



UC Davis Seed Biotechnology Center Three-year summary July 1, 2009 – June 30, 2012

Introduction

The mission of the Seed Biotechnology Center is to mobilize the research, educational and outreach resources of UC Davis in partnership with the seed and biotechnology industries to facilitate discovery and commercialization of new seed technologies for agricultural and consumer benefit.

The Seed Biotechnology Center (SBC) is a center in the College of Agricultural and Environmental Sciences (CAES). CAES requested a five year summary. This document will cover the most recent three years and an existing ten-year summary (attached) will address prior activities of the SBC.

In 1999, CAES provided seed funding to establish the SBC and has continued to support the center through various means. Along with CAES, the California Seed Association (CSA) and the California Seed Advisory Board (CSAB) have been essential partners with the SBC since its inception. The CSAB is a state marketing order authorized by the California Department of Food and Agriculture (CDFA) to administer funds raised by an assessment placed on all sales of vegetable and field crop seeds in California. The CSAB, with the approval of the CSA, has continued to allocate a portion of these funds to provide the core funding for the SBC's operations since 2000. The SBC could not have been established and would not exist today without these partners' continued support. The SBC leverages the core CSAB and CAES funding through grants, courses and other income to support research, education and outreach programs focused on areas of interest to the global seed industry. This report describes the contributions that the SBC has made to the seed industry during the last three years.

Public Service Activities

Many activities of the SBC provide broad benefits to the seed industry. Most of these are not associated with specific funding sources, so are largely supported by the core CSAB contract. Below are some highlights of these activities by the SBC over the past three years.

- **Scientific input on regulatory and policy issues.** The SBC serves as an independent scientific voice on a wide range of regulatory and policy issues affecting the seed industry. The SBC has worked closely with the CSA on legislative issues, such as on Proposition 37, the genetic engineering labeling proposition, which would have significant impacts on the seed industry. Other groups, including the CDFA, the California Farm Bureau Federation, the American Seed Trade Association (ASTA), the Biotechnology Industry Organization (BIO), the Council for Agricultural Science and Technology (CAST) and the US Department of Agriculture (USDA), have benefitted from the scientific expertise of the SBC. SBC scientists have contributed to publications and commentaries that have been utilized by the USDA, the Association of Official Seed Certifying Agencies and other groups when formulating policies and regulations related to GE crops. The SBC has been active locally (e.g., with respect to local ordinances related to GE crops), nationally (e.g., by commenting on regulatory actions and revisions), and internationally (e.g., by participating in meetings negotiating the Cartagena Protocol of the Convention on Biological Diversity).
- **Co-existence of diverse production systems.** In 2011, at the invitation of USDA National Institute of Food and Agriculture program managers, the SBC organized and hosted "The Science of Gene Flow in Agriculture and its Role in Co-existence in Washington DC. More than 110

professionals in agriculture, ecology and plant biology met to discuss both the consequences of unwanted gene flow and methods for its prevention.

- **Biotechnology for Sustainability.** The SBC received a grant from the American Society of Plant Biologists to develop educational and outreach material centered on this topic (sbc.ucdavis.edu/b4s). Fact sheets and other information are posted on our website. In collaboration with the UC Biotech program at Berkeley, an interactive display was created and is available for loan to diverse groups.
- **Seed Biotechnologies.** In 2009-10 the SBC partnered with SeedQuest (seedquest.com) to develop a series of primers about seed biotechnologies that provide educational information to a much larger audience. SeedQuest is the global web portal for the industry. SBC staff and writer Diane Nelson developed this series.
- **SBC Web.** In 2010 the SBC completely overhauled and updated its website to allow visitors to quickly find information and to allow us to better grow the site and to keep it current. During July 1, 2011 – June 30, 2012, the SBC and Plant Breeding Academy sites averaged approximately 20,000 monthly page views.
- **Pollen flow studies.** The SBC has been involved in studies of out-crossing and gene transfer in cotton and alfalfa (see Research section). The more accurate data generated in these studies have been the basis for modifying seed certification standards for both crops.
- **Visitors and tours.** The SBC hosts dozens of visitors and tour groups annually, providing an opportunity to inform them about California's seed industry and about university resources and expertise. These visitors have included CSA-organized tours for legislators and their staff, high school and college students, and diverse international groups.
- **Boards and committees.** The leadership of the SBC serves on numerous industry boards and committees. For a current list, see the 2011 Annual Report, page 24.
- **Seed Central.** Seed Central (seedcentral.org) is an initiative of the SBC and SeedQuest. The first activity occurred in June 2010 when we organized and hosted a scientific presentation (CONNECTS) and webinar for industry personnel, UC Davis faculty, scientists and students. Over 100 attended to learn more about Dr. Simon Chan's work. Subsequently, Francois Korn (SeedQuest) and Mike Campbell (SBC's executive director) made numerous visits to seed companies and related industries and determined that the Seed Central initiative would be valued and supported by industry. The initiative was so successful that it led to its expansion to Food Central, which is also championed by Francois Korn. In addition to serving on the board of advisors, the following highlights past and on-going efforts in which the SBC is involved in connection with Seed Central:
 - **Networking.** From November 2011 through June 2012, monthly networking sessions along with scientific presentations ("Forums") were held (formerly titled CONNECTS) that were attended by over 600 industry personnel, UC Davis faculty, scientists and students. During three of these events we also conducted additional "Brainstorming" and "Science and Technology" presentations. The Brainstorming sessions provided an opportunity for industry and UC Davis personnel to develop solutions for shared needs, such as employment and facility needs. The Science and Technology sessions offer additional opportunities to highlight innovative research at UC Davis.
 - **Facilitation of sponsored research.** Working with Sponsored Research and Corporate Relations, we developed a Corporate Affiliate Partnership Program called the Plant and Seed Sciences Partnership Program. This program was approved in October 2012 and is

already being utilized as a vehicle to enable and facilitate research support by industry consortia.

- ***Collaborative Research (CoRe) Laboratory project.*** The SBC is part of a task force comprised of campus leaders to explore building a facility that will provide a variety of spaces (labs, offices, etc.) for companies to work in close collaboration with campus faculty as well as incubator space for start-up companies. This project is under development with promising progress to date.

Educational Activities

As an academically based organization, the SBC is committed to providing continuing education for the seed industry in all aspects of seed biology, quality, breeding and marketing. The SBC publishes bulletins and offers courses for seed industry professionals that enable them to keep current in the latest scientific advances impacting their work. The SBC is also active in the education of plant breeders and seed scientists both in traditional academic programs and through innovative new programs. Over 5,300 participants have benefitted from SBC courses, workshops and symposia over the past 13 years. These activities are all self-funded through tuition, registration fees and grants (Fig.1). The last three years we focused on the following courses:

- ***Plant Breeding Academy.*** The Plant Breeding Academy (PBA) is a two-year course that enables participants to learn the skills necessary to become (or to be better) plant breeders while maintaining their current positions. The SBC established the PBA in 2006 to augment the numbers of plant breeders being trained in university degree programs. Since 2009 we graduated Classes II and III of the UC Davis PBA. We launched a European program in which we graduated Class I and started Class II. In addition, much planning during this three-year period was underway to establish an Asian PBA that will open in November 2012 in cooperation with the Asian & Pacific Seed Association. As of June 2012, we had trained 85 plant breeders and had another 33 signed up for future academies. The SBC also received funding to establish and coordinate an African Plant Breeding Academy in connection with the African Orphan Crops genome sequencing project. Planning has begun leading to the first session being held in Africa in 2013.
- ***Effective Program Management for Plant Breeders and Technical Leads.*** Planning has been in progress to create and offer this course for plant breeders and technical leads. It will teach the principles of employee and resource management for modern research programs. The first offering will be in 2013.
- ***Seed Biology, Production and Quality.*** This 2-day short course for professionals was first offered in 2000 and has been offered in alternate years since 2001. It provides a broad overview of the biology underlying seed production and quality as well as practical information on seed cleaning, storage, testing and enhancement. SBC staff and expert invited speakers cover both basic information and the latest research results on each topic. Almost 70 participants attended the latest offering in March 2011, indicating continuing demand for this information. This course will be modified and offered again in 2013.
- ***Breeding with Molecular Markers.*** This 2-day short course targets breeders and seed professionals who want to learn how to incorporate molecular (DNA- or protein-based) markers into their breeding programs. The course is continually updated as technologies change and includes invited experts and hands-on experience in data analysis. This program has been offered biennially since 2004 and continues to receive high enrollment. During this period two sessions were held with a combined attendance of 120 people.

- **Seed Business 101.** The SBC partnered with high-level industry professionals to design a one-week course providing a comprehensive overview of the seed business to individuals new to the industry. Since winter 2010, six different week-long sessions were held and reached over 120 students. In response to participant feedback, we recruited additional instructors and developed distinct curricula focusing on either the horticultural or agronomic industries, and have offered the latter course in both Minnesota and Indiana in 2012.
- **Workshops.** SBC staff were involved in a national research and extension consortium focusing on tomato and potato genetic resources and breeding (SolCAP; solcap.msu.edu). This program developed a series of workshops and created public data resources to enable utilization of genomic resources in breeding programs in these crops. This program has reached large numbers of participants through its courses either on-site or via webinars. The SolCAP project received special recognition from the USDA for its high quality and impact. In addition, as noted above, the SBC organized and hosted "The Science of Gene Flow in Agriculture and its Role in Co-existence" in Washington DC. More than 110 professionals in agriculture, ecology and plant biology met to discuss the both the consequences of unwanted gene flow and methods for its prevention.
- **Plant breeding curriculum.** New technologies are rapidly altering the approaches utilized in plant breeding, and it is critical that academic curricula reflect these changes in industry practice in order to educate the next generation of plant breeders. The SBC worked with both public organizations (e.g., the National Plant Breeding Coordinating Committee and the Global Initiative for Plant Breeding) and private companies to support an international assessment of plant breeding curricula ("The Delphi Study"). The study was completed and three peer-reviewed articles were published, providing a global consensus on the critical components of curricula for educating the next generation of plant breeders.
- **Teaching plant breeding to young people.** Based on current research at the SBC and in conjunction with the UC Davis Student Farm, the SBC developed an interactive, hands-on education program on plant breeding and genetic diversity. Over 1,500 students between kindergarten and sixth grades, 50 high school students and over 100 UC Davis freshman undergraduates were introduced to plant breeding in the field. This program also involved graduate students and interns. See asi.ucdavis.edu/sf for more information.

Research Activities

Research activities of the SBC are focused primarily on partnerships with industry collaborators that develop pre-competitive information that "lifts all boats." We concentrate on projects that will facilitate the activities that are central to the continuing improvement of crop and seed performance and to the competitiveness of the seed industry. Funding is received through various sources, including the USDA, USAID, NSF, foundations and seed companies. The UC Discovery Program, which shared the project cost with private collaborators, was a very popular program with our clientele. Although those funds are no longer available, SBC Research Director Allen Van Deynze, has continued to be very successful at developing consortia for research support. SBC researchers have garnered over \$10 million in extramural research funds since 1999. Some of our research projects are highlighted below.

- **Identification and application of molecular markers.** The SBC has been a leader in the development and application of new technologies to advance plant breeding. Some specific projects include:
 - **Tomato.** Cultivated tomato varieties have a narrow genetic basis, making it hard to identify variation that can be utilized in marker-assisted selection. DNA sequencing has enabled

the identification of thousands of new markers in cultivated germplasm that can be utilized in breeding programs.

- **Lettuce.** The SBC and UC Davis Genome Center developed a novel microarray that can simultaneously survey over 35,000 lettuce genes for DNA sequence variation among genotypes. This project has increased the number of mapped markers in lettuce from 2,000 to over 15,000 and enabled high density genetic maps and new approaches that will significantly advance lettuce breeding.
- **Pepper.** A microarray-based approach was developed and applied to survey genetic diversity among cultivated and wild peppers and to develop high-density genetic maps associated with horticultural traits.
- **Cotton.** The complex duplicated genome of cotton has made it difficult to identify useful molecular markers in commercial breeding germplasm. New high-throughput sequencing technologies employed by the SBC have enabled the identification of thousands of new markers for cotton and have clarified its genomic structure.
- **Potato.** With a duplicated genome and vegetative propagation, there is enormous genetic variation present in potato, but until recently little ability to effectively utilize it in breeding. The SBC and collaborators are identifying molecular markers associated with important traits that will facilitate potato improvement.
- **Carrot.** Carrot has had little investment to date in developing genomic resources. The SBC is collaborating with carrot researchers to develop the first extensive DNA sequence database and marker-based genetic maps in carrot.
- **Sunflower.** SBC researchers participate in the Compositae Genome Project, which includes sunflower as well as lettuce, artichoke, and many other crops and weeds. Genetic resources and markers developed through this project are being utilized for sunflower improvement.
- **Transgenes.** The SBC has conducted projects to evaluate the effectiveness of transgenes in conferring specific traits. In one project, the SBC tested whether genes affecting drought tolerance in a model system (*Arabidopsis* plants) would work when transferred to tomato. A current project is evaluating whether drought and stress tolerance of switchgrass can be enhanced to improve its value as a biofuel crop. Another project is transferring a disease resistance gene from pepper to tomato to reduce the need for bactericidal sprays.
- **Co-existence.** Studies on gene flow in cotton and alfalfa have been critical both in regulatory evaluations and in identifying isolation distances required to achieve specific levels of genetic purity and therefore facilitating co-existence and marketing. In another project, growth of switchgrass is being evaluated in a number of environments in order to be able to predict whether it could become invasive if introduced widely into California.
- **Seed biology and technology.** The SBC is conducting research on seed vigor testing funded by extramural grants and seed company partners. Some current projects include:
 - Investigating the molecular and physiological basis of lettuce seed thermodormancy and developing germplasm enabling better germination and crop establishment at high temperatures.
 - Utilizing state-of-the-art technology for measuring respiration of individual germinating seeds in order to investigate the metabolic basis of seed quality.
 - Developing accelerated aging or controlled deterioration tests to predict seed longevity in storage.

- Developing and disseminating a novel method for seed drying using desiccant beads in Nepal, Bangladesh and Kenya, supported by a USAID-HortCRSP grant.
- **Publications.** SBC researchers are active in publishing scientific peer-reviewed publications. Between 2009 and 2012, 21 articles were published in a wide range of journals. For a complete list see sbc.ucdavis.edu/publications/scientific_publications.html.

Plant Breeding Center

The SBC has served as the portal to some of the UC Davis Plant Breeding programs for many years. We have served this industry through our efforts with the Plant Breeding Academy, the Delphi Study and other activities. In 2007 Dr. Allen Van Deynze was asked by CAES to serve as the editor for a publication from CAES titled "100 Years of Breeding." This 52-page book captures the history and impact of plant breeding at UC Davis. To rebuild and strengthen plant breeding at UC Davis, Dr. Kent Bradford was asked by the CAES dean to serve on a strategic planning committee which would review the needs for a Plant Breeding Center (March 2011). Following their report to CAES, the dean appointed an Implementation Committee. Dr. Bradford co-chaired this committee that developed a plan to create and support a Plant Breeding Center at UC Davis. The Department of Plant Sciences has agreed to recruit a faculty member to serve as the director of this center, and we anticipate initiation of that recruitment and creation of the center in the next year. The SBC and the Plant Breeding Center will be co-housed and share staff to enable efficient support for the activities of both programs.

Personnel

In 1999, CAES appointed Dr. Kent Bradford to serve as the director of the SBC (0.50 FTE as Special Assistant to the Dean). This commitment has been instrumental to the SBC and its stakeholders. Susan DiTomaso was hired in 1999 with seed funding from CAES, which was also critical for staff support while establishing a relationship with the CSAB for the core funding. Since 2000 her salary is covered through CSAB funds, the Department of Plant Sciences (0.25) and other funds from our education and outreach programs. Dr. Allen Van Deynze was hired in 2000 as SBC Research Director. His salary is covered through the CSAB core funding and various research grants. Starting in 2006 administrative staff have been hired to operate our various educational programs. Currently the SBC's educational programs support three part-time staff. In addition, in 2009 the SBC hired Dr. Rale Gjuric to teach and oversee the Plant Breeding Academies. Subsequently, his role has expanded to become the Director of Education to oversee all of our educational programs. Salaries for these four positions are covered via course tuition. The SBC also contracts with various industry experts that develop and instruct in various courses.

Based on a stakeholder survey, it was suggested that the SBC grow to increase our activities. In 2007 with industry and CAES contributions, the SBC hired Michael Campbell as executive director. During his three-year tenure, the center was able to initiate many new programs, including the European Plant Breeding Academy, Seed Business 101 and Seed Central (see the SBC 2010 Annual Report, page 20).

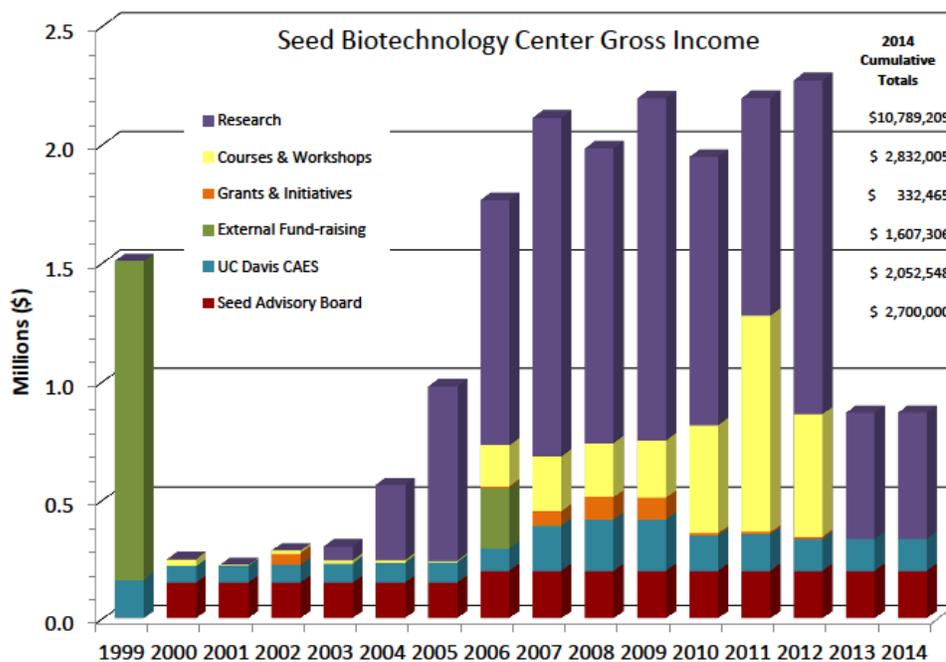
From mid-2009 until early 2011, the SBC was also able to support Dr. Jamie (Miller) Shattuck via a UC Discovery Fellowship. Jamie made significant contributions to the Delphi study, the economic study of the seed industry, Biotechnology for Sustainability, and many other activities. The SBC continues to work with Dr. Shattuck, who is now with the campus' Corporate Relations program.

Currently the SBC research program supports three research associates and four graduate researchers. The Bradford program supports a postdoc, two staff research associates, three graduate students, and

several visiting scientists and interns. Both programs play strong roles in training individuals for careers in plant breeding, seed production and food security.

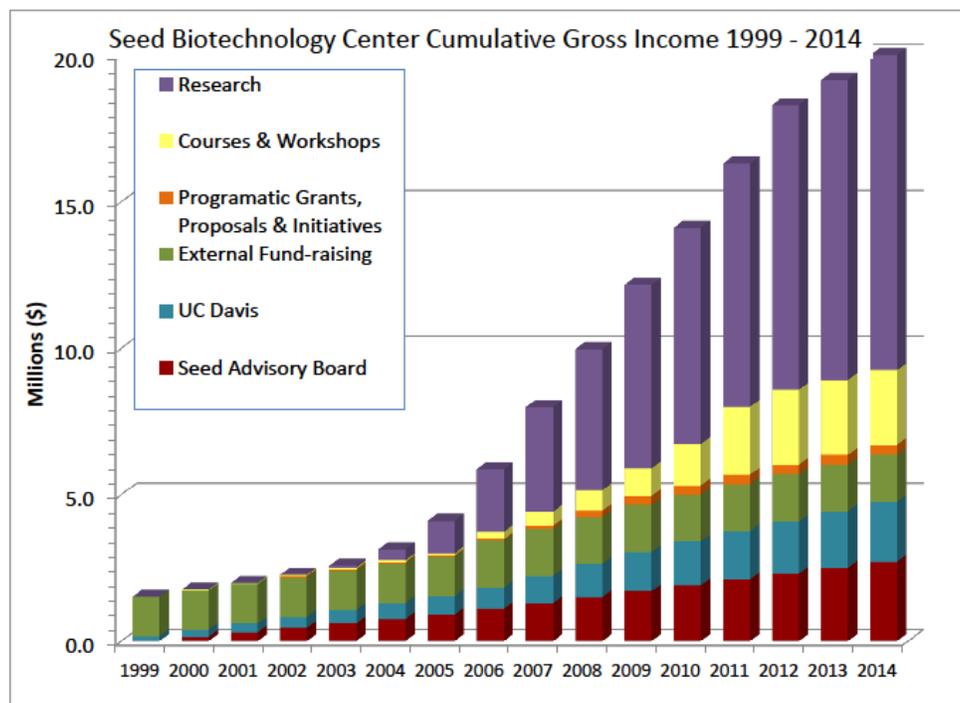
Value of the SBC to the seed industry

The partnership established between UC Davis and the California seed industry 13 years ago has returned significant benefits to both parties. As of 2012 CAES (including the Department of Plant Sciences) has provided the Center \$1.8 million over 13 years in staff and programmatic support. This has enabled the SBC staff to generate an additional \$16.8 million through its educational, research and fund-raising activities (Fig. 1 and 2). Together, these funds have supported cutting-edge fundamental and applied research, educational programs for continuing human resource development and public service activities that have broad beneficial impacts for the seed industry and the mission of the Agricultural Experiment Station.



SBC Cumulative Income 10-12-12.xlsx, 11/29/2012

Figure 1. Annual funding of the SBC according to source since its establishment in 1999 and extending through current grant periods. Cumulative totals for each category and grand total are listed at the right.



For College Report - SBC Cumulative income 8-29-12.xlsx, 10/11/2012

Figure 2. Cumulative funding for the SBC between 1999 and 2014.

A focus on partnership

The original concept and the key to the success of the SBC has been a focus on partnership with stakeholders, consistent with the Land-Grant University mission to be of service to society. The SBC takes this commitment very seriously and seeks to provide high value for the investment it receives. Stakeholder support is particularly critical as public funding to the UC is being cut and many academic programs may be eliminated. In this economic environment, active partnerships with stakeholders who can financially support academic programs are critical to maintaining our ability to continue to achieve that mission.

In July 2011, the SBC hosted a facilitated session to capture stakeholder input on the center's activities. More than 30 industry and UC Davis leaders gathered to provide over 300 items of input. Through a prioritization process, the SBC was given direction on how best to proceed in order to meet stakeholders' future needs. See page 5-6 in the 2011 Annual Report for details.

The SBC is proud of what it has accomplished in partnership with seed industry stakeholders during its first 13 years. Numerous tangible benefits have been provided and a strong foundation has been established for future success. We will continue to work diligently on strengthening these partnerships.

The Future

Currently the CSAB commitment for core funding extends until 2015. In addition, both Dr. Bradford and Dr. Van Deynze have several on-going grants to support personnel and their research. The educational programs are successful and growing and new courses are planned for 2013. The tuition from these courses will continue to support the staff and the director of education as long as there is demand for industry training. The SBC will continue to play a significant role in Seed Central, particularly in establishing the CoRe laboratory. Establishing and contributing to the success of these initiatives and of new Plant Breeding Center will be primary objectives of the SBC for the next several years.

Summary

The SBC would like to thank CAES for its continued support. Since 1999 the college has been instrumental in developing and sustaining the SBC. Through its initial seed funding, programmatic initiative funds for specific activities, support during our growth initiative and now for Seed Central, it is clear that without the CAES partnership, the SBC would not be where it is today. The industry values CAES and the Department of Plant Sciences commitment which strengthens the value for all.