members on January 13, 2011 in San Diego, California.
- ★ **SNP Summit** has been scheduled in conjunction with RGC5 in Cape Town, South Africa. Details regarding the SNP Summit and registration can be found at www.rosbreed.org/rosbreeds-snp-summit
- ★ Check out **RosBREED's new website** at www.rosbreed.org, which now features videos, slideshows, and educational information.

RosBREED by the numbers

37

Number of responses received from the Spring 2010 Rosaceae breeders online survey. This number represents 65% of the Rosaceae breeder community in US and Canada. Results are currently being analyzed by Socio-Economics Team members Chengyan Yue, Karina Gallardo, Nan Yang, Vicki McCracken, Jim Luby, and Ray Jussaume.

The main objective of the breeder survey is to determine the relative importance of genetic traits for apple, sweet cherry, tart cherry, peach, and strawberry. Additional objectives include getting information about breeding programs' characteristics and the use of marker-assisted technology. This information will be important to set a baseline for comparison between breeders' priorities and their marketing channel members' (i.e., producers, packers, shippers, processors, consumers) preferences.



Karina Gallardo and Nan Yang, Washington State University

7,195

Number of households in the dataset that Socio-Economics Team members Mykel Taylor, Qiuji Zheng, and Vicki McCracken used to analyze fresh apple purchases from retail grocery stores during the period of 1998 to 2006. Purchases of Red Delicious, Gala, Granny Smith, Golden Delicious, and McIntosh were tracked to determine consumer preferences for different apple variety characteristics. Demographics used to describe consumers included age, education, income, and presence of children in the household, among others.



Vicki McCracken and Mykel Taylor, Washington State University

10

Number of presentations given by RosBREED Teams about the project at the annual ASHS Conference in Palm Desert, CA August 2-4. In addition to general session presentations, a RosBREED Workshop was held on Wednesday, August 4th.

The Workshop included a brief overview of the project by Amy Iezzoni, Project Director, followed by presentations by the following Teams: Breeding (Jim Luby), Socio-Economics (Karina Gallardo), Marker-Assisted Breeding Pipeline (Cameron Peace), and Extension (Cholani Weebadde).



Jim Luby, University of Minnesota, speaking during the RosBREED workshop at ASHS

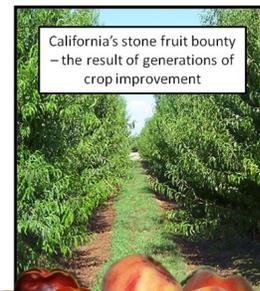
Community Breeders' Page

A stone fruit breeding safari

by Cameron Peace, MAB Pipeline Team Leader

On two sun-drenched summer days in late June, intrepid explorers and RosBREED Extension Team emissaries Greg Reighard and Cameron Peace embarked on a journey of outreach and fruit gorging in the heart of America's fruit bowl, the vast stone fruit and almond production wilderness of California's Central Valley. With resolute purpose, they tracked down those mysterious beings known as "stone fruit breeders" (*Fructimprovus prunii* L.), part of the wider clade of Community Breeders.

On the first day, a stroke of luck brought together three breeders at one gathering place in Davis: Terry Bacon of Sun World (subsp. *privatus*), David Cain of International Fruit Genetics (subsp. *privatus*), and David Ramming of USDA-ARS, Parlier (subsp. *publicus*). The next morning, several other breeders (all subsp. *privatus*) were tracked to their natural settings: Tom Burchell of Burchell Nursery in Oakdale, and Leith and Grant Zaiger of Zaiger's Genetics in Modesto. The afternoon included trekking to the habitat of Glen Bradford and Jon Quisenberry of B Q Genetics in Le Grand, followed by a foray into the hot plains of Fresno to the territory of John Slaughter of Burchell Nursery. Warm greetings as with old friends were the experience at each locale. Fruit of prized selections were tasted and savored, culminating in an orchard tour at Burchell's Fresno breeding plots and indulging the palate with delicious white nectarines, yellow peaches, peen-tos, and succulent apricots. More stone fruit were enjoyed during the Prunus Crop Germplasm Committee meeting at the Davis Repository a few days later, which topped off a feast of delights from this amazing genus. Subsequent encounters with *Prunus* breeders Tom Gradziel (almond, UC Davis, subsp. *publicus*, also moonlighting as RosBREED's canning peach Demonstration Breeder), Malli Aradhya (interspecific rootstocks, USDA-ARS, Davis, subsp. *publicus*), and John Driver (apricot, CandyCot Fruit Company in Waterford, subsp. *privatus*) rounded out the rounding up of California's population of *Fructimprovus prunii*.



Engagement with each breeder revolved around the theme of "This is what RosBREED can do for you". Discussions covered what RosBREED is (a publicly funded initiative to open the flow of socio-economically informed DNA-based knowledge into U.S. Rosaceae breeding programs, both public and private) and what it isn't (another research project asking for money). Recent quarterly newsletters were provided and the components described of a Demonstration Breeder survey of breeding information management capacity and needs. RosBREED project goals are met if we can help make these stone fruit breeding programs more profitable and creative so they can efficiently provide superior cultivars to industry, resulting in superior products for consumers. Invitations were extended for breeders to engage to the level desired with the RosBREED family – a standing offer to all Rosaceae breeders, geneticists, and genomicists.

Demonstration Breeding Programs By the Numbers:

2,090



Jim Hancock and Sonali Mookerjee after planting a subset of the strawberry CR Set at an MSU Research Station

Number of strawberry seedlings propagated and planted by Sonali Mookerjee, RosBREED Project Associate, Michigan State University. Seedlings propagated represent a subset of the strawberry Crop Reference Set (see definition below). Seedlings will be planted at 5 locations: Michigan State University, USDA-ARS/Oregon State University, University of New Hampshire, California (Driscoll's Strawberry Associates), and University of Florida.

34,980



Travis Stegmeir

Number of tart cherry phenotypic data points that Travis Stegmeir, RosBREED Project Associate at Michigan State University, generated for the tart cherry CR Set in June and July, 2010. Fruit and pit weight, length, width as well as soluble solids, and pit cling were recorded. Color readings were generated using a Minota color reader.

Please visit our website for detailed protocols on how the RosBREED's primary five crops are measuring phenotypic traits (www.rosbreed.org/resources/fruit-evaluation).

RosBREED definition

CROP REFERENCE SET (CR Set): Each demonstration crop (sweet cherry, tart cherry, apple, peach, and strawberry) have developed a CR Set, which is a set of pedigree-linked germplasm that represents the diversity in current and anticipated future breeding stock. Each CR Set:

- Is approximately 480 individuals (cultivars, ancestors, founders, breeding lines, selections, and seedlings) that are fruiting in 2010-2012
- Will enable efficient validation and utility assessment of marker-locus-trait associations
- Will be genotyped with genome-wide SNP markers and phenotyped for fruit quality traits and other high-impact targets
- Is a resource for the common benefit of the Rosaceae breeding programs



RosBREED's Pedigree-Based Analysis (PBA) Team – Support in data analysis through software development, training and hands-on assistance

By RosBREED's PBA Team (Eric van de Weg, Marco Bink, Gennaro Fazio, Hans Jansen, Jim Luby, Chris Maliepaard, Cameron Peace, Umesh Rosyara, Roeland Voorrips, and Dechun Wang)

The Pedigree-Based Analysis (PBA) Team is dedicated to developing a Rosaceae-wide statistical platform for identifying and validating diagnostic genetic tests. PBA will be established and demonstrated in RosBREED's Demonstration Breeding Programs.

The PBA Team

In short, the PBA Team develops and documents software and training material, trains breeding personnel in PBA use, and aids in data analyses. The PBA Team Leader is Eric van de Weg, located at Plant Research International (PRI) of Wageningen University and Research Centre in The Netherlands. Eric's fellow Dutch members are Marco Bink, Hans Jansen, Chris Maliepaard, and Roeland Voorrips. Primarily, this group is responsible for development of the statistical methodology and software, as well as manuals, tutorials, and training materials to improve understanding of underlying genetic and statistical concepts and their implementation. Regularly, this group provides in-person whole-group training to the U.S.-based Demonstration Breeders and RosBREED-supported breeding trainees (graduate students). Dechun Wang and Umesh Rosyara are located at Michigan State University, East Lansing, MI, USA. Dechun and Umesh are the on-the-ground local PBA experts who will provide immediate support in PBA data analysis to breeders and trainees. The PBA Team is reinforced by Jim Luby (Breeding Team Leader), Cameron Peace (MAB Pipeline Team Leader), and Gennaro Fazio (BIMS Team Leader), thus ensuring full coordination with other closely associated RosBREED activities.

PBA - an innovative concept

PBA is a statistical framework designed to identify diagnostic genetic tests to inform breeding decision-making. In the PBA approach, DNA information and performance data are integrated in multiple populations of pedigree-linked plants. This approach is suited to ongoing breeding programs of Rosaceae crops, as it uses typical breeding germplasm and routine data, unlike the conventional method of identifying trait-controlling genomic regions in dedicated, single, experimental populations and then ad hoc validation in a wider array of genetic backgrounds more relevant to breeding interests. Of great value to breeders, the outcome of PBA is the association of particular DNA profiles with superior traits such as excellent flavor and keeping qualities. PBA results predict the genetic potential of any breeding parent examined. This information can be used to design efficient parental combinations and to indicate new seedling populations to genetically screen (and weed out inferior seedlings).



From left to right: Marco Bink and Eric van de Weg (Plant Research International, Netherlands) discussing software updates with Dechun Wang (Michigan State University).

Adopting the PBA approach has many advantages, including:

1. Immediate relevance to breeders of genetic tests developed as they have been found in breeders' own germplasm and using breeders' own performance data records.
2. Improved chance for detecting important trait-controlling genes, because:
 - Combined families will usually exceed the size of a single experimental family;
 - Continuity over generations within breeding programs accumulates a tremendous amount of data, increasing statistical power and thereby the ability to detect genes with major effects as well as those with moderate effects.
3. Increased opportunities for identification of multiple variants (alleles) of trait-controlling genes due to the use of multiple families (known as allele mining).
4. Obtaining knowledge about the robustness of diagnostic genetic tests in many genetic backgrounds.
5. Reduction in costs of genetic research as breeding populations already exist and are already evaluated as part of the breeding process.
6. Bridging the chasm between pure science and breeding due to the merging of intentions, germplasm, and data from both "sides" into a mutually intelligible language.

PBA software

The use of multiple families for associating DNA profiles with performance raised the need for new statistical methodologies, as well as software for implementing them. The Dutch members initiated the development of such methodology and software nearly a decade ago. Their efforts led to the development of PBA's two main software packages, FlexQTL™ and PediMap, and PBA-dedicated modules in Genstat have also been developed. Identity-By-Descent (IBD) is a key concept in PBA as it allows integrated analyses of families that are related through common ancestors. Proof of concept was successfully delivered in a recent large European project focusing on apple fruit quality and involving

RosBREED's PBA Team cont.

twenty-seven families and six breeding programs. This software now constitutes the U.S. Rosaceae genomics, genetics, and breeding community's common statistical platform for identifying and validating diagnostic genetic tests. During RosBREED's first year, new software functionalities have been added and user-friendliness has been improved. RosBREED's project director Amy Iezzoni was the first rosaceous crop breeder in the U.S. to adopt PBA and has demonstrated its practical value with sweet cherry at Michigan State University. Independently of Amy, co-PD Cameron Peace (Washington State University) recognized the usefulness of PBA and introduced this approach to Washington apple and sweet cherry breeding.

PBA training activities

In the first year of RosBREED's PBA activities, two training workshops were provided for participants. Last January, during RosBREED I in San Diego, the PBA Team presented genetic and theoretical concepts of PBA and gave the first hands-on training for PediMap software to excited breeders. This June, a two-day workshop for PediMap and FlexQTL™ took place at Michigan State University, East Lansing, MI. A total of 30 eager-to-learn participants attended the vibrant workshop, and left with new knowledge and skills that could be applied immediately to their programs. Among the participants were 10 Demonstration Breeders, 11 Project Associates and the PBA team members, and two representatives from Driscoll's Strawberry Associates (please see www.rosbreed.org/about/project-management/meetings/pba-workshop for handouts from this workshop).

The next training workshop is scheduled for March 2011 to be held at Michigan State University again, with particular focus on QTL mapping. At this workshop, phenotypic data collected of each crop's CR Set in 2010 will be analyzed.



Participants listening to instruction by Eric van de Weg

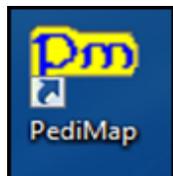


Kate Evans (Washington State University, apple Demonstration Breeder) and Ben Orcheski (Cornell University, apple Project Associate)

PBA software that RosBREED Demonstration Breeders are being trained in and will implement in their breeding programs.

**FlexQTL™**

- Performs QTL analyses
- Estimates Identity-By-Descent probabilities of genetic marker alleles
- Error-checks marker inheritance over pedigrees
- Output includes locus-specific and genome-wide breeding values
- Output compatible with PediMap for pedigree viewing and with MapChart to visualize QTL positions on linkage maps
- Suitable for diploid inbreeding and outbreeding species (extension to polyploids is underway)
- Available under MTA, description: www.biometris.wur.nl/UK/Software/FlexQTL/

**PediMap**

- Graphical representation of simple to complex pedigree relationships
- Phenotypic and marker information also visualized across pedigrees (e.g. trait values, scored alleles, founder origins of alleles)
- Compatible with FlexQTL™
- Suitable for any ploidy level and mating system
- Available for free: www.plantbreeding.wur.nl/UK/software_pedimap.html

**Genstat modules**

- For in-depth QTL studies (e.g., detection of multiple functional alleles, GxG and GxE interactions)
- Suitable for diploid inbreeding and outbreeding species
- Will become public during the course of RosBREED

Who's Who in the Pedigree-Based Analysis Team?



Team Leader: Eric van de Weg
Plant Research International
Area of interest: Genetics in fruit crops towards cultivar development

Plant Research International, Netherlands Team Members:



Marco Bink
Role: Extension of FlexQTL™ software

Hans Jansen
Role: Development of PBA modules within Genstat



Chris Maliepaard
Role: Support in tutorial development

Roeland Voorrips
Role: Extension of PediMap software



Michigan State University, US Team Members:



Dechun Wang
Role: Support to Umesh Rosyara

Umesh Rosyara
Area of interest: Genomics tools for breeding application
Role: U.S.-wide consultant on PBA software and analyses



PBA supporting Team Leaders:

**MAB Pipeline Team leader
Cameron Peace**
Washington State University



**Breeding Team leader
Jim Luby**
University of Minnesota



**BIMS Team leader
Gennaro Fazio**
USDA - Cornell University



RosBREED's Future Breeders



Training the next generation of Rosaceae breeders is critical for the continuity of collaborations for breeding rosaceous crops beyond the life of RosBREED. As a step towards this direction, RosBREED Demonstration Breeders have embedded graduate students as breeding trainees/project associates to provide mentoring through their project activities.

Through RosBREED activities, all Project Associates get an opportunity to interact and network with Industry, Scientific, and Extension Communities of Rosaceae crops early on in their careers.

Sonali Mookerjee,
Michigan State University



Lise Mahoney, University
of New Hampshire



Tim Hartmann,
Texas A&M



Paul Sandefur,
University of Arkansas



Megan Mathey, Oregon
State University



Terrence Frett,
Clemson University

Ben Orcheski,
Cornell University



Meet our 11
Project Associates



Travis Stegmeir,
Michigan State University



Matt Clark, University
of Minnesota



Yingzhu Guan,
Washington State
University



Murali Bellamkonda,
Washington State University

Advisory Panel Member Profile Page

The success of RosBREED will be determined in large part by the people behind it. Because of this, we wanted to give you some insight into these individuals — whether they represent university extension, the scientific community, or industry — who are at the core of Rosaceae. Panel members were asked about their background and what they want to accomplish as part of the RosBREED project. Here is what they had to say.

Extension



DAVID A KARP

Junior Specialist, Department of Botany and Plant Sciences, University of California at Riverside
dkarp@ucr.edu

What work do you do? I write a weekly column and longer features about fruit for the *Los Angeles Times*. As a part-time employee at UC-Riverside, I research citrus germplasm for a project, “Unforbidden Fruits: Preventing Citrus Smuggling by Introducing Varieties Culturally Significant to Ethnic Communities.” In 2007 I co-founded the 1.25-hectare Bunyard Orchard in Morgan Hill, Calif. to research the commercial potential of select heirloom stone fruit cultivars. In 2009 I co-established a germplasm repository for citron (*Citrus medica* L.) in Jiangshui, Yunnan, China.

Why you are interested in RosBREED? I have a longstanding interest in fruit breeding as the “master discipline” that draws together all the strands of pomology; at its best, breeding blends science and art. RosBREED is at the cutting edge of fruit breeding, with great potential for rapid progress.

How you feel you can contribute to RosBREED? I would like to work with breeders to emphasize the importance of selecting for intense and distinctive flavors. Some aspects of flavor may be amenable to analysis and prediction by molecular markers, but others will likely require old-fashioned human judgment. I can also help improve project texts and suggest strategies for communication.

Industry



PHIL BAUGHER

President, Adams County Nursery, Inc. Aspers, PA
phil@acnursery.com

What work you do? Primary responsibilities include variety testing and maintaining relationships with plant breeders and variety managers worldwide. I started my career in sales and marketing and developed an interest in new and novel tree fruit varieties, leading to my involvement in variety testing and licensing.

Why you are interested in RosBREED? I have always been interested in the latest technology in variety development and the significant contributions that new genetics provide our industry.

How you feel you can contribute to RosBREED? I have been involved in the tree fruit industry my entire life and continue to have a passion for the advancement of technology. I also have been very active with US Apple and the promotion of the Tree Fruit Technology Roadmap. It is exciting to see the opportunities resulting from the 2008 Farm Bill and the Specialty Crop Research Initiative.

Scientific



JOE AVARI

Environmental Science and Policy Program, Michigan State University. East Lansing, MI
arvai@msu.edu

What work do you do? I conduct an active research program that has two main objectives. First, it focuses on advancing and testing theories in the decision sciences that deal with how people make decisions (both as individuals and in groups) largely in the absence of formalized decision support. Informed by this work, the second objective of my research is to develop and test decision aids that can be used by people to improve decision quality across a variety of contexts. While some of this latter research is lab-based, a significant portion of it is carried out in the field and is intended to have practical benefit; to this end, much of it is carried out in cooperation with actual decision makers and is set against the backdrop of real-world decision problems.

Why you are interested in RosBREED? Decisions within the agricultural sector are important for a wide variety of social, economic, and environmental reasons. So, it presents a great test bed for the kinds of multi-objective and tradeoff-rich decisions that I like to focus on in my lab.

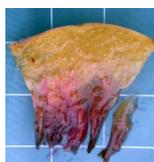
How you feel you can contribute to RosBREED? Plainly, I'm just eager to bring my lab's expertise to the project. Anything, however small, that we can contribute to improve decisions by breeders would be welcome to my students and me.

Breeder profile: Tom Graziel

By Audrey M. Sebolt, project assistant



What is a melting versus non-melting peach?



Melting flesh peaches have flesh that become soft and fibrous at maturity. They tend to have ragged edges when sliced during processing and so are easily damaged. Melting flesh types can be clingstone or freestone.



Non-melting flesh peaches remain firm at maturity. Most commercially canned cultivars are non-melting and all non-melting types are clingstone.

Stony-hard flesh peaches do not produce ethylene and therefore peaches with a stony-hard gene are very slow to soften. Candidate genes for this trait are under investigation with the goal of incorporating MAS during seedling evaluation (www.rosaceae.org/node/176).

What is a clingstone peach?

- In a clingstone peach, the flesh 'clings' or adheres to the stone as opposed to a freestone peach, where the stone and the flesh separate at maturity allowing the stone to be easily removed. Clingstone peaches are also firm and less easy to bruise than their freestone counterpart.
- Because all non-melting peaches are also clingstones, the clingstone trait is tolerated in both processing and fresh market cultivars despite its obvious disadvantages.

The California Cling Peach Industry - By the Numbers (www.calclingpeach.com/html/nav/industry.html)

- \$943 million: CA Peach Industry's contribution to California's total economy
- 450,000-550,000: tons of peaches that are harvested and processed each year
- 4.2 pounds: United States per capita consumption of cling-stone peaches in a given year!
- \$120 million: estimated value of the crop when harvested. The value increases to over \$500 million after processing

Over half the peaches grown in the US are for processing. Most processing peaches are canned, with California accounting for 96% of the total market share, making it the largest producer in the world. Unlike fresh market cultivars, which frequently change in response to market trends, processing peach cultivars entail a long-term commitment by both growers and processors because of the specialized equipment involved. The industry currently processes approximately 25 to 30 different cultivars in a season, which spans the time frame of July 1 to mid-September, with a different cultivar ripening every 2 to 3 days in order to keep the processing plants running at full capacity. To be commercially viable, an acre of processing peaches must produce close to 20 tons per year (44,820 kg/ha) with an expected orchard production period of 20 years or more to be commercially successful. Located primarily in the Sacramento and San Joaquin Valleys of California, there are currently over 600 clingstone peach producers on approximately 30,000 acres (12,140 hectares).

Most processing peach cultivars are non-melting clingstones (see box on left) because the non-melting trait, with its firm, non-melting flesh, allows the fruit to be harvested at the preferred tree-ripe stage, transported to the processing plant and processed without appreciable loss in fruit integrity. This capacity to provide 'tree-ripe' fruit to the market without loss in either eating quality or phytonutrient content,



Tom pointing out young peach seedlings in his UC Davis breeding program.

has also made non-melting, clingstone peaches a popular fresh market fruit in Europe and Central and South America. Many new early-season fresh market US peach cultivars now utilize the non-melting, clingstone trait for this reason. Clingstone peaches are processed for canned peaches and fruit cocktail; other products include frozen peaches, baby food and fruit concentrate.

Tom Gradziel, RosBREED peach Demonstration Breeder, has been at UC Davis since 1988, and welcomes the unique challenges of breeding new cultivars for California. He currently manages 80 acres of high-density peach and almond seedlings at Davis, with additional grower test plantings of over 50 advanced selections in plots located from Redding, northern California, to Bakersfield, southern California.

A major challenge to peach breeding is the very narrow genetic base, making it difficult to impossible to find new genetic solutions to address emerging cultural and marketing needs. Almond, also a rosaceous species that readily hybridizes with peach, however, possesses an extensive genetic diversity in the cultivated landraces and related wild species located throughout Europe, North Africa, and Asia. Tom has utilized this interspecies germplasm in his breeding program to introgress new traits including improved disease and pest resistance, elevated phytonutrient contents, and

Breeder profile cont.**Traits of interest for breeding clingstone peaches for the CA industry**

- Flesh color
- Firmness
- Flavor
- Texture
- Increased phytonutrients (carotene, phenolics, a-tocopherol and fatty acids)
- Increased sugars
- Low incidence of pit fragmentation during processing
- Avoidance of split pits during ripening
- Disease and pest resistance (brown rot, flower blight, leaf curl, mildew, and green peach aphid)
- Rootstock compatibility
- Single pass harvestability (typically a cultivar is picked 2-3 times where only the ripest fruit are harvested, with approximately 3 days between each harvest)
- Fruit that will hold on the tree once ripe a minimum of 2-3 weeks and not undergo post-harvest deterioration



Peach fruit infected with brown rot

improved postharvest fruit texture integrity. It has taken him approximately 10 years to reach the current stage where approximately half of the advanced peach breeding lines and over 90% of the advanced almond breeding lines contain genes from another species.

The unique challenges inherent in this breeding approach, along with the long-term (typically 10 to 15 years) field testing required prior to cultivar release, mandate a team-based approach to cultivar development. The foundation for UC Davis breeding program progress and success has been its ability to leverage the high level of expertise of collaborators such as Abhaya Dandekar and Carlos Crisosto (molecular and postharvest biology); Rick Bostock and Jim Adeskaveg (Plant Pathology); Diane Barrett (Nutrition); and Mary Ann Thorpe (Horticulture).

Tom sees the similarly team-based approach of RosBREED as one of its biggest assets as it allows an efficient and precise evaluation of the extensive molecular and phenotypic data that will be compiled and shared within the group. This result will allow breeders to better understand their genetic lines and core germplasm. More specifically, it may allow a better understanding of the interaction of genes and genomes in vegetatively propagated cultivars and rootstocks.

Tom's program has been using marker-assisted selection (MAS) since the mid-1990s in its efforts to transfer self-fertility from peach to almond. More recently, they have been using markers developed with Cameron Peace and Eben Ogundiwin for characterizing allelic differences for the endoPG gene as markers for peach improvement (see "Jewel in the Ge-

Scion and Rootstocks released by Tom Gradziel

Hesse peach (1992) is high yielding and has increased levels of the phytonutrient vitamin A. The fruit ripen uniformly for minimum pickings and have low incidence of split pits.

Rizzi peach (1992) is a high yielding, midseason variety which offers excellent storage qualities. Fruit can be held in cold storage for up to eight weeks and still maintain good canning quality and so offer a raw product supply buffer to processors during peach production times.

Goodwin peach (2001) has a desirable 'Dixon' season ripening time, good yields, and disease tolerance. Fruit cultivar remain free from the anthocyanin red staining of pit-cavities as occurs in 'Dixon' and 'Andross' cultivars which it replaces.

Lilleland peach (2002) has a desirable 'Halford' season ripening time and produces superior fruit that have excellent flesh color, texture, and flavor. Trees produce high yields of firm fruit with the capacity for 'once-over' harvest.

Winters almond (2002) has high productivity with good kernel quality and flowers with the economically important early 'Nonpareil' almond bloom. Winters has partial self-compatibility, allowing some self-pollination to help buffer production when inclement weather at bloom reduces cross-pollination.

Sweetheart almond (2008) is a premium quality 'Marcona-type' almond, combining high productivity with high kernel phytonutrient levels as well as improved insect and disease resistance. Sweetheart flowers with the economically important early 'Nonpareil' almond bloom and also shows partial self-compatibility, allowing some self-pollination to help buffer production when inclement weather at bloom reduces cross-pollination.

nome" for further details). This extensive experience with MAS has both dampened and rekindled Tom's breeding team's perception of the ultimate value of MAS. Tom further explained how the transfer of self-compatibility gene from peach to almond using MAS was not a wild card that made winning almond cultivars. He said "This was because even the highly desirable self-compatible almonds still needed a wide range of other production and market attributes as well as new disease, pest and stress resistance genes for commercial success." In this situation, while MAS allowed the selection of parents to ensure all seedlings would possess the self-compatibility gene, since the population was also segregating for a large number of other important traits, breeders were not able to only use MAS knowledge to produce a winning almond cultivar.

Because the UC Davis cultivar improvement program is simultaneously pursuing a range of different breeding goals, the MAS game is currently perceived as more similar to 'Solitaire' where the 'right complementation' of genes is being pursued simultaneously for a number of different objectives. In this scenario, the game becomes a lot easier if MAS allows greater knowledge of the cards still hidden in the deck.

Jewels in the genome

By Amy Iezzoni, project director

What is a “Jewel in the Genome?”

- An individual’s genome is the full complement of genetic information that it inherited from its parents. Within this vast repertoire of genetic information, individual genes are being discovered that control critical production and fruit quality traits. As these valuable rosaceous gene discoveries are made and put into breeding applications, we will describe them in this column as “Jewels in the Genome.”

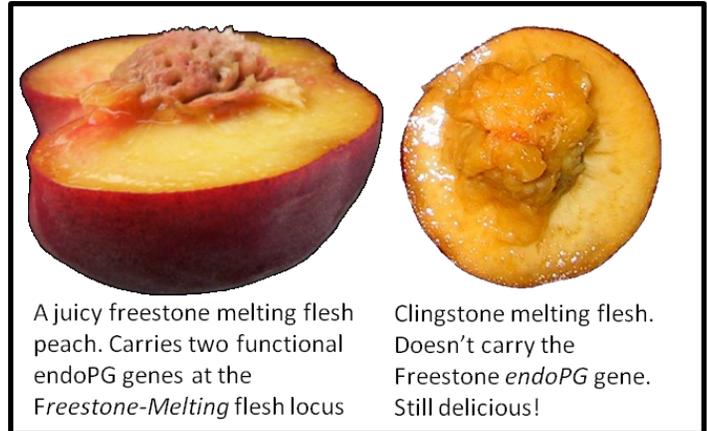
Fruit texture in peaches (and nectarines), characterized by differences in flesh softening and flesh adherence to the pit, defines industry market classes (fresh market or canning) and strongly influences consumer appeal. We know the controlling gene!

“Melting flesh” types, which soften rapidly to a smooth buttery texture, are most desirable for the fresh market. Melting peaches can be freestone or clingstone, which describes whether flesh fibers detach from the stone (seed, pit) when fruit are ripe. Melting types also have the possibility of becoming mealy (dry and grainy, which no one likes!) if they also carry other genetic susceptibility factors and are picked and stored incorrectly.

“Non-melting flesh” types soften gradually to a rubbery texture, and are the mainstay of peaches used for canning. Non-melting types are always clingstone. Two other types soften even less: “clingstone non-softening flesh” and “stony hard” peaches, and both are suitable for fresh eating because flesh remains crisp. All these firmer types do not become mealy.

The gene controlling melting/non-melting and freestone/clingstone is known, residing at the so-called *Freestone-Melting flesh* locus on stone fruit chromosome #4. This gene (*endoPG*) encodes the cell wall pectin-cleaving enzyme known as endopolygalacturonase that also plays a major role in fruit softening in many other fruit crops like pear, avocado, and melon. Twelve *endoPG* variants (alleles) have already been detected in peach. Upon hunting through the USDA’s *Prunus* stone fruit collection in Davis, California, in peach’s stone fruit relatives (plum, apricot, almond, etc.) more than 200 alleles were found! Commercially exploitable differences in peach fruit softening profiles have been associated with these different *endoPG* alleles. For example, one breeding line contains a unique allele associated with gradual softening over a week to a pleasing melting texture. In contrast, there are alleles from wild sources associated with immediate mushiness and others where fruit splits too easily along the suture – undesirable and mostly bred out of the modern industry, but useful to have a genetic handle on for rapid elimination from breeding populations when breeders seek to introduce valuable traits like disease resistance from wild relatives.

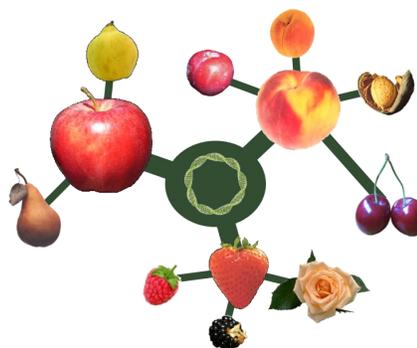
With genetic knowledge of the *endoPG* variants in their plant material, breeders can harness this wide array of genetic and trait diversity to create desirable parental combinations and select superior seedlings prior to field planting. Therefore, because this *endoPG* locus will lead to the more efficient breeding of peaches and nectarines with desirable texture, it is selected as our third featured “Jewel in the Genome.”



RosBREED: Enabling marker-assisted breeding in Rosaceae

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Calendar of events

- **August 22-27: XXVIII International Horticultural Congress, Lisbon, Portugal. Series of RosBREED presentations in various colloquia and workshops.**
- **November 13-14: RosBREED SNP Summit, Stellenbosch, South Africa. Please visit our website for more details at www.rosbreed.org/rosbreeds-snp-summit/.**
- **November 14-17: The 5th International Rosaceae Genomics Conference will be held in Cape Town, South Africa. For more details, see the conference website at www.rgc5.co.za.**