RosBREED

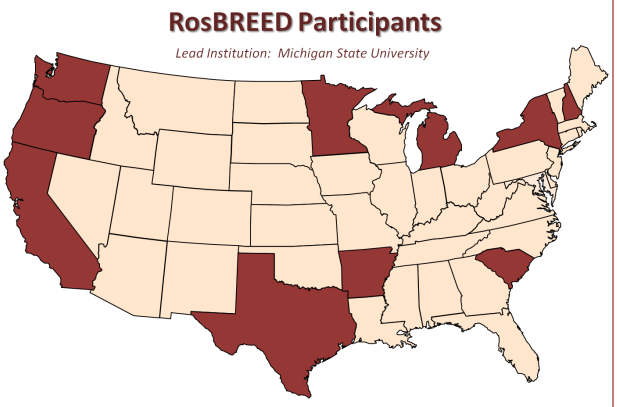
Enabling marker-assisted breeding in Rosaceae

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

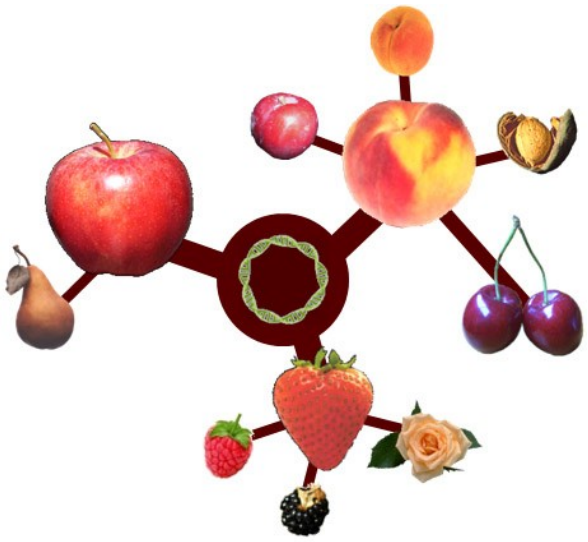
February 26, 2010 **Volume 1 Issue 1**

What is RosBREED?

RosBREED is a multistate, multi-institution, multi-national project dedicated to genetic improvement of U.S. rosaceous crops by targeted applications of genomics knowledge and tools to accelerate and increase the efficiency of breeding programs. This Coordinated Agriculture Project is funded through the USDA Specialty Crops Research Initiative by a combination of federal and matching funds.



What need does RosBREED address? U.S. Rosaceae crop industries face numerous limitations to profitability and sustainability. Overcoming these barriers requires rapid development and deployment of new cultivars with improved characteristics to meet dynamic industry and market needs and consumer preferences. This project seeks to identify breeding trait targets based on knowledge of what industry sectors and consumers value, and utilize genomics information to develop a sustainable technical platform to accelerate and increase the efficiency of cultivar development and adoption.



What crops and traits will be targeted? RosBREED will focus on fruit quality traits for five rosaceous crops: apple, peach, sweet cherry, tart cherry, and strawberry. Market-based information will be used to objectively quantify the importance of fruit quality traits to be targeted for marker-assisted breeding (MAB).

Inside this Issue

NIFA
USDA
United States Department of Agriculture
National Institute of Food and Agriculture

The first annual RosBREED meeting, RosBREED I, took place in San Diego, California on January 7 and 8, 2010

Twenty-seven scientists from the U.S. and 10 scientists from five other countries came together in an unprecedented collaboration for RosBREED I in San Diego, CA. Other attendees included 21 Advisory Panel members representing U.S. fruit industries, university extension experts, allied scientists and international leaders in Rosaceae genomics. Highlights of this inaugural meeting included welcoming the community to this exciting new initiative for rosaceous crops through the coordination of genetics and genomics efforts with project participants and international partners; discussions and feedback sessions with industry, extension, and scientific advisory panel members, and the first project training session for the breeders.

Jim Allen, commenting after RosBREED I, "felt that the breadth and depth of the project as well as the talent was surprising and amazing. I am impressed with how extensively RosBREED works with such a large number of international collaborators."

RosBREED AP Members that attended RosBREED I. From left to right: Jim Allen (New York Apple Association), Bruce Grim (Washington State Marketing Association), Tom Stokes (Tree Top Inc.), and Bill Dodd (Ohio Fruit Growers Marketing Association).

RosBREED scientists discussing goals. From left to right: Marco Bink and Eric van de Weg (Plant Research Intl., Netherlands) and Dechun Wang (Michigan State University).

Socio-economics team member Vicki McCracken (left, Washington State University) interviewing a RosBREED demonstration breeder Susan Brown (right, Cornell University).

Demonstration breeders marveling at how the goals of their individual programs are similar to the goals of others.

RosBREED to utilize socio-economic values to help breeders set breeding targets

By RosBREED's socio-economic team (Chengyan Yue, Karina Gallardo, Vicki McCracken, Ray Jussaume, and Mykel Taylor)

Currently, breeders tend to make their breeding targets based on a production orientation using interactions between their viewpoints, industry input and market forces. We believe that breeders, as well as industry stakeholders, can benefit greatly by including in their decision making, the values and preferences of other market chain participants such as purchasing motives and consumer attitudes; their beliefs, concerns, constraints, and willingness to pay. As such, new cultivars would have targeted appeal to both large-scale and small-scale niche-market segments, be more quickly accepted, and have enhanced commercial impact.

In such a framework, we believe that breeders need market-based information on the impact of different traits for the entire supply chain to broaden the decision-making process. This information must acknowledge and involve different key stakeholders at early breeding decision-making stages. As a means of providing this information to the breeders, through the socio-economic component of RosBREED, we will be estimating social values and economic weights of fruit traits of five rosaceous crops (apple, peach, strawberry, tart cherry, and sweet cherry) valued by the key market chain members as outlined in Figure 1. We will gather information using multiple approaches including one-on-one interviews and telephone surveys. Some of the methods we will use are outlined below:

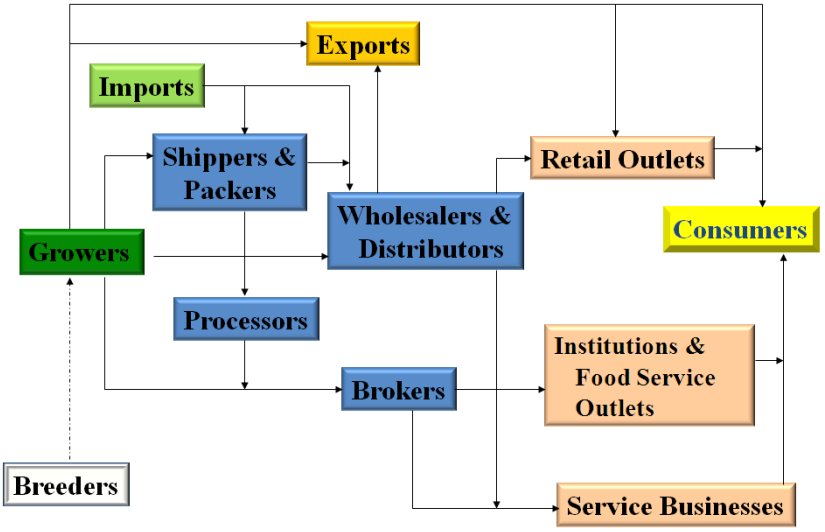


Fig.1. RosBREED's socio-economics team key stakeholders. Figure is adapted from the online power point presentation "Horticultural Marketing" by Uva, W. (1999).

Breeders' current trait selection practices: We will use a breeders' survey to determine specific traits under selection, current relative weights placed on those traits, traits for which they do not select due to limited staffing, technology, or knowledge, and how breeders perceive potential consumer interest in those traits. We will conduct these surveys with breeders in the U.S. through email and by phone and incorporate information on the feasible breeding traits in our subsequent surveys.

Producers'/processors' preferences and willingness to adopt new cultivars with specific fruit traits: We will send a questionnaire to a randomly selected sample of producers/processors in the three top-producing states for each of the five rosaceous crops targeted in RosBREED using a mixture of mail and internet surveys. This survey will include questions on preferences for fruit traits (color, size, texture, etc.) and production traits (flowering, growth habit, annual bearing, postharvest drop, etc.). Through this survey, we hope to obtain information that we could use as baseline parameters to test the likelihood of choosing a new cultivar with a specific trait under alternative plausible scenarios.

Market intermediaries' preference and values for fruit traits: We will also collect information on preferences and values for different fruit quality traits, as well as marketing constraints associated with these traits, along with collected size of operation, product sources, target markets, etc.

RosBREED socio-economics cont.

Consumer preferences and willingness to pay for fruit traits and market segments: We will conduct two major consumer-level research activities: (1) a national survey of consumers, and (2) a focused, non-hypothetical willingness to pay auction/experiment. These two components will allow us to investigate how consumers perceive fruit quality, both in terms of product and production characteristics, and how much consumers are willing to pay for fruits with different traits; assess different market segments; determine the degree of heterogeneity in fruit crop preferences; and analyze consumer attitudes and statistics that may be useful in explaining such heterogeneity. We believe that combining an economic experiment (without the limitations of a questionnaire type instrument) along with a survey (with a larger and more representative sample) will provide complementary data and more robust results than either method used alone.

Also, as part of the consumer preferences study, we are conducting consumer valuation analyses of intrinsic apple characteristics. Work is proceeding on data cleaning and model estimation of a hedonic pricing model (which is a model of the factors (such as quality) that affect prices, so price indices can be adjusted for changes in these factors) for apple varieties. Using grocery store purchases and household demographics, the model is designed to account for the heterogeneity of both consumers and the physical characteristics of common apple varieties. Early results indicate that price, seasonality, education, age, income, and household composition all affect the frequency and quantity of apples purchased. Work will continue to determine the intrinsic value of characteristics like sweetness and firmness, based on cultivar-specific purchases by consumers.

Relative economic weights for fruit quality traits and production traits: We will use all information previously collected to develop and compare the relative economic weights of various fruit quality and production traits posed by different groups on the five crops targeted by RosBREED. We plan to calculate the relative economic weight for a trait as a weighted average of the marginal values that the three key audiences (consumer, market intermediary and producer/processor) place on the trait. We trust that the relative economic weight for each trait will provide accurate information about the overall importance of traits in breeding programs and will supplement weights currently used. Also, all audiences will benefit by having more reliable insights into consumers' willingness to pay or producers' and processors' willingness to adopt.

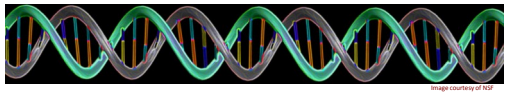
We aim to provide:

- A transparent interactive process for determining social and economic values of production traits and fruit traits and their use in setting breeding targets will be established.
- A method for breeders to routinely use economic weighting of production and fruit traits for selection in Rosaceae MAB.
- Increase awareness of breeding and MAB from Rosaceae producer/processor, marketing group, trade organization and general public.

About RosBREED

What is Marker-Assisted Breeding? This approach uses genetic *markers*, usually DNA-based tests, to monitor the presence of desirable and undesirable *genes* in breeding plants. RosBREED will focus on enabling breeders of apple, peach, tart cherry, sweet cherry, and strawberry to make more informed selection of the *best parents* to combine and the *best seedlings* to advance in cultivar development. Selection for improved fruit quality traits including texture, size, and flavor will thereby be enabled prior to planting young trees or plants in evaluation orchards or field plots, and set the stage for similar advances in other Rosaceae crops. Click here to watch an instructional video about MAB (you will have to click "continue" several times).

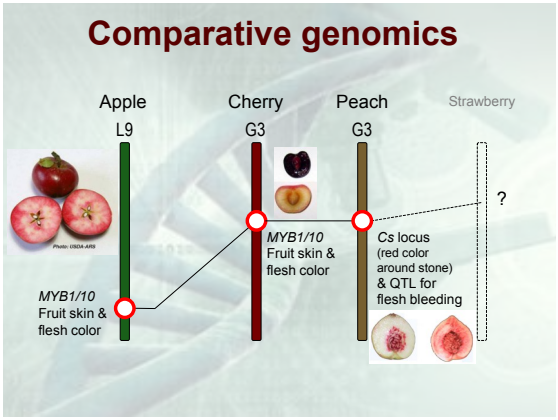
DNA: The genetic code that controls the structure and function of all organisms, including fruit crops.
Gene: A specific segment of DNA that codes for a certain trait.
Genomics: The study of the complete genome of an organism.
Marker: A specific DNA segment that is close to a gene of interest and can be used to predict the presence of the gene.
MAPS: Marker-assisted parent selection
MASS: Marker-assisted seedling selection



Apple, peach & diploid strawberry genome sequences will be available in 2010

Why now? 2010 is a watershed year for the Rosaceae with the anticipated release of the complete peach, apple, and diploid strawberry genome sequences. In addition, over 250 major genes and associations between markers and genes controlling interesting traits have been identified in rosaceous crops. Yet a huge gap exists as this genetic information has rarely been used to improve plant breeding. RosBREED will bridge the application gap and ensure that future breeding efforts leverage genomics and genetics information to more efficiently reach cultivar improvement goals.

Why are we working together as a crop family? The diverse crop types of the Rosaceae are all derived from a common ancestor. This shared ancestry can be harnessed to leverage knowledge and resources across commodity boundaries through a process called comparative genomics. For example, the same gene that controls the presence of red pigment (skin and flesh) in apple (see diagram to right), likely controls the presence of red pigment in cherry fruit and the red color around the stone in peach.



Who will carry out the activities of RosBREED? Twenty -eight scientists from 12 institutions (including USDA-ARS) will conduct RosBREED activities. Six RosBREED researchers serve as team leaders, coordinating various activities of socio-economics, genetics, genomics, information management, breeding, and outreach. All these activities are focused on empowering the 12 RosBREED demonstration breeders of apple, sweet cherry, tart cherry, peach, and strawberry. In addition, we have partners from five other countries who are international leaders in Rosaceae genetics, genomics and breeding.

RosBREED demonstration breeders

RosBREED's 12 demonstration breeders will participate in the full range of RosBREED activities to hammer out and adopt new approaches that allow integration of socio-economics and genomics information into breeding decisions. The goal of the demonstration breeders is to determine the best practices and prove the effectiveness of MAB; these breeders will be the first to implement and demonstrate MAB. The entire community of rosaceous breeders are invited to join us to adopt the latest technology and approaches generated in our project. Please visit our "community breeder" link at www.rosbreed.org/breeding/community-breeders/.

RosBREED demonstration breeders:

Apple
Washington State University (Kate Evans)
Cornell University (Susan Brown)
University of Minnesota (Jim Luby)

Sweet Cherry
Washington State University (Nnadozie Oraguzie)

Tart Cherry
Michigan State University (Amy Iezzoni)

Peach
Clemson University (Ksenija Gasic)
University of Arkansas (John Clark)
Texas A&M (David Byrne)
University of California (Tom Gradziel)

Strawberry
Michigan State University (Jim Hancock)
USDA-ARS Corvallis (Chad Finn)
University of New Hampshire (Tom Davis)


Susan Brown


Kate Evans


Jim Luby


Nnadozie Oraguzie


Amy Iezzoni Photo courtesy of Kurt Stepnitz, MSU


Jim Hancock


Chad Finn
Photo courtesy of USDA-ARS


Ksenija Gasic


John Clark


Tom Davis


Tom Gradziel


David Byrne

Breeder profile: Jim Luby

By Audrey M. Sebolt, project assistant

Jim Luby, University of Minnesota apple breeding program director.

Jim Luby is the current apple breeder at the University of Minnesota, which is one of the oldest breeding programs in the U.S, second possibly to Cornell University's apple breeding program. The program has essentially been running since 1878 and over its history has had five breeders, who together have released 27 apple cultivars. More than 75% of the cultivars grown in the state of Minnesota were developed by these breeders. Although Minnesota is ranked 24th for apple production in the U.S., the innovative contributions of these breeders to the apple industry are inspiring because they have developed trees that withstand the harsh winters of the Midwest and produce quality fruit enjoyed by North American consumers.

Today the strength of the breeding program continues to be exemplified by the flavorful and high quality cultivars that have been commercially released. One such cultivar, 'Honeycrisp', released in 1991, has been such a wide success that citizens of the state of Minnesota successfully petitioned that this cultivar be named the state fruit.

Due to their long generation time, breeding for orchard crops can take many years until a new cultivar is developed. For example, an initial cross was made in 1988 by Jim Luby and his assistant David Bedford, and after 10 years of evaluation, the original seedling was selected in 1999 to be released as Sweetango® apple (Minneiska cultivar). It was not until 2009 that the first commercial fruit from this cultivar were sold to the public.

Jim Luby began working for the University of Minnesota in 1982. In addition to breeding apples, Jim's program also breeds grapes, blueberries, and strawberries. He also collaborates with Dr. John Clark, another RosBREED demonstration breeder, in a project to develop primocane-fruiting blackberries (a type of blackberry that fruits on current-season canes) for the northern U.S. With such extensive commitments to the various breeding programs, Jim feels fortunate to have a dedicated and knowledgeable breeder, David Bedford, working with him. David has more than 30 years of apple breeding experience.

Jim Luby and David Bedford in the apple orchard determining which selections to make crosses

Jim and David manage an apple breeding program that has between 35 to 40 acres and more than 20,000 seedlings. These seedlings are located 30 miles west of the main campus at the Minnesota Agricultural Experiment Station's Horticultural Research Center. Located 200 miles north of the main campus is an additional test site where apple seedlings are tested for cold hardiness.

In the spring, Jim and David make crosses at the research station. Often, at least one of the parents is an advanced selection from their program. Other parents may be contemporary commercial cultivars, selections from other breeding programs, wild apple (*Malus sieversii*) from Central Asia USDA plant introductions, or heirloom cultivars with exotic names such as 'Pitmaston Pineapple', 'Alkmene' or 'Esopus Spitzenburg'. In a typical spring, 20 to 30 parental combinations are made with a target of producing 5,000 F_1 (first generation) seedlings. This

Breeder profile cont.

target seedling number must be high as only 1 out of 10,000 seedlings actually becomes a cultivar that is commercially released.

During the fall, as many as 500 to 600 apple seedlings are evaluated each day for appearance, taste, and texture (click here to see video). Advanced selections are evaluated for numerous traits such as cold hardiness, acidity, skin color (amount of blush, hue, and stripes), firmness, juiciness, crispness, and reduced flesh browning to name a few! The apple breeding program also screens seedlings for disease resistance, primarily scab resistance.

Photo courtesy of David Hansen, University of Minnesota

David Bedford pollinating apples, University of Minnesota apple breeding program.

All of these traits combined ensure an exceptional cultivar, which is important for grower, industry, and consumer preferences. In regards to consumer preferences, Jim states that good appearance will achieve the first sale of an apple cultivar, but quality texture and excellent flavor will ensure a repeat sale. As to what exact appearance or shape of apple the public finds most appealing, Jim said, "That's a good question!" He hopes questions like this will be answered in the RosBREED's socio-economic team's consumer surveys and is looking forward to incorporating these results in his decision-making process.

Although marker-assisted breeding can increase the efficiency of breeding, we are not there yet. There is a chasm between genomics knowledge and its application via marker-assisted breeding. Currently, the University of Minnesota's apple breeding program is only using DNA markers for fingerprinting. For example, Jim's program used DNA markers to identify the true parentage of 'Honeycrisp'. It was originally believed that this variety was a hybrid of the apple cultivars 'Macoun' and 'Honeygold'. However, Jim, David, and other researchers (Cabe et al., 2005) found that 'Keepsake', another cultivar developed by the University of Minnesota's apple breeding program in 1978, is one of the parents of 'Honeycrisp', while the other parent has yet to be identified. The exact lineage of 'Honeycrisp' may be elucidated using cutting-edge software (FlexQTL™) that will be made available to RosBREED's demonstration breeders. In RosBREED, founding clones for breeding programs as well as advanced selections will be genotyped and, through a process called "identity by descent," the other parent and its genetic origin may be discovered. Jim's program is also working towards defining locations in the genome that control fruit texture, such as the explosive crispness of 'Honeycrisp'.

Jim is a demonstration breeder for RosBREED. This means he is one of the 12 breeders who will be the first to test the software and breeding tools developed by RosBREED. Jim, in addition to being the apple crop team leader, is the breeding team leader for RosBREED. His responsibilities include organizing the 12 RosBREED demonstration breeders so that uniform phenotyping protocols are developed, ensuring that critical deadlines are set and kept, and ensuring that the breeders contribute to and understand the new technologies being developed and used by RosBREED.

Jim hopes that the successes of RosBREED will enable his breeding program to routinely screen parental selections with DNA markers for texture as well as other important economic traits. He is also hopeful that seedlings from crosses will be screened for critical markers early during their juvenile phase to eliminate those that will likely have inferior fruit quality.

Reference

Cabe, P.R, A. Baumgarten, K. Onan, J.J. Luby, and D.S. Bedford. 2005. Using microsatellite analysis to verify breeding records: a study of 'Honeycrisp' and other cold-hardy apple cultivars. HortScience 40:15-17.

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."*

Apple texture is a critical eating quality trait. Firm, juicy, crisp-fleshed apples are more desirable than those with soft mealy flesh. A gene that influences apple texture has been identified: *Md-ACS1* (*Malus domestica* 1-aminocyclopropane-1-carboxylic acid synthase). There are two natural variants of this gene. One is involved in normal production of the ripening hormone ethylene in fruit (resulting in softer fruit before and usually after storage) and the other is associated with much lower production of ethylene, thereby allowing fruit to maintain excellent texture for longer periods. A DNA marker that can flag the *Md-ACS1* gene helps to identify which variant is present in any apple plant. Using this marker, apple breeders can now determine which variant each potential parent has. With this valuable genetic insight, they can design crosses that will yield a large proportion of seedlings predicted to have firmer fruit because they have lower ethylene production.

Additionally, those offspring still carrying the undesirable variant can be weeded out at the very young seedling stage so that breeders avoid wasting resources producing and growing trees that will eventually bear soft mealy fruit. Therefore, because *Md-ACS1* will lead to the more efficient breeding of firm, juicy, crisp-fleshed apples, it is selected as our first featured "Jewel in the Genome."

Photo courtesy of Cameron Peace, Washington State University

Soft Apple

Photo courtesy of Cameron Peace, Washington State University

Squishy Apple

Photo courtesy of Cameron Peace, Washington State University

Cameron Peace tasting an apple that is not firm (and not very tasty either!).

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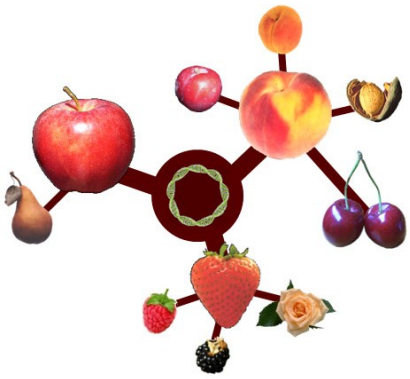

Visit us at

www.rosbreed.org

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Amy Iezzoni (Michigan State University)

RosBREED team leaders:

Name	Team leader for	Organization
James Luby	Breeding	University of Minnesota
Chengyan Yue	Socio-economics	University of Minnesota
Eric van de Weg	Pedigree-based analysis	Plant Research International, The Netherlands
Gennaro Fazio	Breeding information management system	USDA-ARS, Cornell University
Dorrie Main	Genomics	Washington State University
Nahla Bassil	Genotyping	USDA-ARS, Corvallis
Cameron Peace	MAB pipeline	Washington State University
Cholani Weebadde	Outreach	Michigan State University
Jim McFerson	Stakeholder	Washington Tree Fruit Research Commission

Calendar of events

- **March 1: International Fruit Tree Association meeting, Grand Rapids, MI. Dinner with Advisory Panel members and Co-PDs.**
- **August 2-5: American Society for Horticultural Science Annual meeting, Palm Springs, CA. RosBREED workshop, introduction to the U.S. Rosaceae community breeders.**
- **August 22-27: XXVIII International Horticultural Congress, Lisbon, Portugal. Series of RosBREED presentations in various colloquia and workshops.**