Developing Comprehensive Approaches to Meet the Science Needs of the Horticultural Community

T. Bewick, G. Smith, and D. Schmoldt
U.S. Department Of Agriculture/National Institute of Food and Agriculture
1400 Independence Avenue, SW, Mailstop 2220, 20250
Washington, District Of Columbia, United States

Keywords: competitive grant programs, continuing education, public policy, student education, workforce development

Abstract

The U.S. Department of Agriculture (USDA) held a series of stakeholder listening sessions in 2006-2007 in preparation for the impending farm bill. They received thousands of comments from horticultural producers, handlers and processors. Overwhelmingly, these comments emphasized the need for science-based solutions to the challenges facing U.S. horticultural industries. In response, USDA created the Specialty Crop Research Initiative (SCRI) and charged the Research, Education and Economics Mission Area with implementation. During the implementation phase, stakeholders identified workforce development as a critical need and USDA responded by including this as one of five major areas in a strategic implementation plan for the SCRI. With passage of the farm bill in 2008, SCRI received US$230 million over 5 years in mandatory funding for a competitive grant program to address the science needs of the horticultural community. The overall focus of this grant program is to discover new knowledge and technologies to insure a sustainable supply of horticultural products. The development of new knowledge and technology further emphasizes the need for education and training of both the current and future workforce in horticulture. A comprehensive plan spanning university graduate education to primary education has been developed. The goal is to link the entire agricultural education system in a coordinated series of programs that inspires youth to choose horticulture as a career and that enables those already in horticultural careers to expand their knowledge into areas of future need. There will be a continuing need to create new educational opportunities as horticultural industries become more knowledge and data intensive.

INTRODUCTION

The Food, Conservation and Energy Act of 2008, commonly referred to as the farm bill, was an historic piece of legislation for horticultural industries in the United States. Legislatively referred to as “specialty crops.” this bill elevated the stature of horticultural crops in the policy discussion at USDA. The term specialty crop is legally defined in the United States as “fruits and vegetables, tree nuts, dried fruits, and horticulture and nursery crops, including floriculture.”

USDA began a series of over 40 listening sessions across the U.S. in 2006 in order to inform Administration policy decisions concerning the most current farm bill. They received over 10,000 comments from the agricultural sector, including thousands from representatives from the horticultural industries. These comments overwhelmingly indicated that horticultural producers and industries were interested in USDA programs that would generate and deliver new knowledge that would lead to sustainable systems in a global marketplace. In response to this input, then USDA Secretary Johanns created the Specialty Crop Research Initiative (SCRI) early in 2007 and called for a 10 year investment of $1 billion for internal and external programs aimed at creating sustainable horticultural systems. SCRI, as envisioned by the Secretary, emphasizes problem solving that leads to measureable outcomes. The Research, Education and Economics (REE) Mission Area, which is composed of the Agricultural Research Service (ARS), the Economic Research Service (ERS), the National Agricultural Statistics Service (NASS) and the National Institute of Food and Agriculture (NIFA), was charged with implementing the SCRI. In response, a planning and implementation team was formed that was composed of leaders from each of the four REE agencies.

Over the course of approximately six months, this team developed a strategic plan for specialty crops for REE agencies. The plan was based on stakeholder input gained from numerous workshops organized by REE agencies and others. Participants at these workshops included growers, processors and shippers of specialty crops, university partners, federal scientists, state departments of agriculture, trade associations and other non-governmental organizations. The vision of the team was that USDA/REE supports the continued growth of a specialty crops economy that meets the needs of consumers, producers, processors, distributors and the public at large through innovations in research, education, economics and extension programs. Five goals were identified:

1. A high-quality, safe and, where appropriate, nutritious supply of specialty crop products.
2. Specialty crop production, processing and distribution systems that enhance economic opportunities for rural communities.
3. Specialty crop industries that anticipate and respond to shifting consumer needs and preferences.
4. Production, processing and distribution systems that are sustainable, efficient and cost-effective.
5. Workforce that has the skill and expertise to support innovative, sustainable specialty crop production, processing and distribution systems.

Five results were envisioned for the last of these goals, which is the one that most focuses on the training of future horticulturists.

- Increased number of undergraduate and graduate students studying plant breeding, genetics and plant improvement.
- Increased number of undergraduate and graduate students studying horticulture at land-grant universities and colleges.
- Increased number of engineering students working on automation and sensor technology for specialty crops.
- Increased availability of training programs, such as certificate programs, to provide rural citizens and others with the opportunity to gain the expertise needed to participate in newly developed specialty crops production, processing, and distribution systems of the future.
- Increased number of technical colleges and community colleges that offer curricula providing students with the foundation for participation in the specialty crops economy.

The 2008 farm bill required the Secretary of Agriculture to implement a competitive, extramural grant program as the Specialty Crop Research Initiative and provided $230 million in mandatory funding over 5 years. This authorization was delegated to NIFA and the first grants were awarded in 2008.

DISCUSSION

Implementation of the Specialty Crop Research Initiative

A team of National Program Leaders from NIFA (then the Cooperative State Research Education and Extension Service) was assembled early in 2007 to develop the conceptual framework for implementation of the extramural portion of the SCRI. A concept paper was developed and is available at: nifa.usda.gov/about/white_papers/pdfs/specialtycrops.pdf. This document emphasized the need for economic, environmental and social sustainability to form the foundation of the program. Adopting and implementing this perspective means that discipline-focused approaches alone cannot achieve effective problem solving in the identified need areas of productivity, efficiency and profitability. Specialty crop industry challenges (and their solutions) must be viewed and treated as systems of interrelated processes, participants, institutions, collaborations and technologies in a comprehensive manner.

This vision of a systems-based approach (Fig. 1) consists of a hierarchical taxonomy of systems which, in total, define a "producer to consumer" system. The

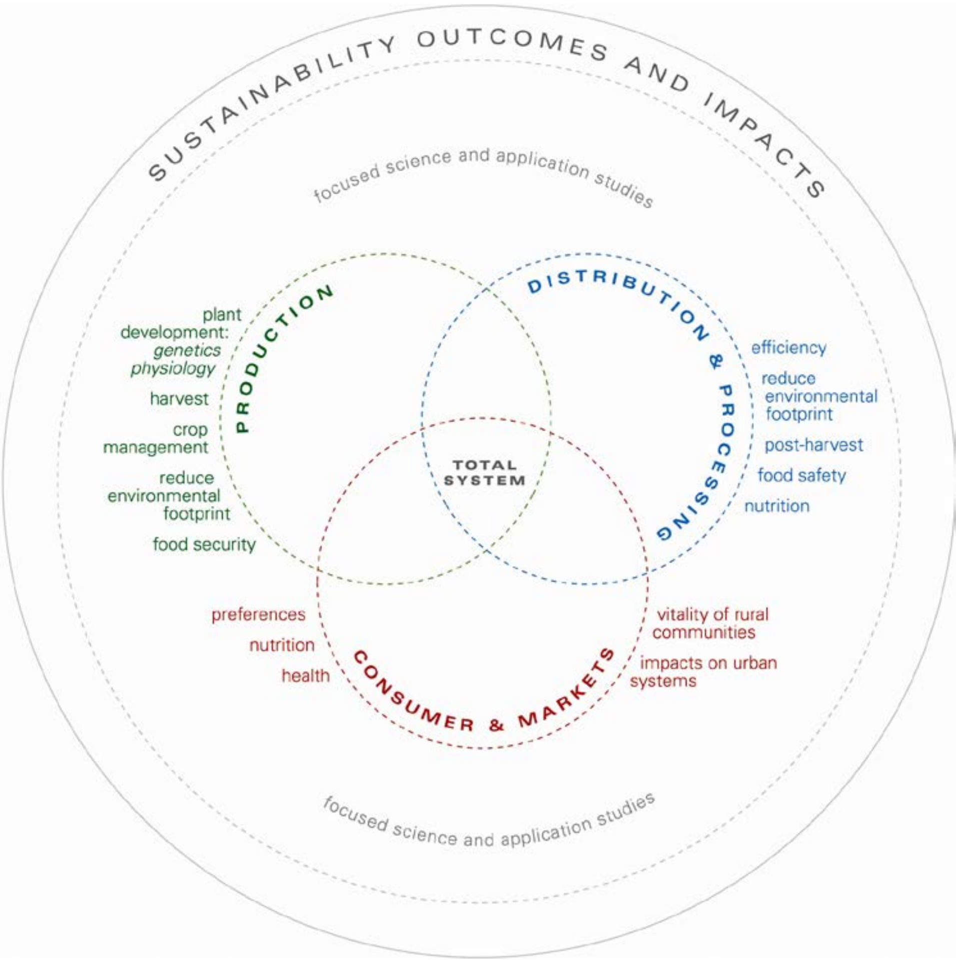

Fig. 1. Conceptual model for implementation of the Specialty Crop Research Initiative Competitive Grants Program.

primary specialty crop systems—crop production; processing and distribution; and consumers and markets—appear at the highest level, with specific subsystems found within each. Emphases are placed on efforts that focus on an entire primary system or where two or more primary systems overlap/intersect. At the most specific level of the hierarchy, one finds traditional, disciplinary research, development and application efforts, which are also part of the initiative.

Just as specialty crop industry challenges and solutions are viewed in a systems context, the science enterprise of SCRI must also be viewed in a similar context. In this model, research, formal education and extension comprise the three primary systems. Knowledge generation through basic, developmental and applied research necessarily overlaps and integrates with the formal education and extension functions of teaching, engagement, technology transfer and outreach. In this integrated framework, formal education and extension assume the role of stakeholder for research and research becomes a stakeholder for education and extension activities. The success of this approach is dependent on continuous feedback from producers and consumers to all three components of the science enterprise.

An important aspect of SCRI implementation is the realization that not all challenges faced by producers and consumers can be solved by biology alone. In order to realize the USDA vision that SCRI would deliver measurable outcomes that solve problems "at the speed of business", a trans-disciplinary approach was adopted. SCRI defines trans-disciplinary as the integration of biological and physical sciences with economics and social sciences. Such an approach puts an emphasis on people as an integral component of all systems.

Implications for Workforce Development and Training of Future Horticulturists

One by-product of the reductionist approach that has dominated science for almost 400 years is the condition of the educational system. The traditional view of training and education, still widely held, is one of various systems working in isolation. In the U.S., the primary education system (ages 4 to 18) is viewed in isolation from all other components. Similarly, technical and vocational schools, two-year colleges, baccalaureate granting colleges and graduate universities are often viewed as separate, independent entities among which communication and collaboration is not necessary and, in some cases, not desirable. And Extension, potentially one of the most powerful training and education tools available, is viewed as being completely apart from the formal education system.

Early successes of SCRI challenge this view and other USDA programs developed over the last five years have demonstrated that it is possible to provide both targeted and comprehensive science education by integrating traditional classroom instruction, experiential learning and hypothesis driven research. Such an integration produces students with a solid fundamental foundation who are able to think critically and who are able to adapt their knowledge to real world situations.

Research and Extension Projects as a Vehicle for Student Training

The SCRI is not specifically authorized to fund formal education projects. Graduate student stipends can be awarded as part of research and extension projects and other students can be hired to perform various activities in a project work plan. Although this is beneficial for the students so funded, it does not allow for the development of a comprehensive strategy for developing a cadre of innovative thinkers who can form the next generation of scientists and practitioners needed to insure the sustainability of horticultural industries. SCRI has emphasized funding projects that adopt innovative approaches to imparting knowledge. Two such projects are Comprehensive Automation for Specialty Crops (CASC) and RosBreed: Enabling marker-assisted breeding in Rosaceae.

CASC is a consortium led by scientists from Carnegie Mellon University, which is a private research university not normally associated with finding solutions for agricultural problems. Within the Carnegie Institute of Technology, however, there are teams of scientists and technicians who are interested in finding real-world solutions to problems wherever they occur. As a result of collaboration with several horticultural industries, the CASC team is adapting and refining technologies developed for other purposes to horticultural field environments. A major emphasis of this program is the involvement of both graduate and undergraduate students in the research and outreach components of the project. Table 1 contains the names of the students involved to date along with the role they have played in the project. By involving students in all phases of the project, project leaders have successfully created a cohort of students who are interested in horticultural challenges despite being trained in a discipline not traditionally associated with horticultural science. As is often the case, these students meet on a regular, informal basis to discuss other situations where their particular skills and training can be used to address other and future horticultural challenges.

RosBreed is a consortium of nine U.S. universities and several USDA/ARS labs working in collaboration with scientists from the EU. The goal of this consortium is to create a dynamic, sustained effort in research, infrastructure establishment, training and extension for applying marker-assisted breeding (MAB) to deliver improved plant materials from the rose family more efficiently and rapidly. One of the specific objectives of this ambitious program is to enhance the sustainability of cultivar development by transferring MAB technologies to the public and private community of Rosaceae breeders through training current and future breeders. Team leaders also want to engage the general public with facts about MAB technology to insure that cultivars so derived are accepted in the market place. The project team has been very aggressive in pursuing this objective. Within the first twelve months of funding, 11 graduate students were recruited into the team. Additional students will be trained in future years of funding. Also in that first year, RosBreed team members conducted a workshop for 30 participants on using the data management and quality control tools employed by the team. A second workshop is planned for early in 2011. These activities have had the immediate impact of greatly increasing the talent pool in the area of Rosaceae breeding and genetics.

CONCLUSION

SCRI is not specifically authorized to fund formal educational activities, which potentially could prevent the program from contributing to the training of the next generation of horticulturists. But by engaging students in the research and extension functions of science, projects funded by the program have been able to positively impact students to become interested in horticulture. Many of these students are from countries other than the U.S., so the impact of the program will reach into the international community. As refinements in SCRI are authorized and implemented, these impacts should expand.

Table 1. Students who are or have been involved in the SCRI project, *Comprehensive Automation for Specialty* Crops. When two institutions are listed, the first is where the student is interning for CASC work and the second is his/her home school. An (S) next to their level of study indicates summer intern.

Institution	Name	Area	Level of study	Thematic area	Activities
Carnegie Mellon Univ.	Alex Reece	Robotics	Undergrad.	Reconfigurable mobility	Developed new user interfaces for the APM.
	Anjali Patwardhan	Mechanical Engineering	Undergrad.	Augmented harvesting	Designed and developed novel bin filling systems.
	Asif Siddiqi	Mechanical Engineering	Undergrad.	Augmented harvesting	Designed and developed novel bin filling systems.
	Brian Kliethermes	Mechanical Engineering	Graduate	Augmented harvesting	Designed and developed novel bin filling systems.
	David Ferguson	Robotics	Graduate	Reconfigurable mobility	Developed and field-tested algorithms for robust row turning.
	David Stonestrom	Mechanical Engineering	Undergrad.	Augmented harvesting	Developed physics-based simulations of passive bin filing systems.
	Dong Hyun Choi	Mechanical Engineering	Undergrad.	Augmented harvesting	Designed and developed novel bin filling systems.
	Gwendolyn Barr	Mechanical Engineering	Graduate	Augmented harvesting	Designed and developed novel bin filling systems.
	Jacqueline Libby	Robotics	Graduate	Accurate positioning	Developed and field-tested algorithms for vehicle localization.
	Jung Hwan Park	Mechanical Engineering	Undergrad.	Augmented harvesting	Designed and developed novel bin filling systems.
	Lauren Von Dehsen	Human-Computer Interaction	Undergrad.	Reconfigurable mobility	Developed and field-tested a grower-friendly interface for the APM.
	Lily Li	Human-Computer Interaction	Undergrad.	Reconfigurable mobility	Developed and field-tested a grower-friendly interface for the APM.
	Luke Kambic	Mechanical Engineering	Undergrad.	Augmented harvesting	Designed and developed novel bin filling systems.

Institution	Name	Area	Level of study	Thematic area	Activities
	Matt Aasted	Robotics	Graduate	Reconfigurable mobility	Developed and field-tested a system to automate thinning with the Darwin machine.
	Matt Morrill	Human-Computer Interaction	Undergrad.	Reconfigurable mobility	Developed and field-tested a grower-friendly interface for the APM.
	Sangwon Lee	Mechanical Engineering	Undergrad.	Augmented harvesting	Designed and developed novel bin filling systems.
	Seoyeon Yang	Mechanical Engineering	Undergrad.	Augmented harvesting	Designed and developed novel bin filling systems.
Carnegie Mellon Univ./Pennsylvania State Univ.	Robin Pritz	Robotics	Undergrad. (S)	Augmented harvesting, reconfigurable mobility	Designed and developed novel bin filling systems, assisted with APM field testing.
Oregon State Univ./ Clackamas Community Coll.	Brian Moore	Horticulture	Undergrad.	Caliper measurement	Assisted in ground-truthing the on-the-go caliper device at Bailey and J. Frank Schmidt Nurseries.
Oregon State Univ./ Univ. of Puget Sound	Jackson Kowalski	Biological Systems	Undergrad.	Caliper measurement	Assisted in ground-truthing the on-the-go caliper device at Bailey and J. Frank Schmidt Nurseries.
Pennsylvania State Univ.	Alex Leslie	Agricultural & Biological Engineering	Undergrad. (S)	Augmented harvesting, outreach	Tested energy absorbing materials; built and tested mock-ups of passive bin fillers; assisted with efficiency trials in pilot orchards.
	Bethany Ely	Communications	Undergrad. (S)	Insect monitoring	Assisted in checking traps on a daily/weekly basis; checked for IFM injury in orchards.
	Juliet Hulse	Biology	Undergrad. (S)	Insect monitoring	Assisted in checking traps on a daily/weekly basis; checked for IFM injury in orchards.

Institution	Name	Area	Level of study	Thematic area	Activities
	Katie Reichard	Horticulture	Graduate (S)	Outreach	Assisted with efficiency trials in pilot orchards.
	Matthew Hartwig	Biology	Undergrad. (S)	Insect monitoring	Assisted in checking traps on a daily/weekly basis; checked for IFM injury in orchards.
	Nicolas Liebrum	Bio-engineering	Undergrad. (S)	Insect monitoring	Assisted in checking traps on a daily/weekly basis; taking pictures of IFW injury in orchards.
	Reuben Dise	Agricultural & Biological Engineering	Graduate	Augmented harvest, outreach	Researched and helped modify orchard harvest platform for autonomous control; assisted with efficiency trials in pilot orchards.
	Russell Rohrbaugh	Agricultural Systems Management	Undergrad.	Augmented harvesting, outreach	Assisted with efficiency trials in pilot orchards and harvest platform.
	Tom Kon	Horticulture/pomology	Graduate	Outreach	Assisted with efficiency trials in pilot orchards.
Pennsylvania State Univ./Grove City Coll.	Evan Moore	Social Science	Undergrad. (S)	Outreach	Assisted with efficiency trials in pilot orchards.
Pennsylvania State Univ./James Madison Univ.	Ryan Hilton	Alternative Energy/ Engineering	Undergrad. (S)	Outreach	Assisted with energy efficiency trials in pilot orchards.
Pennsylvania State Univ./Kalamazoo Univ.	Cody Musselman	Social Science	Undergrad. (S)	Outreach	Assisted with efficiency trials in pilot orchards.
Pennsylvania State Univ./McDaniel Coll.	Jennifer Rouzer	Biology	Undergrad. (S)	Outreach	Assisted with efficiency trials in pilot orchards.

Institution	Name	Area	Level of study	Thematic area	Activities
Pennsylvania State Univ./Michigan State Univ.	Jacob Koan	Agricultural Engineering	Undergrad. (S)	Augmented harvesting, outreach	Tested energy absorbing materials; built and tested mock-ups of passive bin fillers; assisted with efficiency trials in pilot orchards.
Pennsylvania State Univ./Millersville Univ.	Celine Kuntz	Economics	Undergrad. (S)	Outreach	Assisted with efficiency trials in pilot orchards.
	Mattie Kuntz	Biology	Undergrad. (S)	Plant stress and disease detection	Assisted with laboratory, greenhouse and field studies on tree stress and fire blight detection.
Pennsylvania State Univ./Oberlin Coll.	Amelia Jarvinen	Social Science	Undergrad. (S)	Outreach	Assisted with efficiency trials in pilot orchards.
Pennsylvania State Univ./Shippensburg Univ.	Andrew Haun	Biology	Undergrad. (S)	Insect monitoring	Assisted in checking traps on a daily/weekly basis; taking pictures of IFW injury in orchards.
Purdue Univ.	Caleb Tan	Electrical and Computer Engineering	Undergrad.	Insect monitoring	Assisted in the assembly of digital trap prototypes.
	German Holguin	Electrical and Computer Engineering	Graduate	Insect monitoring	Designed and assembled digital trap prototypes.
	Guiqin Li	Electrical and Computer Engineering	Graduate	Plant stress and disease detection	Developed algorithms for detecting internal feeding worm damaged apples.
	James Kim	Electrical and Computer Engineering	Post-doctoral	Plant stress and disease detection	Carried out performance evaluation of NDVI sensors. Designed multi-sensor system for stress and fire blight detection.

Institution	Name	Area	Level of study	Thematic area	Activities
	Kuan-Po Chen	Electrical and Computer Engineering	Undergrad.	Insect monitoring	Assisted with the development of a solar harvesting system.
	Wei Jian Chan	Electrical and Computer Engineering	Undergrad.	Insect monitoring	Assisted with the development of a solar harvesting system.
Washington State Univ./Columbia Basin Community Coll.	Art Flores	Nursing	Undergrad.	Outreach	Assisted with outreach efforts and field trials of equipment at Washington State University.