Plant Breeding Center at UC Davis

Five years ago, the Seed Biotechnology Center’s Allen Van Deynze led a project to document the contributions to agriculture of 100 years of plant breeding at UC Davis. This document makes both educational and inspirational reading, as it illustrates the remarkable advances in yield and quality that have been made through plant breeding in a wide range of crops and recognizes the personalities behind these achievements. Many of these individuals are icons in the history of plant genetics and breeding, including Charles Rick, Gurdev Khush, Royce Bringham, Robert Allard, Fred Briggs, Jack Hanna, Henry Jones, Harold Olmo, Charles Schaller, Cal Qualset, Dale Kester, Harold Forde, Paul Knowles, Ted Welch, Paul Smith, Frank Zink, Ron Voss and others.

In addition to the new crop varieties and breeding methods developed, these individuals were in many cases outstanding educators and mentors, inspiring a generation of working plant breeders, educators and extensionists who expanded their important work. Subsequent UC Davis plant breeders and geneticists have continued this tradition of excellence in a wide range of crops important in California, including strawberry (Doug Shaw), lettuce (Richard Michelmore), alfalfa (Larry Teuber), wheat and barley (Jorge Dubcovsky, Lee Jackson, Lynn Gallagher), rice (Neil Rutger, Kent McKenzie, David Mackill, Pamela Ronald), tomato (Allen Stevens, Roger Chetelat, Dina St. Clair), beans (Steve Temple and Paul Gepts), celery and brassicas (Carlos Quiros), flowers (Jim Harding), maize (Jeff Ross-Ibarra), walnuts (Gale McGranahan), almonds and peaches (Tom Gradziel and Fred Bliss), grapes (Andy Walker), plums (Ted DeJong), pistachio (Dan Parfitt) and other crops (Dan Kleibenstein).

Despite this long history of valuable contributions to California’s agriculture, a faculty study in 2011 documented the loss of 17 plant breeding positions at UC Davis in the past 15 years without replacement. Also in 2011, the SBC organized a brainstorming session with seed/food industry leaders where continuing both the practice and training of plant breeding at UC Davis was ranked as a high priority. It was recognized that maintaining active germplasm improvement programs is critical both for supporting the breeding efforts of private industry and for ongoing training of skilled plant breeders for that industry.

Fortunately, with the support of both the Department of Plant Sciences and the College of Agricultural and Environmental Sciences, a vision for continuing and enhancing the investment in plant breeding at UC Davis is emerging. With the support of former Dean Neal Van Alfen and current interim Dean Mary Delaney, the concept of a Plant Breeding Center (PBC) at UC Davis has been developed. First proposed by the faculty study group in 2011 and subsequently developed into an implementation plan in 2012, it is envisioned that establishment of the PBC will reverse the erosion of plant breeding resources and instead begin to restore and expand our research and education activities in this area.

Several new faculty positions in plant breeding and genomics are on the Plant Science Department’s academic plan, including one associate or full professor who will be recruited to serve as director of the new center. The director and the PBC will provide leadership and focus for public plant breeding activities and foster mutually beneficial interactions with the seed and breeding industry. In particular, attention will be directed toward enhancing recruitment, support and training of students in genetics and plant breeding to meet the burgeoning global demand.
The SBC will work closely with the new Plant Breeding Center, including merging of administrative and support staff for both efficiency and synergy. It is evident that some SBC programs, such as the Plant Breeding Academy, will benefit from an organized, renewed and committed plant breeding faculty and will mesh immediately with the goals of the PBC. As was emphasized by participants in our brainstorming session in 2011, the SBC itself will not be replaced by a PBC as we enhance plant breeding at UC Davis. Instead, the renewed investment in plant breeding will be complementary to the SBC’s research, educational, outreach and public service programs and will enhance the overall value of the public-private partnerships that support California’s agricultural industry.

Kent J. Bradford, director
Photo by: Neil Michel
Education

Plant Breeding

Many of the Seed Biotechnology Center’s (SBC) activities are associated with plant breeding. The following activities occurred in 2012.

Plant Breeding AcademySM

The UC Davis Plant Breeding Academy (PBA) is a postgraduate program that teaches the fundamentals of plant breeding, genetics and statistics through lectures, discussion and field trips to public and private breeding programs. Employers appreciate the opportunity to provide their valued employees advanced training without disrupting their full-time employment. Upon completion of the program, participants will have spent over 300 hours in classes, workshops and the field, training to become professional plant breeders. To date, the Academy has or is training a total of 114 breeders.

Highlights in 2012

Davis Class III met at UC Davis in February and again in June for their graduation. Participants were:

- Miguel Ahumada, Driscoll Strawberry Associates, USA
- Laura Brown, K&B Development, LLC, USA
- Jarunee Buaboocha, Chia Tai Co. Ltd., Thailand
- Kanlayanee Chaichana, Chia Tai Co. Ltd., Thailand
- Jonathan Gienapp, HM Clause, USA
- Francine Giusti, Monsanto Vegetable Seed Co., USA
- Anna Hall, Bayer CropScience, USA
- Jim Irvine, Boll Horticultural Company, USA

Europe Class II: This class completed sessions in Angers, France, Gatersleben, Germany and Enkhuizen, The Netherlands. Course participants include:

- Fulya Arslan, Monsanto Vegetable Seeds, Turkey
- Aimi Bar, A.B Seeds, Israel
- Constanze Böhmel, KWS Saat AG, Germany
- Anđrija Brkic, Agricultural Institute Osijek, Croatia
- Tomás David Tomas Cano, Monsanto, Spain
- Bruno Chombart, Syngenta, France
- William Colfer, Plant Sciences, Inc., USA
- Santiago Garcia Fernandez, Semillas Fió, Spain
- Juan Antonio Fernandez Garcia, Semillas Fió, Spain
- Selda Guzelkucuk, HM Clause, Turkey
- Katja Hämäläinen, Boreal Plant Breeding Ltd., Finland
- Sophie Lücke, Norddeutsche Pflanzenzucht Hans-Georg Lembke KG, Germany
- Sandor Parisci, Dow AgroSciences, Hungary
- Miguel Roca Rodriguez, Syngenta Seeds, Spain
- Julia Rudloff, University of Goettingen, Germany
- Barbara Scheike, Deutsche Saatveredelung AG, Germany
- Derya Tescilar, MayAgro, Turkey
- Harold Verstegen, KWS Lachow GmbH, Netherlands
- Jakob Witten, Monsanto SAS, France

Davis Class IV began at UC Davis in September 2012. Meet Class IV:

- Xavier Barreto, East-West Seed Company Inc, Philippines
- Craig Bednarz, Bayer CropScience, USA
- Matthew Calloway, Rice Experiment Station, USA
- Linda (Chia-Hui) Chang, Known-You Seed Co, Taiwan
- Adrianne Difuntorium, HM Clause, USA
- Diego Alejandro Drucetta, NuSeed S.A., Argentina
- Peter Flett, NuSeed, Australia
- Stephane Gorin, Green Seeds Inc, USA
- Ginger Light, Bayer CropScience, USA
- Rogelio Marchetti, Pioneer DuPont, USA
- Renae Robertson, Driscoll’s Strawberry Associates, USA
- Robert Schimerowski, Pannar Seed, Inc., USA
- Rolando Solano, Ball Horticulture Company, Costa Rica
- Mariano Sposaro, Nidera S.A., Argentina
- Jennifer Vaughn, Pioneer, USA
- Michelle Wood, Bayer CropScience, USA
Asian Class I: The newest addition to the program started in November 2012 in Chiang Mai, Thailand, in collaboration with the Asian & Pacific Seed Association and East-West Seeds.

The Asian Academy participants include:
Nor Azwani Abu Bakar, Malaysian Palm Oil Board, Malaysia
Thu, Bui Viet, Syngenta, Vietnam
George Jubay, Syngenta, Philippines
Chanapong Khamkanya, Chia To Co., Ltd., Thailand
Maria Venus Salutan, East-West Seed Company, Philippines
Chun-Lin Su, Known-You Seed Co. Ltd., Taiwan
Chanin Taweekij, Syngenta, Thailand
Gang Wang, Urumqi Yunong Seed Co. Ltd., China
Zulkifi Yaakub, Malaysian Palm Oil Board, Malaysia
Pichet Yamyen, Hortigenetics Research, Thailand
Ren Yi, National Engineering Research Center for Vegetables, China
Shuancang Yu, Beijing Vegetable Research Center, Beijing Academy of Agriculture and Forestry Science, China
Luan Zhaoshui, Degao Vegetable Seed and Seedling Research Institute, China

African Plant Breeding Academy

Last year the African Orphan Crops Consortium launched an effort to sequence the genomes and facilitate breeding of some of Africa’s neglected native crops. In partnership with African scientists, the consortium will genetically sequence almost 100 crops, making the information freely available and enabling advanced breeding techniques to develop new varieties that are higher yielding, more nutritious, and more tolerant to environmental stresses such as drought. In time, the selected species could play important roles in the African diet and help improve health, food security and economic vitality on the continent.

As part of the initiative, the SBC is establishing the African Plant Breeding Academy in Nairobi, Kenya to train African scientists and breeders in the latest technologies for applying genomic information to crop breeding. In 2012, much of the curriculum was developed and plans were made for the program. The SBC is pleased that Dr. Rita Mumm, Department of Crop Sciences, University of Illinois agreed to contribute to the development and delivery of the program, which is anticipated to begin in December 2013.

Doug Shaw Retires from PBA

Dr. Doug Shaw has decided to retire from teaching in the Davis PBA. The SBC would like to recognize his involvement, dedication and commitment to the PBA. Dr. Shaw was one of the founding instructors who helped to build the program. Dr. Shaw became involved before the first session in 2006 to design the curriculum, plan the schedule and help select the first class. Participants thoroughly appreciated Dr. Shaw’s ability to take complex topics such as quantitative genetics and selection theory and explain them so effectively. One participant who already had a PhD in another discipline noted that Dr. Shaw was the best instructor he had ever had. The SBC appreciates Dr. Shaw’s role in creating the Academy and establishing its high standards.
Modern Tools in Plant Breeding Symposium
This one-day program supported by Pioneer Hi-Bred and UC Davis was held on April 20, 2012. Graduate students, including SBC’s William “Zeb” Rehrig, organized and hosted the event, providing training in essential management skills and public speaking. Presentations and speakers included: Genomics and epigenomic variation among maize inbreds, Dr. Nathan Springer, University of Minnesota; Next-generation tools for studying genomics of wheat evolution and improvement, Dr. Eduard Akhunov, Kansas State University; Engineering rice for disease resistance and submergence tolerance, Dr. Pamela Ronald, University of California, Davis; Comparative genomics of plant-pathogen specificity, Dr. Richard Michelmore, University of California, Davis; Genomic selection in plants: empirical results and implications for plant breeding, Dr. Mark Sorrells, Cornell University; and Genetic and epigenetic diversity of maize from a plant breeding perspective, Dr. Antoni Rafalski, Pioneer Hi-Bred. Over 150 participants attended this annual event in person or via webinar.

SolCAP Workshops
Allen Van Deynze and his Solanaceae CAP (SolCAP) project colleagues hosted two workshops for plant breeders seeking to make better use of DNA sequence data in the context of crop improvement. Each workshop was also offered via a webinar. The first program was on August 1, 2012 in Miami, Florida in conjunction with the American Society for Horticultural Science. The second was on August 8-9, 2012 in Denver, Colorado during the Potato Association of America Annual Meeting. SBC’s Jeannette Martins coordinated the workshops. All talks were recorded and broadcasted as webinars and are available on the website (www.extension.org/plant_breeding_genomics).

Breeding with Molecular Markers Course
The fifth offering of this course brought over 60 participants to campus for two days of instruction. A diverse range of people, including some from overseas, learned and discussed the application and integration of molecular markers into their plant breeding programs. This intensive course was taught by experienced academic and industry professionals including Allen Van Deynze, Rale Gjuric, Richard Michelmore, Jorge Dubcovsky and Alison Van Eenennaam, UC Davis, David Francis, The Ohio State University and Edie Paul, Geneflow. In addition to lectures, a half-day hands-on computer session focused on integration of genomic data in breeding. The SBC is offering this course again in February, 2014 when it will be titled “Breeding with Genomics.”

Program Management for Plant Breeders
A new course is being developed to enhance the management skills of professional scientists who are leading and directing plant breeding and laboratory programs in modern agricultural research and development programs of agribusiness companies and the public sector. This new and exciting course launches September 17–19, 2013 at UC Davis.

Here are a few topics that will be presented:

- Understanding where your plant breeding or research program fits in the overall strategy of the organization. Establishing a vision and goal for your program and defining your key strategies and capacities.
- Comprehending the financial aspects of your program. Managing budgets, expenses, capital projects and period reporting. Reading and understanding a financial statement and managing your resources within the goals of your organization.
- Leading and managing people towards a common goal. Learning the principles of effective hiring, retention, evaluation, promotion, training, mentorship and motivation. Handling difficult situations using conflict resolution. Dealing with and embracing change and creating a culture of innovation.
- Creating effective and efficient programs. Understanding the principles of work flow, scheduling, safety, and legal compliance. Learning issues surrounding intellectual property and contracts, treaties and agreements.
Plantbreeding.ucdavis.edu – Updated
The Department of Plant Sciences provided funds to update this website under the direction of Dr. Allen Van Deynze. The new site better communicates the breadth and capacity of plant breeding expertise at UC Davis by highlighting faculty research programs, centers and affiliated activities as well as UC Davis’ strong history in plant breeding. In addition, to strengthening outreach to potential undergraduate and graduate students, it also provides information on plant breeding educational opportunities for industry professionals. Kudos to Kitty Schlosser for creating the new site. To keep current on the latest UC Davis plant breeding activities, go to: plantbreeding.ucdavis.edu.

Seed Business 101SM
This one-week course exposes participants to the five functional areas of a seed company (research and development, production, operations, sales and marketing and administration). The course content is delivered in a very interactive way by creating a virtual seed company and exploring case studies for each functional area. The program gives people new to the seed industry a broad understanding of the major aspects of a seed company’s operations and cross-departmental knowledge of best practices for profitability. The course is taught by widely respected industry executives with additional help from experts participating as guest speakers. In June 2012 we began offering two distinct programs, one focusing on field crops and the other on horticultural crops. More than 170 participants have completed this course since 2010. The following sessions were offered in 2012:

- January 16-20, Wimauma, Florida
- Field - June 11-15, Minneapolis, Minnesota
- Field - September 17-21, Lafayette, Indiana
- Horticulture - December 3-7, Davis, California
OUTREACH & PUBLIC SERVICE

Seed Central/Food Central

Seed Central is an initiative of the Seed Biotechnology Center and SeedQuest, joined by a growing number of companies and organizations in the global seed and food industry. Formally launched in November 2011, Seed Central’s purpose is to energize the seed industry cluster surrounding UC Davis and to bring science to market faster. Seed Central activities are funded via industry memberships and sponsorships. Seed Central is a non-profit corporation and the SBC serves as its UC Davis liaison. In 2012, Seed Central added Food Central to its efforts, enabling the seed industry to become better engaged with the food industry and visa versa. To attend the Forums and value-added afternoons, please mark your calendar on the second Thursday of each month (during the academic year) and join us. Each Forum typically has 80-100 students, faculty, industry scientists, entrepreneurs and economic development officials attending, providing a truly unique and powerful networking opportunity.

2012 Seed Central Forum Presenters and Topics:

Dr. Eduardo Blumwald, professor, Department of Plant Sciences, Engineering environmental stress resistance in crop plants.
Dr. Pamela Ronald, professor, Department of Plant Pathology, “Engineering plants for tolerance to stress and resistance to disease.”
Dr. Roger Chetelat, geneticist, Department of Plant Sciences, “The relationship between self and interspecific incompatibility in tomato, and potential applications in the use of wild germplasm resources.”
Dr. Roberta Cook, extension specialist, Agricultural and Resource Economics, “Key trends in the fresh produce industry: opportunities and challenges.”
Dr. Luca Comai, professor, Department of Plant Biology, “Multiple tools for crop improvement through DNA sequencing.”
Dr. Barry Eisenberg, vice president, Food Safety Services, United Fresh Produce Association (this program was at Hartnell College at the Alisal Campus), “New food safety demands and challenges for our industry.”
Dr. Carl Keen, professor, Department of Nutrition, “Flavanol-rich foods: an approach to helping maintain good vascular health?”
Don Goodwin, president, Golden Sun Marketing, “A fresh perspective on changes to our local food systems. The retailer’s perspective on GMOs, community-assisted agriculture, and the rising new trend of urban hothouses.”
Dr. Alan Bennett, professor, Department of Plant Sciences, “Linking plant genomes to food quality – making a better tomato.”
Dr. J. Bruce German, professor, Department of Food Science and Technology, “Foods for Health: bringing health benefits to genetic traits.”

In addition to the Forums, three “value-added” afternoons featured lively brainstorming and science sessions. For a complete list of activities see www.seedcentral.org.

Corporate Affiliates Partnership Program
The Seed Central team worked diligently with the UC Davis technology transfer office to create the Plant and Seed Sciences Partnership Program (PSSPP) which was approved in October. This program, coordinated by the SBC, will facilitate interactions between UC Davis, Seed Central and its members. The PSSPP offers three “tiers” of collaboration with a range of benefits. A special thanks goes to PIPRA’s Dr. Cecilia Chi-Ham, part of the Seed Central team, for leading the effort. The SBC was the first campus program to use this vehicle to enhance industry collaborations with campus programs. For more information visit www.seedcentral.org.

Collaborative Research (CoRe) Laboratory
Discussions continued with campus leaders, companies and faculty to determine the need and interest in establishing a new collaborative research facility located on the UC Davis campus. Such a facility is envisioned to provide laboratory and administrative space for companies, house sponsored research projects, provide access to shared service programs, and contain space for start-up ventures. In addition, meeting and educational spaces for symposia and courses are also being explored. Visits were held with individual companies to gauge interest and support for this initiative along with investigations of other research park models. Additional development will continue to be explored in 2013. See www.seedcentral.org for more information.

An endowment for the future
The Seed Biotechnology Center has established a thriving partnership with the seed industry, enabling it to become a vibrant part of the university and a critical resource for the advancement of seed science. However, state funding does not guarantee a faculty position dedicated to seed science nor a director for the Seed Biotechnology Center. An Endowed Chair in Seed Science would create a new position for a faculty member at UC Davis who would be focused on seed biology and technology and would serve as the director of the Seed Biotechnology Center. An endowment will ensure that the seed industry’s needs for academic research, education and public service can continue to be met in perpetuity. For more information or to contribute to this goal, contact scditomaso@ucdavis.edu.

Her Royal Highness Princess Maha Chakri Sirindhorn of Thailand visits UC Davis
On May 14-15 the Princess of Thailand and senior Thai academic scientists accompanying her showed high interest in the newest developments in agricultural and nutritional research presented to them by UC Davis faculty. HRH the Princess is a knowledgeable and dedicated supporter of agricultural research and education. (continued on page 10)
At the UC Davis workshop, Allen Van Deynze and Kent Bradford had the honor to present a summary of recent SBC activities. Allen described a new SBC educational program, the Asian Plant Breeding Academy that began in November 2012 in Thailand in collaboration with the Asian & Pacific Seed Association. Kent updated HRH the Princess on a novel technology (desiccant drying beads) that is being implemented to address the challenge of safely drying and storing seeds under humid conditions such as occur in Thailand. Such expertise and methods will be instrumental for adoption of advanced seed technologies in Thailand’s agricultural industry. HRH was sufficiently intrigued that she subsequently participated in a Drying Beads Showcase held in Bangkok in October, considerably elevating the profile of that event.

**Enticing the Next Generation of Plant Breeders**

The SBC continued its collaboration with the UC Davis Student Farm and Children’s Garden program, managed by Raoul Adamchak and Carol Hillhouse, respectively. Through this integrated program, graduate student Ildi Carlisle-Cummins worked with undergraduates to develop K-12 activities and lessons that were delivered to 500 elementary school students and 115 high school students. Activities included pepper identification, pepper crossing and diversity, taking field notes and “Soils to Salsa” cook-offs. In addition, undergraduate interns provided informational pamphlets on plant breeding with their community garden customers, including the UC Davis Food Services.

**UC Davis & Wageningen University Collaboration**

Members of the College of Agricultural and Environmental Sciences, including several from the SBC, participated in an April workshop with a group from Wageningen University (WUR) to discuss future collaborations, funding needs and potential opportunities. The SBC’s Kent Bradford and WUR Seed Center’s Henk Hilhorst were awarded funding for “Planning for complementary courses on seed biotechnology and production at WUR and UC Davis.” These funds will be used to develop a 2013 instructional exchange program.
California Proposition 37 – GMO Labeling

Center director, Kent Bradford, provided a voice for science leading up to the vote on Proposition 37 (Prop 37). Along with other items, Prop 37 would have required the labeling of food that may contain any genetically modified ingredients, and in addition, it could not be labeled as natural. The proposition would have had significant impacts on agriculture, the food industry and consumers. Dr. Bradford served on panels, provided scientific information to agencies, legislators and associations and participated in many interviews in order to make sure the science behind plant genetic engineering was not overlooked. In the November vote, the proposition was narrowly defeated in California, but similar initiatives were underway in other states.

Visitors

Each year the SBC hosts numerous visitors from the global seed industry, from universities, agencies or other programs. In 2012 we met with very diverse groups; the following lists highlights a few examples:

- A delegation from Russia through the US Department of State International Visitor Leadership Program.
- A group of twenty representatives from multiple agencies in Washington DC (i.e., Food and Drug Administration, Environmental Protection) Agency, United States Department of Food and Agriculture, Center for Disease Control and Prevention, etc.).
- The American Seed Trade Association FUSE participants.
- Representatives from the Chinese Academy of Agricultural Sciences.
- The Cochran Fellows, a program of the Foreign Agricultural Service.

Board and Committee Service

American Seed Trade Association
Biotechnology Committee - Kent Bradford, Allen Van Deynze
Future Seed Executives - Susan DiTomaso
Intellectual Property Rights Committee - Kent Bradford, Allen Van Deynze
Stewardship Committee - Allen Van Deynze

California Crop Improvement Association
Board of Directors - Kent Bradford

California Potato Research Advisory Board
UC Liaison - Kent Bradford

California Seed Association
Board of Directors - Susan DiTomaso
Industry Communications & Youth Committee - Susan DiTomaso
Plant Breeders & Biotechnology Committee - Kent Bradford (chair), Allen Van Deynze
Vegetable and Flower Seed Committee - Kent Bradford, Allen Van Deynze
Seed Industry Conference Committee - Susan DiTomaso

European Plant Science Organization
Plant European Technology Platform (ETP) Education Working Group Member - Rale Gjuric

Genome
Journal Associate Editor - Allen Van Deynze

International Seed Testing Association
Advanced Technologies Committee - Kent Bradford

National Association of Plant Breeders
Eucarpia liaison - Rale Gjuric

Plant Breeding Coordinating Committee
Chair - Allen Van Deynze

Plant Variety Protection Office
Advisory Board Member - Kent Bradford
2012 was an exciting year for our research efforts to develop and apply tools in plant breeding and seed improvement, as the SBC expended over $1,400,000 in extramural funds that supported 20 associate researchers, assistant researchers, postdocs, MS and PhD students, visiting scholars and several undergraduate and high school interns.

**Seed Drying Technology**

HortCRSP Seed Systems project extends novel seed drying methods for humid regions

The US Agency for International Development (USAID) and the Horticultural Collaborative Research Support Program (HortCRSP) awarded SBC director Kent Bradford and collaborators in Thailand, Bangladesh, Nepal, India and Kenya almost $1 million in 2011 for a 3-year project to improve and disseminate a novel method for seed drying using desiccant beads. The drying beads enable seeds to be dried to safe storage moisture contents even in high humidity climates, and also protect the seeds from damage due to molds, insects and rodents by storage in waterproof containers. The drying technology is scalable from individual farmers to large industrial seed drying and storage facilities. For more information, see http://hortcrsp.ucdavis.edu/main/4Seeds.html.

**Carrot**

Applying new tools for carrot breeding

SBC’s Allen Van Deynze continues to work with Philip Simon (USDA/ARS, Wisconsin) and an international industry consortium (Bejo, Nunhems, Rijk Zwaan Takii and Vilmorin) to develop and apply new tools for carrot breeding. In 2012, they genotyped 4,000 SNPs on 192 diverse carrot lines from around the world. A recent publication from this work (Iorizzo et al., 2013) reveals that domesticated carrots from the East and West have a common ancestor in Asian carrot and that there does not seem to be a genetic bottleneck between wild and domesticated carrots based on the same level of diversity among and within these groups. The consortium has expanded to also include Carosem, Monsanto and Sumika to sequence the carrot genome, taking advantage of the partnership between UC Davis and Beijing Genome Institute. The genome sequence will be available in 2014.

**Cotton**

Development of a haploid induction system for cotton

In collaboration with David Tricoli and David Stelly (Texas A&M), the SBC is translating research developed in Arabidopsis in the Simon Chan lab to cotton. Chan identified a specific chromosomal protein (CenH3) that can be modified to simplify the development of haploid plants. To continue the work from 2011, the orthologous gene from cotton was isolated, modified and transformed into cotton at the Ralph M. Parsons Foundation Plant Transformation Facility. Furthermore, a more efficient transformation protocol for cotton is being developed. This work was funded by Cotton Incorporated.

Sampling nucleotide diversity

The SBC continues to refine its resources and databases on cotton diversity. We have combined resources with Joshua Udall (Brigham Young University) and David Stelly (Texas A&M) to add sequences of cotton diploid progenitor species Gossypium arboreum and G. raimondii. By doing so, we have developed an efficient bioinformatics pipeline to mine and validate SNP markers in cotton across five species with multiple accessions addressing barriers due to polyploidy in cotton. These markers are currently being evaluated with the intention to combine them into a public Illumina Infinium array for genotyping in cultivated cotton. Furthermore, the gene sequences identified in this work were made available to the D-Genome sequencing project providing significant resources to functionally annotate the cotton genome (Paterson et al., 2012). This work was funded by Cotton Incorporated.

**Lettuce**

Identification of genes involved in lettuce seed thermoinhibition

Germination of lettuce (*Lactuca sativa*) seeds is delayed or inhibited when planted at warm temperatures, leading to delays or failures in germination and seedling emergence and resulting in yield losses and higher costs. The Bradford lab in collaboration with the Michelmore lab identified a quantitative trait locus (QTL) that regulates the temperature sensitivity of germination and subsequently demonstrated that a gene (*LsNCED4*) encoding an enzyme in the biosynthetic pathway for abscisic acid (ABA) is responsible for the trait. Germplasm containing the native trait introgressed into a cultivated background and mutants in the *LsNCED4* gene (in collaboration with Arcadia Biosciences), both with capacity for germination at higher temperatures, are available for public distribution for research purposes. A second QTL from a different genetic source that also improves germination at high temperatures is currently being fine-mapped and characterized. This research is supported by the National Science Foundation, USDA-National Institute of Food and Agriculture and the UC Davis Department of Plant Sciences.
Effects of maternal environment during seed development on lettuce seed thermoinhibition
As noted previously, cultivated lettuce seeds generally lack the ability to germinate at warm temperatures. However, the upper temperature limit for germination is sensitive to the environment in which the seeds were produced: seeds matured at warm temperatures can germinate at higher temperatures than seeds matured at lower temperatures. The Bradford lab is seeking to identify the genetic mechanisms responsible for this environmental plasticity with the goal of making seed performance more consistent and less dependent upon the location of seed production. This work is supported by the Western Regional Seed Physiology Research Group, a consortium of seed and seed technology companies (American Takii, Ball Horticultural, Bejo Zaden, East-West Seeds, Enza Zaden, Germain’s Technology Group, HM.Clause, INCOTEC, Monsanto Vegetable Seeds, Nunhems USA, Rijk Zwaan, Sakata Seed America, Seed Dynamics and Syngenta).

Role of ethylene in lettuce seed thermoinhibition
In addition to ABA, the plant hormone ethylene also can influence lettuce seed germination at warm temperatures. With support from Rijk Zwaan, the Bradford lab is investigating genes involved in ethylene synthesis and action that may be associated with regulating germination. The project aims to identify and clone genes in which mutations have altered ethylene responses and germination behavior.

Pepper

Defining the genetic basis of Phytophthora capsici resistance
In an effort to define the inheritance and combine genetic factors controlling resistance to Phytophthora capsici in pepper, the SBC is leveraging technology developed to screen 31,000 genes simultaneously (Hill et al., 2013). A high density genetic map was generated from 63 RILs derived from Criollas de Morelos (CM334) and Early Jalapeno with 3,800 unigenes. The population has been screened with 20 isolates of P. capsici from Mexico, US and Peru. Virulence of isolates was not correlated with species or region collected from. Dense genetic maps have revealed high quality candidate genes in major QTL for resistance. These are being verified in other populations using functional genomic approaches. This research has been utilized to recruit grade school and undergraduate students into plant sciences (see Education). This project is funded by the USDA National Institute of Food and Agriculture and Department of Plant Sciences, UC Davis.

Developing novel sources of virus resistance in pepper
The SBC is working with Jose Ruiz-Luna from Autonomous University, Aguascalientes, Mexico and Bob Gilbertson, UC Davis, to screen 150 wild C. annuum var. glabriusculum accessions collected in western Mexico for resistance to viruses. Lines are also being crossed with a Jalapeno line to integrate resistance genes in chile pepper. This work is supported by a NSF fellowship awarded to Ms. Randi Jimenez, a PhD student working on the project.

Determining the basis of haploid induction
Doubled haploid plants provide simpler genetics and can significantly enhance breeding programs. They are pure breeding and can be produced in a single generation using various methodologies, including culture of pollen grains (microspores). In pepper, only certain lineages are amenable to this technology. Through the UC Discovery program, the SBC partnered with Rijk Zwaan to study the genetic bases of embryogenesis and regeneration of plants from microspores in pepper. The SBC is currently screening a large RIL population to correlate genotype with phenotypes, with the goal of identifying genes regulating embryogenesis and regeneration that may confer genotype specificity to anther culture in pepper.
Spinach
Spinach production in California has increased steadily with the introduction of fresh market clipped products in the 1990s. This is also accompanied by an increase in incidence of disease, including Pernospora farinose (downey mildew), fusarium wilt and verticillium wilt. To develop molecular tools to address the challenges in controlling these pathogens, the SBC is taking advantage of the UC Davis Corporate Affiliates Partnership Program with a consortium of Seed Central members and BGI to sequence the genome of spinach. Consortium members include Rijk Zwaan, Pop Vriend, Syngenta, Enza Zaden, Nunhems, Sakata Seed America and Takii. The sequence will become publicly available.

Tomato
Developing and applying SNP markers
The SBC and David Francis, Sung-chur Sim (The Ohio State University) and David Douches (Michigan State University) extended the efforts of the Solanaceae Coordinated Agricultural Project (SoCAP) to public tomato breeders by developing and applying markers (SNPs) to four public breeding populations from Sam Hutton (University of Florida), Dilip Panthee (North Carolina State University), Leonie Moyle (Indiana University) and Martha Mutschler (Cornell University). These populations segregated for fruit quality and disease resistance. This work is supported by the USDA National Institute for Food and Agriculture.

Engineering disease resistance
Bacterial spot is a serious disease in tomato production, especially in humid areas such as Florida and Ohio. The SBC partnered with 2-Blades Foundation to transfer resistance to this pathogen from pepper to tomato using genetic transformation. Over 800 genetic events were created at the UC Davis Ralph M. Parsons Foundation Plant Transformation Facility and tested molecularly and for disease resistance using greenhouse assays. A subset of lines was also tested in the field with Jay Scott, University of Florida, with promising results.

Seed physiology and technology
Seed respiratory patterns during germination
As soon as they take up water, seeds begin to respire in order to generate the energy required to power germination. The SBC has been using an instrument, the Astec Q2, to study respiratory patterns of individual seeds during germination. New ways to analyze this data have been developed that make the results more readily understandable and amenable to analyses commonly applied to seed germination data. There is potential for Q2 data to substitute for labor-intensive determinations of germination time courses. This research was supported by a consortium of seed and seed technology companies (Bejo Zaden, Callas International, Coating Supply Inc., Germain’s Technology Group, Hoopman Equipment, INCOTEC, Monsanto, Nickerson-Zwaan, Rhino Research, Rijk Zwaan, SESvanderHave and Syngenta).

Seed storage and longevity
Seeds are very sensitive to moisture content during storage. Just a 1% increase in seed moisture content can reduce seed storage life by half. Interestingly, seed moisture content differs depending upon whether the seeds are gaining or losing water (termed hysteresis). SBC research has now shown that these differences in seed moisture content, which average about 0.5% of fresh weight, result in corresponding differences in seed longevity for several species (carrot, pepper, radish and sweet corn). This indicates that the longevity of seeds in storage can be extended simply by first drying them to low moisture contents and then raising their moisture content back to the desired storage level. This work was supported by the Western Regional Seed Physiology Research Group (see above).

The SBC Research Team
PUBLICATIONS


SBC Team

Thank you Jeannette

The SBC congratulates Jeannette Martins for her move to become the program representative for the newly established West Coast Metabolomics Center. Jeannette started volunteering at the SBC in March 2007. For nearly one and a half years, she learned about the SBC and developed numerous outreach materials as well as provided extra hands at events and other activities. In 2008 we hired Jeannette to be one of our program representatives where she served as the lead support person for the SolCAP workshops, many of our two-day courses and ultimately, Seed Business 101. The center is grateful for all of her work and dedication and we wish her the best in her new position.

The team...

Kent Bradford
Allen Van Deynze
Sue DiTomaso
Rale Gjuric
Joy Patterson
Donna Van Dolah
Jeannette Martins

Meet Sally Mohr

In November 2012, Sally Mohr joined the SBC to provide support for the Asian Plant Breeding Academy. Sally works with instructors, on-site organizers and participants to ensure that all aspects of the academy run smoothly and seamlessly. We are pleased to add Sally to the team. In addition to her work at the SBC, she also plans workshops and other events for the UC Davis California Center for Urban Horticulture.
George Kotch visits the SBC

In June, George Kotch came to the SBC as a visiting scientist after leaving a global research and development position in a worldwide seed company. He was instrumental in helping to expand Seed Central into Food Central and provided valuable input on the CoRe Lab project and the Corporate Affiliates Partnership Program. He was also involved with developing curriculum for an Associates degree focused on seed technology. The SBC thanks George for becoming a part of our team during his six-month visit.

SBC Advisory Council

The center would like to recognize and thank our Council for their valuable support, insights and advice provided on behalf of the seed industry.

Phil Ashcraft, Rick Falconer, Paul Frey, George Gough, Gary Hudson, Francois Korn, Betsy Peterson, Chip Sundstrom, Mary Wadsworth, Gary Whiteaker and Chris Zanobini.

In memoriam: Simon Chan

On August 22, 2012, SBC colleague and friend Dr. Simon Chan passed away. Dr. Chan was best known for his research on the function of centromeres of chromosomes, resulting in a novel strategy for creating doubled haploids. His brilliance and generosity will be missed, even as the SBC and many others continue to explore the implications and applications of his research discoveries.
Plant Breeding Education: Responding to the need

There is no doubt that there is an ongoing demand for formal education degrees (BS, MS and PhDs) in plant breeding. As chair of the US Plant Breeding Coordinating Committee and member of the National Association of Plant Breeders, I had the opportunity to have direct input into the future investments in plant breeding, including education. For example, we stressed the importance of maintaining strong public plant breeding programs in order to educate plant breeders in the field. This is supported by the USDA, as Dr. Catherine Wotecki, Undersecretary of USDA’s Research, Education and Economics section has created and is leading a Plant Breeding Working Group across USDA programs. Furthermore, the 2012 Presidential Advisory Science Committee and Technology Committee recommended increasing funding in agriculture, emphasizing plant breeding to address food security. Strong lobbying and guidance will be needed to implement these activities.

Formal degrees are only the beginning of learning, especially in the rapidly evolving discipline of plant breeding that encompasses an increasing number of topics and technologies in plant agriculture. For over a decade, the SBC has listened to its partners in industry and developed continuing education programs, offering 2-day courses in Seed Biology, Production and Quality and Breeding with Molecular Markers in alternating years since 2001. These classes are taught by UC Davis faculty and leading industry experts and are routinely attended by 60-70 participants. In 2012 J.D. Bewley, K.J. Bradford, H.W.M. Hilhorst and H. Nonogaki released a third edition of their book, Seeds Physiology of Development, Germination and Dormancy.

With continuous interaction with the seed industry, it became apparent in 2005 that the supply of plant breeders was drastically short of demand. To respond, the SBC developed the Plant Breeding Academy, a 2-year postgraduate program that allows industry personnel to advance as plant breeders without leaving their jobs. The response has been overwhelming. An integrated program is delivered by practicing plant breeders at UC Davis, across Europe and in 2012 a new program was launched in Thailand. Thus far, 114 plant breeders have been trained through this program. Expansion is planned for Africa in collaboration with the African Orphan Crops Consortium which aims to improve nutrition of African indigenous
crops through plant breeding and genomics. Since 2006 several programs have complemented the Plant Breeding Academy, such as similar program offered by Wageningen University in The Netherlands, an online MS by Iowa State University, an online PhD by Texas A & M and a 2-week class on breeding for drought resistance in Nebraska. The Illinois Corn Breeding School in its 49th year continues to address the need. In 2012, the SBC responded to industry requests by creating Seed Business 101, a one-week course aimed at individuals new to the seed industry. This program uses interactive case studies to educate participants in the different components of the seed industry, from research and production to marketing and human resources. In 2012, two classes of Seed Business 101 for field crops were offered in Minneapolis, MN and in Lafayette, IN and two for horticultural crops at Wimauma, FL and UC Davis. For 2013, plans were made for a new class, Program Management for Plant Breeders, and a Seed Captain short course focusing on seed marker technologies in collaboration with the International Seed Academy. All classes are in high demand.

The development of the UC Davis Plant Breeding Center will further improve our plant breeding education at UC Davis and integrate experiential learning on campus and with the seed industry as part of our plant breeding degrees. As part of its research program, the SBC includes recruiting new students into the plant breeding industry by developing K-12 programs, internships, training of undergraduate and graduate students, postdocs and visiting scientists, as well as contributing to online resources and webinars (see www.extension.org/plant_breeding_genomics). We are gratified to see increasing demand for both degree and continuing education programs in plant breeding.

To date, SBC’s educational programs have reached over 2,500 people. They are directed by Dr. Rale Gjuric with support from Joy Patterson, Donna Van Dolah, Sally Mohr and Jeannette Martins. The SBC continues to listen to its partners to create and deliver continuing education for the seed and breeding industry.