United States Department of Agriculture

Plant Breeding Listening Session, August 15, 2013

Final Report

Research, Education, and Economics Mission Area

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EXECUTIVE SUMMARY

Plant breeding is an integral part of the U.S. Department of Agriculture's (USDA) mission to ensure food, fuel, and fiber for a growing population. On August 15, 2013, the USDA's Research, Education, and Economics (REE) mission area sponsored a plant breeding stakeholders listening session to begin gathering input on the current status of plant breeding research across the Federal Government, industry, and non-profit sectors (see Federal Register Notice, Appendix 1). Approximately 80 attendees (Appendix 2) from universities, scientific and professional societies, and growers groups, as well as numerous USDA representatives, came together to discuss the future of publicly funded plant breeding. The day's agenda (Appendix 3) began with a welcome from Chief Scientist Dr. Catherine Woteki and an overview of USDA plant breeding efforts and investments provided by USDA agency representatives. The remainder of the day was devoted to stakeholder presentations and breakout sessions in which groups discussed and responded to questions from USDA (Appendix 4).

All interested stakeholders, whether present at the meeting or not, were invited to submit written comments to address what they saw as major challenges and needs in the field of plant breeding, especially with respect to publicly funded efforts. In addition to the 18 presentations given during the listening session, USDA also received a total of 38 sets of comments (Appendix 5a,b). These comments touched on broad topics including: defining the mission, outreach, funding, breeding priorities, other research priorities, partnerships, recruiting and training plant breeders, other needed resources, open access, and evaluation. There was significant overlap between some of the topic areas, and many points were repeated by different stakeholders.

Common comments and suggestions received from stakeholders during the listening session and comment period (July 29 through August 22, 2013) included needs for:

- More funding/efforts directed at regionally adapted breeding to develop finished cultivars adapted to the local environment and the needs and challenges of the local farmers and consumers;
- More funding/efforts directed at traditional public plant breeding and cultivar development;
- Longer term and collaborative USDA priority setting for outcome-driven programs;
- Developing mechanisms to encourage public-private collaboration;
- Longer–term support, in the form of granting cycles spanning more than five years;
- Engaging with farmers in setting priorities, through listening sessions, the grant application process, and participatory breeding;

- Strengthening germplasm collections in the interests of both the public and private sectors;

- Effectively demonstrating the impacts of plant breeding through the media, field days, educational outreach, and connecting with policymakers;

- More funding for land-grant universities, which are currently the sole source of public plant breeding and an important training ground for students;

- Keeping cultivars in the public domain; or, at a minimum, freely available for use in further breeding ("breeders' exemption");

- Recruiting the next generation of plant breeders by advertising its potential as a rewarding career and offering more training and mentoring opportunities;

- Supporting communication on plant breeding by setting up a new website that could be a one-stop shop for information on USDA plant breeding efforts and success stories;

- Developing tools and resources to enable discovery and advanced breeding of underserved commodities;

- Promoting technology transfer of genomics research to field outcomes.

ACKNOWLEDGMENT

The REE Mission Area thanks Jenna Jadin and Tawny Mata, American Association for the Advancement of Science (AAAS) Fellows, for preparing the summary and compiling and editing this report.

This report contains a summary of all comments received, listening session documents including the Federal Register announcement, copies of all written comments, a participant list, and a glossary of acronyms. ***In this report, USDA does not intend to show any preference or endorsement for any organization. This report should be read as an unbiased report on views expressed during the listening session and through the public comment process. The opinions and recommendations in the "Summary of Comments" section do not represent opinions, recommendations, or value judgments of USDA.***

INTRODUCTION

Plant breeding and USDA's mission

When Congress established USDA in 1862, the new Department was given two primary responsibilities: to assemble books, information, and statistics; and to *procure, propagate, and distribute new and valuable seeds and plants.* Today, some 150 years later, changes are everywhere: in science, trade, law, culture, and climate patterns. USDA's responsibilities are formulated as strategic goals, as in the current USDA Strategic Plan (2010-2015):

1. Prosperous rural communities.
2. Resilient national forests, working lands, and water resources.
3. Agricultural production, exports, and food security.
4. Accessible, safe and nutritious foods.

One aspect that is unchanged is that plants play critical roles in achieving USDA's goals. The original assignment regarding plants remains a key part of USDA's service to the United States and to the world. Support for plant breeding is integral to this mission. Emerging threats to plant-based food, fuel, and fiber require continued investment. Recent disease outbreaks, such as citrus greening, cucurbit downy mildew, and wheat rust, as well as the shifts in regional climate and severity of weather, have highlighted the importance of plant breeding for future U.S. and global prosperity.

In response to these growing needs, USDA's Office of the Chief Scientist (OCS), in the REE mission area, convened an internal USDA Plant Breeding Working Group (PBWG). The PBWG is made up of the USDA agencies primarily involved with "procuring, propagating, and distributing" seeds and plants (Table 1). The PBWG is tasked with maintaining an overview and assessment of plant breeding activity, including strengths, gaps, needs, and opportunities, to support USDA leadership in decisionmaking and planning.

Table 1. USDA agencies that work to "procure, propagate, and distribute" seeds and plants.

Agency and 2013 Representative(s)	Program(s)
Agricultural Research Service (ARS) Rep: Roy Scott	National Program 301: Plant Genetic Resources, Genomics, Genetic Improvement
Economic Research Service (ERS) Rep: Kelly Day-Rubenstein, Paul Heisey	Natural Resources and Environment
National Institute of Food & Agriculture (NIFA) Reps: Mathieu Ngouajio, Edward Kaleikau, Ann Marie Thro	Funding programs for extramural plant breeding (several programs)
Forest Service (FS) Rep: Randy Johnson	Research and development programs in Forest Health, Biomass and Bioenergy; National Forest System applied breeding for reforestation & restoration
Natural Resources Conservation Service (NRCS) Rep: John Englert	Plant Materials Program

The present document is a report of a stakeholder listening session convened August 15, 2013, by OCS as part of initial input gathering for the PBWG. To provide a common frame of reference, the session began with:

- A generalized overview of steps involved in developing a variety (Table 2), to help ensure a common understanding during the session;
- A PowerPoint introduction to each PBWG member agency and its programs related to plant breeding.

Table 2. Typical steps involved when plant breeders develop a crop variety or cultivar**.** There is much program-to-program variation and no single list is definitive.

Stage	**Processes**
Preliminary	-Assess needs and opportunities – e.g., via research, stakeholder meetings, and field days -Collect, maintain, and characterize germplasm
Core	-Introgression, population development, and pre-breeding -Trait development and testing -Line development and parent development -Advanced crosses, hybridization; generation advance -Field plot testing and on-farm testing (g x e testing) -Quality testing: nutritional value, processing, and other quality characteristics -Associated research: crop management and other aspects
Final	-Seed increase and seed testing -Distribution; sales

USDA Agency Programs Related to Plant Breeding

Agricultural Research Service (ARS)

The Agricultural Research Service (ARS) is the in-house research arm of USDA with congressional appropriations directed towards plant breeding. ARS has over 160 in-house breeding projects focused on agriculturally important crops that are critical to U.S. food security. These include grain crops, oilseeds, legumes, vegetables, sugar crops, berries, fruit and nuts, forages, ornamentals, floral and nursery crops, energy crops, cacao and hops. ARS develops strong partnerships with many universities across the U.S. as well as the private sector through various types of cooperative agreements.

ARS research is conducted under various national programs. Plant breeding research is done under National Program (NP) 301 entitled: Plant Genetic Resources, Genomics and Genetic Improvement. This program has three components: (1) Crop Genetic Improvement, (2) Crop Genetic and Genomic Resources and Information Management, and (3) Crop Biological and Molecular Processes.

Outcomes of ARS Work and Support:

Key outputs of ARS under NP301 are: enhanced plant germplasm and varieties; enhanced genetic, genomic, bioinformatic, genetic resource research, management, and breeding capacities; and enhanced knowledge and research toolkits. In the last 7 years alone, ARS scientists have made approximately 700 new germplasm releases of a wide range of crops that will improve the quantity and quality of our food, feed, energy, fiber, and ornamental crops. The USDA National Plant Germplasm System (NPGS) for the conservation of plant germplasm, which is housed at ARS, plays an essential role in ARS in-house plant breeding programs, as well as facilitation of research and breeding domestically and internationally. The NPGS includes over 560,000 samples from 14,800 species and annually freely distributes an average of about 200,000 samples to researchers worldwide, with 75 percent distributed domestically and 25 percent internationally. A few highlights of ARS plant breeding include:

- The timely release of wheat germplasm with resistance to the Ug99 strain of stem rust that threatens wheat production worldwide;
- Identification of maize genotypes with a 16-fold increase in pro-vitamin A; and
- Development of drought tolerant soybeans.

ARS is very active in plant breeding training and mentoring of new plant breeders. During the last 5-year cycle, ARS's National Program for Plant Genetic Resources, Genomics and Genetic Improvement has supported training of over 300 post doctoral researchers, nearly 400 graduate students, and 1,400 undergraduate students.

Economic Research Service (ERS)

The Economic Research Service (ERS) mission is to inform and enhance public and private decision-making on economic and policy issues related to agriculture, food, the environment, and rural development. ERS supplies economic data and analysis to inform (without advocacy) decisions about public investments in agricultural science, but does not produce or conserve genetic material of any kind. A cross-branch, cross-division research effort focuses on agricultural science policy, agricultural productivity, and agricultural innovation systems. Approximately ten ERS economists work at least part-time in this broad area, two of which devote part of their time to issues related specifically to plant breeding and plant genetic resources.

ERS assesses the role of plant breeding in the process of genetic enhancement, technology creation and adoption. Focusing mostly on major field crops,ERS works on the economics of plant genetic resources or plant breeding. using the concept of public goods, the role of incentives such as intellectual property rights, and availability of resources to elucidate the optimal mix of public and private effort in plant breeding. Examples of ERS research projects include:

- Using empirical information to anticipate future directions for plant breeding and the need for plant breeding in future adaptation to climate change;

- Guiding the search for plant traits using economic methods, such as probabilistic models that analyze what genetic resources to search for, when to search for them, and when to stop searching; and
- Estimating returns to research, including the value of genetic enhancement.

Outcomes of ERS Work and Support:

ERS research and analysis has come to three major conclusions about investment of agricultural research:

- Increased productivity, arising from innovation and changes in technology, is the main contributor to economic growth in U.S. agriculture;
- Public and private agricultural research has been the foundation for these advances in agricultural productivity; and
- Analysis indicates that public and private research may, in some cases, function as complements, not substitutes.

In 2000, ERS (along with ARS/NPGS and International Food Policy Research Institute) conducted a study of users of the NPGS. This study found:

- The demand for genetic resources was rising;
- More NPGS materials were used by respondents in plant breeding programs than anticipated, particularly in developing countries;
- Use of NPGS resources (in active breeding and R&D programs) was higher than previously thought; and
- The demand for genetic resource use was expected to increase in the future.

National Institute of Food and Agriculture (NIFA)

The National Institute of Food and Agriculture (NIFA) manages USDA extramural research funding and makes awards to plant breeding research, education, and extension.

Capacity programs: NIFA-managed capacity programs include Hatch (1862) and Evans-Allen (1890) Land Grant Universities, and McIntire-Stennis (State forestry) schools. Characteristics of capacity programs include specific eligibility, leverage of significant non-Federal matching funds (typically 100 percent), research use including graduate assistantships and infra-structure, and Federal-State and multi-State interaction. Within-program priorities for capacity funds are determined at State level by State Agricultural Experiment Stations (Hatch), Agricultural Research Directors (Evans-Allen), and State Forestry Directors (McIntyre-Stennis), respectively.

Competitive programs: Some of the NIFA competitive grant programs that have funded plant breeding include: Agriculture & Food Research Initiative (AFRI), Organic Agriculture Research & Extension Initiative (OREI), Specialty Crop Research Initiative (SCRI), Biomass Research & Development Initiative (BRDI), and Small Business Innovation Research (SBIR). Characteristics may include integration across functions (research, education, and/or extension) and broad eligibility. All NIFA competitive programs require peer panel review. Competitive programs vary in matching-funds leverage, degree to which eligible project types are defined by

the funding authority versus determined by NIFA, and extent of post-award interaction with NIFA**.**

NIFA establishes priorities for its competitive grant programs within the context of the congressionally authorized purposes of each program, and with input from a broad range of stakeholders. In addition, each Request For Application (RFA) for a competitive program includes a request for public comment.

Special grant programs: NIFA special grant programs that currently include plant breeding are Potato Breeding Research and the Supplemental and Alternative Crops.

Outcomes of NIFA Work and Support:

Successes from projects funded by NIFA are typically achieved in partnership with other funding sources, such as other USDA REE agencies, crop growers and farmers, industry groups, non-profit associations, and the private sector. A few success stories include:

- Development of hard white wheat, which looks and tastes like refined wheat products but has whole-wheat nutrition. NIFA competitive and capacity funds, ARS funds, State funds, farmer/grower funds, and industry funds all contributed to this advancement;
- Northern Organic Vegetable Improvement Cooperative (NOVIC) development of new varieties to adapt to organic systems, as well as increased local and regional sales of vegetables. NIFA capacity and competitive funds, ARS funds via use of the NPGS, and farmer funds fueled these developments; and
- Strengthening and innovation in research, education, and extension partnerships through the Plant Breeding Training Network (PBTN) and the Plant Breeding and Genomics Community of Practice (PGBCoP). These two projects, partially funded through NIFA AFRI competitive grants, provide a wide range of educational materials, plus contacts and tools for problem solving, networking, and collaboration.

Forest Service (FS)

The USDA Forest Service (FS) manages 193 million acres of national forests and grasslands (the National Forest System), provides technical and financial assistance to landowners and resource managers to help sustain the Nation's forests and protect communities and the environment from wildland fires (State and Private Forestry), and provides science to improve the health and use of our Nation's forests and grasslands (Research and Development). FS has internal programs that encompass breeding research and operational breeding programs. The operational breeding programs typically focus on developing tolerance to diseases, pests and abiotic stress in seed sources used for reforestation on National Forest System and other forest lands. Most applied programs are run through the National Forest System, but Research and Development maintains some operational programs as well.

FS research efforts include: developing genomic tools and markers for identifying genes underlying key traits (disease and insect resistance, adaptive traits, wood quality, & growth),

developing screening procedures to identify resistance to diseases and pests, and documenting genetic variation and structure over the landscape for key adaptive traits. This information is used to improve breeding programs and to develop deployment options for forest managers with regard to disease and pest resistance, climate change, and adaptation (seed movement guidelines and seed zones).

Outcomes of Forest Service Work and Support:

National Forest System breeding programs have provided reliable sources of seedlings for reforestation and restoration with improved disease/pest resistance and/or improved growth rates. Genetics studies also guide the development of seed zones and seed movement guidelines for "unimproved" seed sources to ensure plants are not deployed in environments to which they may not be adapted.

Results from Research and Development have been crucial in developing breeding strategies and screening procedures for a number of diseases (white pine blister rust, fusiform rust, Swiss needle cast, and others). Genomic studies help to identify the genes underlying crucial traits (disease and pest resistance, and adaptive traits) and can also assist in deploying the right resistance mechanisms in the right places.

Natural Resources Conservation Service (NRCS)

The Natural Resources Conservation Service (NRCS) provides technical and financial assistance to America's ranchers and farmers to encourage soil and water conservation practices on private lands. NRCS' Plant Materials Program supplies the proper vegetation to support this mission. Born out of the Dust Bowl era, and established to produce large quantities of seed and nursery stock, NRCS today operates a nationwide network of 25 Plant Materials Centers. NRCS works on the premise that there are already plants available which will address natural resource conservation needs. For example, grasses are the foundation for soil stabilization while legumes are useful for improving soil quality. NRCS works to find and evaluate plants useful in restoration and mitigation through a process of collection, assembly, evaluation, possible reassembly/crossing, field testing, and release. Much of the Plant Materials Program's work is done in cooperation with other Federal and State agencies and with private industry.

Outcomes of NRCS Work and Support:

During its history of collecting and evaluating plants, NRCS has released 733 plants, of which 600 are still actively used (an 80% success rate), with a value of $100 M/year to commercial seed and plant producers. The vast majorities of these are native plants (485 released selections), most of which are grasses (399 released selections). Some of the most successful NRCS plant selections include the following:

- "Critana" thickspike wheatgrass (*Elymus lanceolatus* ssp. *lanceolatus*) is a native perennial grass selected for use in 10 to 20-inch precipitation zones of the northern Rocky Mountains and adjacent Great Plains areas. Critana provides fast cover on erosive and

degraded sites, is an important component for range restoration, and provides early forage for livestock. Since 1971, commercial growers produced over 9 million pounds of this grass and used it to revegetate over 1.5 million acres for a total economic and ecological benefit of more than $70 million.

- "Selection 75" kleingrass (*Panicum coloratum*) is an introduced perennial grass released to the public in 1969 for soil stabilization in the Southern Great Plains. Selection 75 is important for rangeland seeding, erosion control on disturbed sites, and for wildlife habitat. Over 7 million pounds of seed have been commercially produced and planted on more than 4 million acres, for a total economic and ecological benefit of more than $135 million.
- "Cape" American beachgrass (*Ammophila breviligulata*) is the premiere native perennial grass used for stabilizing dune systems along the Atlantic coast from Massachusetts to North Carolina. Although the total area planted is small, with over 180 million plants produced since 1970, the narrow ribbon of "Cape" American beachgrass protects critical coastal habitats and high-value properties.

Technical information developed by NRCS on how to propagate, plant, and manage these conservation plants is found in over 2,300 documents on the NRCS website, downloaded over 2 million times per year.

NRCS conservation plants are vital to both private and public land resource conservation efforts on millions of acres of private and public lands each year. A recent cost-benefit study found that over the history of the Plant Materials Program, every $1 invested in the program yielded $3.65 in economic and environmental benefits. The Plant Materials Program has a long and successful history of finding vegetative solutions to support U.S. natural resource conservation efforts.

SUMMARY OF COMMENTS

Approximately 80 stakeholders were in attendance at the August 15, 2013, event. Of these 80 participants, 18 individuals representing universities, professional societies, or commodity groups formally presented their perspectives on the future of publicly funded plant breeding. In addition, all interested stakeholders were invited to submit written comments; a total of 38 sets of comments were received. These comments covered topics including: defining the mission, outreach, funding, breeding priorities, other research priorities, partnerships, recruiting and training of plant breeders, other needed resources, open access, and evaluation. There was significant overlap between some of the topic areas, and many points were repeated by different stakeholders. The following is a synthesis of all of these comments, with no quantification of frequency of comments. If a specific group or organization is referred to in the text, it is because a stakeholder comment specifically called that group or organization out.

USDA does not intend to show any preference or endorsement for any organization. This report should be read as an unbiased report on views expressed during the listening session on August 15, 2013, and through the public comment process lasting from July 29 through August 22, 2013. The opinions and recommendations in this "Summary of Comments" section do not represent opinions, recommendations, or value judgments of USDA.

Defining the Mission

While many comments that emerged from the listening session dealt with specific technical and programmatic issues, there were a small number of comments that suggested large-scale changes in the way USDA programs and funds plant breeding, and moreover, the way publicly funded plant breeding in the United States is planned and managed. Stakeholders recommended a longer term approach to USDA priority-setting for plant breeding. The plant breeding field is wide, incorporating classical and molecular plant breeding tools, and related disciplines in pathology, entomology, among others. Plant breeding is also a very applied discipline, requiring strong engagement with stakeholders so that outcomes can be integrated into production systems. Some stakeholders saw a need to define the stakeholders and their objectives, from growers, to seed companies, to processors, to retailers and consumers. Many suggestions were put forward about how to develop a new national strategy for plant breeding. One suggestion included having a plan for training all levels of plant breeding workers, from field workers to program leaders, which would include continuing education opportunities in new technologies for plant breeders. To attract bright, young minds into this field, it was suggested that USDA and the plant breeding community should come to a consensus about how to promote plant breeding as an important, exciting field of work that allows great creative input and great impact for those working in it. The National Institute of Health (NIH) could serve as an example.. NIH has "waved the flag" of cancer research, drawn national attention to it, had advertising campaigns about it, and as a result have convinced Congress and the public that this is an area for investment. This movement has shown young researchers that this is a stable and well-funded field to enter. In the same way, USDA could aggressively promote "healthy food," "food

security," or "sustainable agriculture" as essential components of our national health, and valuable and necessary fields for young scientists to pursue.

There were also several calls from stakeholders for NIFA to setup a new AFRI program in support of such an effort, and one commenter specifically suggested that 5 percent of AFRI funds should be allocated to this new program. For most annual and biennial crops, 5-year grants with the possibility of renewal would be adequate. It was noted that the reason that public plant breeding has sharply declined is because so few people do it anymore, which means there are less relevant, locally adapted crops available, and fewer breeders to train the next generation of breeders. As several participants noted, there is a need to evaluate plant breeding research (e.g., creation of new knowledge through theoretical advances, new method development, germplasm evaluation, pre-breeding) and operational plant breeding (i.e., cultivar development), using different review panels and different criteria for evaluation. For this reason, many felt that AFRI needed a new program that focused specifically on breeding and farm-ready, publicly available cultivar development, and some suggested that this program should encourage meaningful farmer participation, perhaps during the review process, or perhaps during the research and development phase. Projects within this program should focus on regional needs, such as regional food preferences, organics for local markets, and climate-adapted varieties.

While specific components of such a program are detailed more in the sections below, some broad ideas from stakeholders included the need for USDA and the Federal Government in general to include stakeholders much more frequently, as well as the need for this program to address fundamental challenges that can be developed by the public sector versus the private sector. An assessment of the best science and capabilities of each sector should guide any changes to existing plant breeding granting mechanisms or development of new ones. Proposals for this program could be evaluated on the likelihood of success in developing cultivars that will address NIFA national goals. Individual grants could support cultivar development and hypothesis testing research. Such research could include comparison of selection methodologies, germplasm sources, or different physiological, morphological or agronomic solutions to address farmers' needs.

Among stakeholder comments was a call for any new AFRI program to have a leader who would ensure greater cross-agency communications and coordination of research activities at USDA relating to classical plant breeding for public cultivar development. It was suggested that the leader of such a public cultivar development program should establish a working group that reports to the Secretary, to be comprised of individuals who are responsible for the management or administration of public breeding programs for public cultivar development in the Department. This working group would include ARS, OREI, and this new public cultivar development program, as well as USDA staff for the National Genetic Resources Advisory Council (NGRAC) and NPGS. This working group could set investment goals for breeding research in each agency after assessing current investments. This program might also focus on conservation, broadening the genetic base of major crops, breeding for improved nutritional value, and translational genomics (i.e., integrating genomic discoveries into breeding programs).

Outreach and Communication Among Stakeholders and the Public

Many participants voiced opinions on the need for better outreach in the publicly funded plant breeding sector to satisfy ends of both increased involvement and better prioritization processes. Some ideas included the need to have stakeholder listening sessions or summits on a regular basis to help develop priorities. They also expressed the need to specifically involve breeders and farmers in the prioritization process by having brainstorming sessions with them every few years. To do this, there would need to be more outreach to farmers through Extension, breeders, and USDA leadership. Stakeholders stated that USDA should think about how to work better at the State and local level to get farmers involved in breeding projects and prioritization by having more field hearings on various subjects that, in turn, would allow for a better understanding of regional and local issues. Farmer surveys and economic analysis, especially when trying to determine the funding priorities that will have the biggest impact, could also be useful. In addition, for niche areas of the seed market, some stakeholders felt that USDA should consider special outreach with farmers in order to understand niche needs that are mostly overlooked in standard plant breeding grants. This type of outreach may need to include breeders, farmers, and the seed companies themselves. Some felt that breeders should also be encouraged to do more outreach with the commodity groups, and the breeding community might want to think about more communication partnerships with organizations that act as liaisons between private and public, such as the University of California at Davis' Seed Biotechnology Center. Breeders and USDA might also consider releasing farmer-ready seed varieties that come with fact sheets that are written in a publicly accessible language and clearly communicate the history of, traits that went into, and the public benefits of the new variety.

Further, participants suggested that some grants should specifically target underserved audiences: doing this would not only help promote the field of plant breeding to young scientists from these populations, but it is also necessary that USDA gain a better understanding of what underserved communities need, including urban communities who might have needs for varieties that can be grown in city gardens. These communities have long been disempowered in plant breeding, and stakeholders felt that this needs to change. One stakeholder suggested addressing this by dedicating some grant money to projects that involve collaborations with universities that do not currently have plant breeding programs.

Many stakeholders mentioned room for improvement in how results of breeding are communicated to the stakeholders and the general public. Participants suggested that grants could have requirements for outreach explicitly written into them, and that evaluation of outreach should be a component for determining future ability to get grants. Proposals could require plans for cultivar development and release, delineating how the final cultivar will be distributed and disseminated to farmers. Some comments also asserted a need for scientists to get training in media relations so that when a new variety is released, they not only know how to contact the media and let them know, but they also know how to talk to the media and Congress about the value of their work. Both USDA and individual breeders could get better at telling success stories such as 'What are the great developments that have come out of publicly funded plant breeding in the past decade and how have these developments had positive impacts on society?'

Participants felt that this is the type of information the public sector needs to put together, and disseminate widely, through getting communication training for scientists, or through working more closely with communicators. Telling well-communicated, convincing success stories could help raise public awareness of plant breeding. There are many existing great stories plant breeders can tell, emphasizing that the field is not asking for an increase in funds from historic levels, just to get back to where levels were; explaining how the field of plant breeding is losing knowledge and lines; discussing the age of the average plant breeder and the need for new recruits; describing how germplasm centers have insufficient resources to properly conserve the seeds they are charged with preserving; highlighting the value of continuous support to avoid loss of germplasm and institutional memory; and pointing out how 2012 was the biggest drought since the 1950's but the U.S. did well thanks to good varieties. Participants suggested that USDA could play a role in gathering and making publicly available more of these success stories for the entire field of public plant breeding to share and disseminate, perhaps by providing a system for better tracking plant breeding innovations. USDA might also do a huge service to support communication on plant breeding by setting up a new website that could be a one-stop shop for information on plant breeding efforts and success stories.

Media training and story–telling were not the only changes in communication strategy suggested by stakeholders. Some felt that ARS scientists need to be more involved with outreach to the general public and not just farmers. Outreach activities could include hosting field days at land-grant university stations, providing materials to local botanical, school, and community gardens for display, and enlisting the help of local chefs to highlight varieties. And finally, participants noted several times that breeders need to not only communicate with the public, but communicate aggressively with Congress as well, highlighting success stories from the field of breeding as a reminder of its value to their constituents and encouraging funding it during appropriations processes. One respondent also noted that USDA and the plant breeding community can look to the film "Stewards of the Ground" as an example of public outreach. Using funding from NIFA, this film was put together to let growers speak for themselves about their needs from the plant breeding researchers and communicators. All of these activities will underscore the importance of plant breeding to food security.

Funding

The vast majority of comments from stakeholders dealt with the issue of funding, with the most frequently heard comment being that more funding for public plant breeding is needed. One commenter pointed out that with insufficient funding there is not enough money to properly prioritize, as there is too great a need in too many areas to identify ones that need it the most. Many stakeholders insisted that both Formula Funds, which are the basis for a lot of the long-term applied research at land-grant universities, as well as competitive grants, must be bolstered. Participants suggested that waivers of any matching funds be available to encourage the widest participation among universities, and that it is important to find a balance between large, integrated projects and smaller individual investigator grants that promote more risk-taking. As mentioned earlier, participants felt that a new AFRI program dedicated specifically to plant breeding could revive what is now a dwindling workforce and research area. As funding in this field has decreased over the years, it has been harder and harder to find support for minor crops and novelty varieties, with the consequence that growers and the pubic are not getting the crops

they want or need. One participant pointed out that while the bigger commodities might not feel the impacts of less public breeding funding immediately, they will eventually feel the consequences in the long term as fewer new breeders are trained.

The need for more engagement with famers was reiterated by many stakeholders. It was suggested that to better target public needs, grant proposals should be required to include letters of support from farmers. The direct involvement of farmers in the project, from project design to on-farm trials and selection, should be encouraged and considered during the panel review process. Several participants also emphasized the need for more participatory breeding initiatives, which breed both important plants and good will by directly involving end-users in research. Non-governmental organizations (NGO's) and Extension have a role to play in developing these initiatives. It was suggested that any new AFRI grant program dedicated to plant breeding specifically invite proposals for participatory projects.

There were also many calls for increased funding for graduate assistantships, both at large research institutions and at smaller schools. Many participants cited a lack of properly trained classical plant breeders entering the field as a major concern for the future, and noted that USDA has the ability to make an impact on this by providing more assistantships in classical breeding. Many also noted that in addition to a general increase in funding, a particular problem with funding was the low overhead funds included in breeding grants. When breeders get grants with low overhead, they are forced to compete with their NIH-funded colleagues within their department who are providing a significant paycheck for their universities. This puts breeders in an awkward position and may force some of them out of classical breeding programs and into molecular research that comes with these higher funds. Stakeholders expressed concern that this effect is being felt in hiring. It was noted that to keep the research engine going, administrators have no choice but to turn to the generation of indirect costs. When an administrator must make a decision regarding the type of researcher to hire, part of the calculation inevitably involves the potential for the generation of indirect costs. As indirect cost recovery becomes more important, the likelihood of hiring a classical plant breeder decreases; instead, a bioinfomaticist or molecular biologist may be hired and called a plant breeder. Several participants felt that increasing the indirect recovery rates would allow administrators the ability to make hiring based on the needs of the clientele.

Aside from a general call for more funding, many stakeholders requested that longer term funding cycles be implemented. The process from germplasm development, to field testing, to cultivar release is very long-term and often cannot be successfully completed using the short-term (3-5 year) funding cycles that currently exist through most USDA grants. Tree researchers are especially hampered by short funding cycles and pointed out that extending these need not necessarily be more expensive: often they just need to pay for part-time monitoring over a longer period of time. Stakeholders noted that FS and land-grant universities have done a good job supporting some long-term forest tree research and should continue to do so, but more is needed for non-forest species. Some felt that funding cycles need to be extended to 10 years, or longer, so that the entire process from development to release can be funded and more accurately tracked.

The method of funding varies. Some stakeholders suggested more long-term Coordinated Agricultural Project (CAP) grants, while some cautioned that CAP grants take money from foundation programs, which hurts young investigators. Others suggested that there be a balance of funding for projects divided between formula funding and grants, a view echoed by many who felt that formula funds were essential for long-term projects, but competitive grants were good at fueling innovation. It was felt that there will have to be a mix of external competitive grants, formula funding, organizational funding, and emergency funding; in short, funding models that recognize the inherent differences in varietal creation and crop utilization. One proposed solution was updating the Federal-State recurring funding models to focus on regional breeding programs and inter-state collaboration amongst plant breeders. This recurring support for cultivar development would provide base funding for breeding program operation, and it could be integrated with the other funding streams that support essential activities of public-sector plant breeders, including instruction, generation of new knowledge, and outreach. Several participants also suggested that there be a mechanism for rapid and flexible renewal of short-term grants if emerging threats, such as new insects, diseases or other stresses, require more research into a particular variety. Lastly, long-term investments in capacity-building at public and land-grant universities are needed. Many of these institutions are nearly 100 years old and working with outdated equipment that makes it difficult to translate basic genetics and biotechnology into deployment of public cultivars.

Many stakeholders also commented on funding priorities and the need for balance. Participants stated support for funding strategies that promote breeding that is integrated with current germplasm, current production technology, current market chains, and current producer and consumer values. There was a repeated call for a greater balance in funding between molecular and classical plant breeding: genetic and molecular research has been getting the greatest share of funding in recent years. While that research is important, many commented that USDA needs to reallocate some resources within its portfolio to classical plant breeding and cultivar development, or emphasize cross-disciplinary approaches that include classical breeding. It was noted that classical, field-based, phenotypic-centered breeding is still a proven, vital, and cost-effective approach. One commenter stated that, to date, more than 90 percent of all gains in crop yield, quality, and adaptability to regional climatic and soil conditions have arisen from classical methods and not from genetic engineering or other high-tech methodologies such as genomic analysis or marker-assisted selection. Many comments also addressed the need to balance funding between major and specialty crops, with attention paid to pressing regional needs. It was suggested that competitive cultivar development grants should support specialty crops, local markets and the development of cultivars for ecological farming systems. And, several noted that within existing USDA programs for specialty crops and organics, such as Sustainable Agriculture Research and Education (SARE), OREI, and SCRI, there is not enough money allocated for classical breeding. Participants also suggested other funding options for specialty crops, including the use of commodity check-off programs, with the caveat that this method may only work for highly consumable, high-value crops like apples and other fruits and nuts. One stakeholder suggested that the Federal Government fund a for-profit organization to support development of specialty crops.

Working on regional solutions to plant breeding issues was a recurring theme, including discussions on allocations of funds. Several stakeholders suggested that USDA try to manage its

grants regionally, and to look at other successful programs, such as USDA SARE and Department of Energy (DOE) Sun Grants, as a model for how to do this. Regionally allocated funding was not universally supported, however. One commenter suggested that, within ARS, funds should be given to National Program Leaders (NPL), rather than Area Directors, because NPLs have a better sense of the balance needed across the entire discipline.

Finally, there was a subset of comments on how funding of grant proposals should be evaluated, specifically in reference to review panels. Many suggested that review panels should include more Extension specialists, plant breeders with demonstrated background in classical techniques and cultivar development, farmers, and other sorts of end users who are actually using the cultivar and can better assess the practical output of the project. As they are now, participants felt that reviewers often focus on "best science," which emphasizes research that is broadly applicable, able to be generalized and basic. They stated that effective plant breeding, however, is fundamentally local and regional, specific and particular, and thus not necessarily addressed by what is classically considered "best science." A responsive plant breeding program can look trivial to non-stakeholders because clients of the end product are the only ones who know if plant breeders were successful.

Resources Needed

Though funding is at the foundation of all resources needed in plant breeding, some technologies and infrastructure were specifically mentioned by stakeholders during the listening session. Though these resources are not as flashy as new research, stakeholders felt that they are important to making progress nonetheless.

A frequent listening-session request was for supporting germplasm collections, many of which are housed in underfunded State and private facilities and are therefore poorly maintained. Capacity funding for plant introduction and experiment stations will greatly enhance germplasm collections nationwide as well as contribute to workforce training. Stakeholders felt that stewardship of germplasm collections is a long-term commitment not suitable for the private sector. Germplasm should be preserved not only for genetic diversity, but also for phenotypic diversity that relates directly to economically important traits. Future needs are not easily predicted, so preserving the widest degree of diversity should be the goal. USDA-ARS maintains the NPGS, but it is underfunded in terms of maintaining the collection as well as coping with shipping and phytosanitary costs for germplasm requests. Several groups strongly recommend that USDA assess current NPGS holdings and start a rigorous priority-setting process for maintenance and regeneration of current holdings. For example, within NPGS's Germplasm Enhancement of Maize (GEM) project, a crucial resource for corn breeding in the U.S., 38 percent of its accessions are inaccessible due to lack of resources. Similar to traditional germplasm stewardship, a few participants felt that this is also time to emphasize the need to support the centralized and coordinated system of plant-associated microbes known as the National Microbial Germplasm Program (NMGP). This is a living culture collection that can be used for screening for resistance, comparative genomics as new strains appear, and identification of emerging diseases. Lastly, for both germplasm and microbes, in addition to other pests, participants felt that USDA should also facilitate the development of protocols for shipping these

organisms within the U.S. and internationally to facilitate stewardship of and research on these resources.

There were several calls from stakeholders for better analytical, computational and electronic resources. Breeders working with perennial crops, or crops that take a long time to mature, need better tools for analyzing spatial and temporal data sets. Several types of databases were called for, including one for tracking current projects, one focused on storing diverse types of plant breeding data (image, molecular, and phenotypic), one to track success stories, and one to monitor the workforce. The University of California at Davis pointed out that, in coordination with the Plant Breeding Coordinating Committee, it has sought to use USDA CAP data to document the current capacity of breeding programs in the U.S. to meet national needs in a way that captures trends for future years and could guide agencies in funding. Funding, however, has not been available. Finally, several stakeholders mentioned the need for threat assessment tools, and it was suggested that researchers and Extension specialists need to be brought into the conversation and that the National Security Agency might be able to provide a framework.

Plant Breeding Priorities and the Role of Public Breeders

Many comments in this section could be cross-listed with comments in earlier sections; however, specific priorities in terms of breeding were called out. It was pointed out that Miller et al. (Plant Sciences 179: 645-652) represents the outcome of a 2-day workshop of international plant breeding experts and outlines a set of long-term goals that provide guidance in setting plant breeding priorities. These goals were reiterated in a survey of the U.S. National Association of Plant Breeders and the American Seed Trade Association (ASTA) Summit in 2011. These goals include breeding that addresses food security, biofuels, climate change, and varieties that are stable across different environments. A few stakeholders noted that the research priorities and scientific or policy goals identified at the American Seed Research Summit in 2008 as a good guide for where breeding efforts should be focused. Summarized recommendations from this source include: conserving, characterizing and utilizing novel germplasm; preserving biodiversity in both agricultural and natural environments; understanding basic genetic mechanisms; developing efficient, high-throughput analysis systems; managing complex traits, including quantitative traits; deciphering the genetic basis of plant environmental responses; increasing plant efficiency and quality; continuing to develop cost-efficient risk analysis systems for products of new technologies; improving seed health, quality and performance; and creating knowledge from information by improving systems for management and analysis of large data sets and developing standardized formats for distribution of information.

Many participant comments suggested that USDA needs to focus more on minor/specialty/orphan crops, on regionally adapted varieties (including varieties for Hawaii, Puerto Rico, and the Virgin Islands), varieties for local markets that have high flavor and nutrition, and organic varieties. Put in another way, there were suggestions to focus on "neglected" areas, which would include neglected farmers (i.e., those working in low input/organic systems, those in commodity or small-scale systems who wish to be able to save their own seed and/or refrain from using genetically engineered (GE) varieties, and home gardeners), relatively neglected crops (like many vegetables, nuts, and fruits), and very neglected crops (like minor grains and minor vegetables). And it was noted that in these systems, the plant

breeding community could not only use more work on breeding, but also integration of genomics with breeding. Generally, many noted that because organic, minor, ecologically adapted, and specialty systems are not as profitable as large-scale commodities, industry will not put a lot of effort into developing these varieties, and, therefore, USDA has a critical role to play.

To address the perceived neglect in these areas, stakeholder comments included that USDA should fund breeders who breed for sustainability by conserving genetic diversity and developing more locally adapted varieties that build up top soil, are climate resilient, can deal with pests and diseases, and perform other ecosystem services. Nurseries were heavily discussed because of their need of resources to focus on ecosystem services, pest and disease concerns. Nurseries tend to have resources and incentives to deal with aesthetic issues, but not ecosystem services. A stakeholder also mentioned the specific needs of organic producers in the eastern U.S. for tomato varieties that are resistant to the fungal and oomycete diseases that are promoted by rainy climates, especially late blight (*Phytophthora infestans*) and septoria leaf spot (*Septoria lycopersici).*

Finally, one stakeholder recommended that USDA make a clear policy statement prioritizing public goals as the primary purpose of Federal plant breeding research to help drive funding priorities within USDA. This prioritization should also include a discussion about intellectual property rights around federally funded research, an issue which is discussed further below.

Other Research Priorities

While the majority of comments on research priorities were focused on breeding goals, there were a significant number of comments that addressed other research priorities. Several comments dealt with genomics, in terms of the need for translational genomics to move technology from the lab to the field, the need for high-quality genome sequences for major and minor crops, and the need to assume the plant genome initiative from sequencing groups who are primarily concerned with producing sequences and not with using genomic information to improve crops. The need for improved and high-throughput phenotyping methods for cultivar development was also mentioned by several stakeholders.

Some comments noted that agriculture has divorced itself from food, and that food-related priorities need to be re-evaluated, including integrating more nutritional testing into breeding projects. It may also be necessary to develop new testing and screening methods that can measure nutritional value, or other important factors like pathogens or stress; the example was noted of a rapid, non-destructive near infrared spectroscopic assay that made selection for lysine and methionine possible.

Some listening-session participants noted the need to evaluate plant-insect and genotype by environment interactions in sustainable agriculture systems. Some felt that research on systems that deploy multiple modes of control, such as multigenic approaches to breeding for insect resistance, or combined systems such as resistant crops and crop rotation, should be given priority for funding. Stakeholders felt that the plant breeding field needs to understand the etiology of pest and pathogen infection and environmental factors that influence expression of resistance, and that a natural system approach will be required to map key genes and expression

analysis. There is also a need for more research on the population genetics of plant pathogens and how strain-specific interactions and partial resistance evolve.

Investment in social science research was also discussed. One commenter noted that stakeholders in natural resources are very poorly coordinated because they are dispersed and unaccustomed to asking for help from plant breeders. Grants to researchers in the human dimensions of natural resources or to teams that include human dimensions researchers could improve connections between natural resources stakeholders and plant breeders.

Partnerships

Participants noted that partnerships of many forms can play an important role in extending and leveraging scarce resources in the field. Public and private breeders, commodity groups, professional organizations and end users are some of the key players in the plant breeding community, and there are opportunities for building new partnerships and strengthening existing ones. Participants described a need for mechanisms for improved communication and collaboration among public and private breeders. Also mentioned was a need for more clearly defined end users so that all breeders and commodity groups can better serve their needs. Among stakeholder suggestions was that capacity for variety development might be increased through partnerships between USDA and small private programs that promote a "triple bottom line" of public, environmental, and economic good, such as High Mowing Seeds (Vermont), Fedco Seeds (Maine), and Southern Exposure Seed Exchange. Fostering regional partnerships could also be a productive approach to encouraging relevant plant breeding research by addressing place-specific social, environmental and economic issues. A comment noted in the earlier discussion about funding, but worth echoing here, is the potential for participatory breeding programs to form productive, region-specific partnerships between public breeders, Extension, farmers, small companies, and other members of the public. One participant noted that looking outside of a region, however, may bring unexpected benefits: partnering with off-season nurseries in warmer climates has accelerated some breeding programs.

Many organizations have a role to play in plant breeding. Participants suggested that USDA utilize these organizations as sounding boards for ideas and that USDA assemble teams of scientists, teachers, practitioners, and industry personnel to draft a long-term approach to prioritization. Many promoted more public-private partnerships in general, and several stakeholders suggested that USDA look to other Federal partners for models of how to establish partnerships, such as the National Science Foundation/ Industry and University Cooperative Research Program. Public-private partnerships can have many uses, including opportunities for those in industry to get additional training, opportunities for those in industry to act as mentors, opportunities for faculty to work on industry projects, opportunities for small seed and specialty companies to have more support for their plant breeding needs, and also possibly as a source of additional salary for public breeders who might otherwise be tempted to leave the profession due to low pay. One suggested approach to forming more partnerships between the public and private sector is arranging adjunct professorial appointments with non-university plant breeders. This plan could boost the presence of plant breeding at universities while also building networks that could lead to funding and career opportunities for students. Several examples of successful public-private partnerships were mentioned. For example, the National Clean Plant Network

wipes clean disease and stores material that has been useful in the past, allowing industry to get the resources they need. It is a collaboration between the nursery industry, growers, State regulatory agencies, land-grant universities, and USDA to provide clean and healthy planting stock to small and mid-sized producers. USDA's Cochran Program is another good example of public-private partnership, in which USDA partially funds training for mid- and senior-level professionals from the public and private sector in middle-income, emerging democracy and emerging market countries to improve their local agricultural sector and enhance trade relations with the U.S.

Many participants remarked on the need to partner with scientists from other disciplines, because this will not only strengthen research in the field but will also improve graduate education. Multidisciplinary teams of geneticists, plant breeders, entomologists, pathologists, plant nutrition specialists, cropping systems scientists, physiologists, soil scientists, meteorologists, and climatologists all need to be collaborating and working to together on targeted goals. Some felt that USDA could have a role in purposefully funding grants that specify these sorts of partnerships. Interdisciplinary collaborations can be useful in developing varieties that are most suitable for consumer needs (such as by working with social scientists) or developing varieties that have particular traits (such as by working with entomologists on insect resistance). The Institute of Plant Innovation at the University of Florida was suggested as useful model. The Institute uses social scientists to understand what the consumer wants and tries to reduce those values into traits that can be selected.

Participants noted USDA is already doing some things right in terms of partnerships, and there were some areas that were identified as areas for continued support. Those included the PBWG, which several applauded and urged to continue. They also included the many ongoing partnerships between ARS labs and neighboring universities, which have provided opportunities for enhanced graduate training, as well as opportunities for ARS scientists to act as mentors. Several suggested that the PBWG liaise with various professional and scientific societies that could work with the USDA to help gather stakeholders and set priorities, as well as help USDA disseminate new plant breeding information. One participant also suggested that USDA, ARS and NIFA hold joint meetings for stakeholder input, priority-setting, and planning. Participants pointed out that USDA's participation and facilitation of partnerships would be greatly enhanced by the ability of employees to travel.

Stakeholders emphasized that international partnerships are also important. Global development alliance partnerships have been useful because they allow universities to partner with private firms, resulting in broader impact of public-sector breeding outputs, greater access to proprietary traits, and reduced risk for private firms exploring new markets. It was noted that the efforts of U.S. plant breeders to stay ahead of threats from pest, disease, and drought would also be greatly enhanced by the ratification of the International Treaty on Plant Genetic Resources for Food and Agriculture. It was signed by President Bill Clinton for the U.S. on November 1, 2002, and sent to the Senate for ratification, where it remains. Ratifying the treaty would give U.S. researchers access to some international germplasm and provide for grants to sustain germplasm collections in countries that lack the resources to do so.

Lastly, partnerships within the Federal Government also have a role to play in plant breeding. It was suggested that USDA find ways to collaborate and coordinate with other Federal agencies (NSF, DOE, NIH) doing basic research with applications to plant breeding.

Recruiting, Training, and Retaining Plant Breeders

Another very popular topic for stakeholder comments was the topic of training and recruiting the next generation of breeders, with the most general comment being that the field needs to find ways to attract and retain new talent. Good outreach on the value, successes, and potential careers in plant breeding is essential. The American Phytopathological Society (APS) has put substantial resources into the newly organized Coalition for a Sustainable Agricultural Workforce (CSAW, http://www.sustainable-ag-workforce.org). This organization was formed in response to the lack of trained personnel for agriculture and other plant science industries. In a recent survey of a few of the industry members, industry expects to hire 1,000 full-time employees between now and 2015, of which more than 40 percent will need a Ph.D. (Preliminary findings from the 2013 Agricultural Science Workforce Census). Recruiting and training students to fill these jobs is key to meeting the needs of the field. One suggestion was that a survey of students leaving plant breeding disciplines could provide direction on where to focus efforts with students. It was also suggested that a regular survey of users and providers in plant breeding, similar to the University of California at Davis' Delphi study, would ensure that students are being recruited and trained in accordance with current needs in the field.

Many listening-session participants suggested that USDA and the field of plant breeding in general need to start early by attracting youth, possibly through USDA Higher Education Challenge Grants for K-12, which could provide resources to teachers that highlight the importance of plant breeding and issues like genetics, biotechnology, and bioinformatics. ASTA provides one example with its First the Seed Foundation, which supports programs that provide an early introduction to plant science to K-12 students. Many noted that internships and hands-on experience are really important for giving students valuable experiences that might persuade them to enter the field, and that outreach to K-12 and undergraduate advisers is an important part of getting students in the door with these experiences. One suggestion was that USDA granting mechanisms could work on connecting K-12 educators to partners in the university system. The University of California at Davis mentioned that one of its most successful programs has been leveraging the Student Farm Program, which attracts 1,500 K-6 students every spring from across California. Students represent diverse ethnicities, income groups, and backgrounds. Through this program, a graduate student is funded to incorporate plant breeding modules with hands-on activities into a K-6 curriculum. Another comment was that USDA could promote hands-on learning in younger students by coordinating and funding high school internships. Lastly, USDA might facilitate more hands-on learning by promoting conservation programs and tax incentives that increase agricultural and forest land near urban areas, so that teachers and professors could then use the land for experiential learning related to plant breeding, potentially with curricula developed with USDA grant support.

Stakeholders noted that today's culture of food offers some unique opportunities for promoting traditional plant breeding. Using the history of plant breeding, such as accounts by ethnobotanist Gary Paul Nabhan, could draw students in by showing how successful traditional breeding has

been historically in creating land races and food crop development. Additionally, appealing to some students' desire to address climate change, minimize resource depletion, and find non-genetically engineered alternatives could attract them to the field. Students working for community-supported agriculture programs represent one such population with those interests. One suggestion was that USDA could consider funding more undergraduate scholarships in plant breeding, which might include initiatives like competitions with scholarship prizes for creative solutions in plant breeding. While catering to students' current interests in school, however, it is important to address their future as well. It was noted that follow-up outreach to undergraduate job fair participants and educators would also recruit more people to the field by portraying plant breeding as an important, useful, and rewarding career.

Stakeholders made the point that attracting students to the discipline will not do any good if strong programs are not in place to take them. At the most fundamental level, land-grant universities and other higher learning institutions must offer interdisciplinary coursework in plant breeding and genetics. One participant suggested that USDA should develop and support Masters of Science programs in applied plant and animal breeding. From there, universities, community colleges, Federal programs, and the private sector can partner, with coordination help from USDA, to offer the critically important hands-on experience in classical plant breeding, germplasm evaluation, and selection methods that could potentially lead directly to employment. Participants felt that focusing on creating paid or for-credit opportunities for students in the summer at USDA and partner facilities could be the most effective way to attract students to the hands-on opportunities that are likely to get them excited about the field. USDA could incentivize its own labs and employees to participate in graduate course teaching and graduate student and intern (high school, community college, and upper division student) advising by giving credit on annual evaluations. Universities could also benefit from better coordination and incentives to promote plant breeding education. Stakeholders pointed out that a key recommendation of the Seed Research Summit was the creation of Centers of Excellence in plant breeding at public institutions for coordination of research capacities among universities and increased incentives and support for students. Whether students gain experience in government, university, or private labs, participants felt that mentorship from plant breeders, especially those close to leaving the field who have a wealth of knowledge, is important to developing the next generation of plant breeders.

Many stakeholders who participated in the listening session agreed that increasing the reach of plant breeding education should be a top priority. USDA should promote initiatives aimed at reaching non-traditional students, such as through online certificate and degree programs in crop sciences. This type of program offers private-sector employees opportunities for staying current with the latest advancements in plant breeding. There is also a need to broaden participation of under-represented groups in plant breeding. One suggested that USDA increase funding for the National Needs Fellowship grants, which support under-represented graduate students in agricultural fields. Universities presented a few models that they use to increase diversity, including hiring minority faculty who are then successful at recruiting minority students and designating fellowships especially for qualified minority students. Private entities, from corporations to commodity-focused groups, are sometimes also willing to provide financial support for under-represented students when those students can be recruited into their global operations after finishing their degree. The University of Illinois Urbana-Champaign partners

with the International Rice Research Institute to fund international Ph.D. students in crop sciences who split their dissertation time between the university and research locations in Southeast Asia, with the hope that the students will return to their home country after their degree to help solve pressing problems in agricultural research.

The content and breadth of student training was also a common theme among listening-session comments. Public and private plant breeding programs need staff that are competent with the increasingly complex analytical aspects of plant breeding, both in the field and in the lab. Some participants stated that student plant breeding training should be more expansive so that they can address current hot issues in plant health, and training should include such fields as pathology, nematology, and entomology in addition to traditional plant-related fields. Stakeholders felt that training needs to strike a balance between broad training and specialization, with students having achievement-based means of demonstrating their proficiency. Many noted that graduate students tend to get training in molecular techniques more than training in classical breeding, and that good programs need to emphasize a mix of both. The lack of classical training has left industry and universities, both in the U.S. and abroad, in great need of classically trained plant breeders. Some participants felt that fellowships should be especially targeted towards increasing training in classical breeding techniques while also addressing growing interests in specialty fields, such as organic systems. Lastly, stakeholders commented that students should be trained to communicate across the diverse disciplines that participate in plant breeding as well as with lay people and business people. Plant breeding relies heavily on communication across disciplines and stakeholder groups to be effective.

Stakeholders made the point repeatedly that funding is central to the issue of recruiting, training, and retaining the next generation of plant breeders. By requiring Requests For Proposals (RFPs) to include teaching and Extension components in addition to research, some felt that USDA could codify the training of the next generation of plant breeders in its own granting mechanisms. Stakeholders also suggested that funding graduate student training should be standard in plant breeding grants and provide for tuition-sharing. Some felt that as it stands, incentives have been removed from training graduate students as their tuition and fees have become more expensive, making them similar in cost to postdoctoral researchers, but with slower returns on investment. It was suggested that a cost-effective way to fund graduate students through USDA would be to put out an RFP in collaboration with industry and NGOs that cooperatively funds graduate students to address the most pressing needs in plant breeding. Many private plant breeding companies are already involved in funding graduate students in some way. For example, the Illinois Plant Breeding Center (IPBC) housed in the Department of Crop Sciences has had success with a cooperative funding model. This multi-disciplinary association of plant scientists collaborates to secure external funding from Federal and private sources and train students in the diverse disciplines associated with plant breeding. The IPBC has been instrumental in growing the pool of Crop Sciences graduate program applicants from 53 in 2007 to 162 in 2012. Outside of funding through research grants, increasing the number and funding rate of graduate fellowships was also a frequently repeated recommendation.

Open Access

Most of the stakeholders who provided input commented that there is a critical need for public sector breeding programs to remain strong. Public breeding programs promote environmentally and economically sustainable interests where there are not incentives for industry to do so. They are critical not only to assure genetic diversity, representation of minor crops and organics, and locally adapted seeds for farmers, but also to assure that concentration in the private seed technology market does not result in unreasonable seed costs to farmers. The agriculture community is currently experiencing a dramatic transition in how plant germplasm is distributed, developed, and released, from a freely available resource primarily in the public sector into proprietary structures managed largely by the private sector. Access to diverse cultivars and traits is being restricted due to seed industry consolidation and use of a wide variety of intellectual property right protections. It was noted that universities can also be complicit in patenting research outcomes in a way that hampers open access. Farmers often say they became interested in plant breeding when their favorite varieties were dropped after seed company mergers or because they did not have a large enough market share. This is true for both specialty crops and commodity crops grown outside the primary growing regions. In addition, commodity farmers who are in primary growing regions are concerned about their lack of variety choices because of consolidation in seed companies and their offerings. Participants asserted that the issue of seed security is paramount, with farm families depending on farm-saved, locally adapted seed and breeds for their immediate and future survival.

While public breeding is important and costs to farmers should be minimized, stakeholders asserted that there is a need for public breeders to be paid for their efforts. There must be a balance between compensation and the public good, but participants felt that the majority of profits should feed directly back to public breeding programs. The Plant Variety Protection (PVP) Act offers some guidance. PVP allows parties with business interests in cultivars to retain rights to sale for a number of years, but does not prevent farmers from saving seeds or other breeders from using the variety in future breeding projects. One stakeholder also suggested that release and documentation through NPGS would contribute to open access and should be a standard part of public plant breeding.

Program Evaluation

There was a general consensus among the stakeholder comments received that USDA needs more coherent information on the outcome of its plant breeding efforts. Several participants pointed out the distinction between plant breeding research (e.g., creation of new knowledge through theoretical advances, new method development, germplasm evaluation, pre-breeding) and operational plant breeding (i.e., cultivar development). They felt that each of these needs to be evaluated separately, the former through peer-reviewed publications and competitive grant awards, and the latter through number of varieties released, their success in the marketplace, and evaluation of progress over time in the target crop. It was suggested that evaluation committees for public breeding programs should represent university breeders, NGOs, seed companies, and consumer groups, with a focus on people with expertise in classical plant breeding and cultivar development.

Several stakeholders expressed that USDA needs to coordinate, track, and analyze current and future breeding efforts across USDA agencies and suggested that within the public and private research community, NIH, Department of Defense, and Defense Advanced Research Projects Agency may provide useful examples of tracking long-term projects and outcomes. USDA's Current Research Information System (CRIS) is making some progress toward being able to query public plant breeding activity in the database, but participants felt that a dedicated funding stream is needed for tracking USDA's plant breeding efforts, from proposal to outcomes. A stakeholder suggested that competitive grant programs need project evaluation requirements within the RFA to provide valuable data on the outcomes of USDA-funded plant breeding efforts. It was further proposed that these federally funded breeding programs provide data and be evaluated on standard and non-standard criteria, including development of germplasm, peer-reviewed scientific publications, good communication with stakeholders, number of graduate students trained, development of new breeding methods, and establishment of cooperative activities across regions and nationally. Principal investigators could also be required to list cultivars they have released as part of their grant reporting and point out other grants contributing to those cultivars to give USDA a better of sense of the composition of funding contributing to cultivar development. Participants commented that submitting samples to NPGS is generally a standard part of any classical plant breeding grant, and should be for molecular and genomic projects as well. The importance of genetic diversity to ensuring a stable food supply was emphasized repeatedly, and to this end, participants also felt that submitting germplasm information to the Germplasm Resources Information Network (GRIN) should be required for federally funded projects and entries on GRIN should be linked to researchers and funding sources involved.

Once USDA has a mechanism for tracking plant breeding activities, one commenter suggested that USDA perform a self-study of plant breeding outcomes on a crop-by-crop basis, surveying growers and Extension agents about what advances have been most important for yield and sustainability in the past generation, who performed the work, and how the work was funded. One participant also noted that "bad" outcomes from lack of plant breeding research should be tracked as well, to provide a foundation for public plant breeding support. An investigation like this may turn up valuable, but often overlooked, contributors to plant breeding, including experiment stations. It would also possibly help ARS track breeding activities and distinguish them from genomic research if they were to re-classify their crop breeders as "crop breeders" or "cultivar developers" rather than "research geneticists." Participants supported the PBWG's goal of tabulating the total investments that each research agency actually spends on public breeding efforts and encouraged the Department to build on these findings by subsequently evaluating and tracking the adequacy of human and financial resources needed to ensure that plant breeding can meet the challenges of the 21st century.

Appendix 1. Federal Register Notice

Notices

Federal Register
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This section of the FEDERAL REGISTER contains documents other than rules or proposed rules that are applicable to the public. Notices of hearings and investigations, committee meetings, agency decisions and rulings, delegations of authority, filing of petitions and applications and agency statements of organization and functions are examples of documents appearing in this section.

DEPARTMENT OF AGRICULTURE

Plant Breeding Listening Session meeting

ACTION: Notice of a Plant Breeding Listening Session Meeting.

SUMMARY: The Office of the Chief Scientist of the United States Department of Agriculture (USDA) announces a Plant Breeding Listening Session stakeholder meeting for all interested plant breeding and cultivar development stakeholders.

DATES: The Plant Breeding Listening Session will be held August 15, 2013. The public may file written comments up to one week after the meeting with the Contact Person.

ADDRESSES: The meeting will take place at the Jamie L. Whitten Building, 12th Street and Jefferson Drive SW., Washington, DC 20250. Written comments from the public may be emailed to the Contact Person identified in this notice.

FOR FURTHER INFORMATION CONTACT: Jenna Jadin, Advisor, Office of the Chief Scientist; telephone: (202) 260–8318; or email: *jenna.jadin@osec.usda.gov.*

SUPPLEMENTARY INFORMATION: The Under Secretary of Research, Education, and Economics, Dr. Catherine Woteki, and the Director of the National Institute for Food and Agriculture (NIFA), Dr. Sonny Ramaswamy, have been invited to provide brief remarks and welcome stakeholders during the meeting.

On Thursday, August 15, 2013, the listening session will be held from 8:30 a.m.—5:30 p.m. in room 107–A of the Jamie L. Whitten building. Specific topics of discussion in the morning session will include an introduction to the plant breeding portfolio of all of USDA's relevant mission areas, including a discussion of relevant work, goals, and results.

In the late morning, the audience will listen to 10 minute presentations from stakeholders that discuss their plant breeding and cultivar development programs and/or their perception of needs and potential improvements in publicly-funded plant breeding and cultivar development research. Following lunch, stakeholder presentations will continue, and will be followed by a summary and discussion session in which participants will be asked to discuss their reactions to the information presented earlier in the day, as well as respond to a set of questions presented by the organizers which are aimed at getting feedback on plant breeding and cultivar development needs. The meeting will adjourn by 5:30 p.m.

All stakeholders are welcome to apply for a 10-minute presentation slot, however, due to time constraints, a limited number will be selected on a first come, first served basis. To apply for a slot, please email the Contact Person listed above. All presentations may be simple oral presentations or given in PowerPoint, however, the organizers request that a written transcript of the talk be submitted no later than one week after the event. Written comments by attendees or other interested stakeholders will be welcomed before and up to one week following the listening session (by close of business Thursday, August 22, 2013). All statements will become a part of the official record of the Office of the Chief Scientist and will be kept on file in that office.

All parties interested in attending this event must RSVP no later than August 8, 2013 to the Contact Person listed above.

Due to size constraints in the meeting room, only the first 70 responders will be accepted.

Done at Washington, DC this 23rd day of July 2013.

Ann Bartuska,

Deputy Under Secretary, REE, Chief Scientist, USDA.

[FR Doc. 2013–18153 Filed 7–26–13; 8:45 am]

BILLING CODE 3410–03–P

DEPARTMENT OF AGRICULTURE

Commodity Credit Corporation

Notice of Second Sugar Purchase and Exchange for Re-export Program Credits

AGENCY: Commodity Credit Corporation and Office of the Secretary, USDA.

ACTION: Notice.

SUMMARY: The Commodity Credit Corporation (CCC) announces the intent to purchase raw cane sugar to be offered in exchange for Refined Sugar Re-export Program credits as a follow-up to the notice of sugar purchase and exchange for Re-export Program credits published in the **Federal Register** on June 18, 2013 (78 FR 36508–36510). CCC will purchase the sugar from domestic sugarcane processors under the Cost Reduction Options of the Food Security Act of 1985, and concurrently exchange such sugar for credits under the Refined Sugar Re-export Program.

DATES: Effective date: July 29, 2013.

FOR FURTHER INFORMATION CONTACT: For current market conditions, eligibility, and criteria for evaluation information contact Daniel Colacicco; telephone (202) 690–0734. For sugar purchase and general exchange information contact Pamela McKenzie; telephone (202) 260–8906. For Refined Sugar Re-export Program information contact Ron Lord; telephone (202) 720–6939. Persons with disabilities who require alternative means for communications (Braille, large print, audio tape, etc.) should contact the USDA Target Center at (202) 720–2600 (voice and TDD).

SUPPLEMENTARY INFORMATION: Under the previous sugar purchase and exchange for Re-export Program credits announced in the **Federal Register** on June 18, 2013 (78 FR 36508–36510), and the inclusion of Certificates of Quota Eligibility (CQEs) issued pursuant to the United States-Colombia Trade Promotion Agreement and the United States-Panama Trade Promotion Agreement announced in the **Federal Register** on June 26, 2013 (78 FR 38286), CCC purchased approximately 91,000 metric tons (MT) of sugar from the domestic market and exchanged the purchased sugar for 300,000 MT of credits from Refined Sugar Re-export Program licenses and CQEs issued under the United States-Colombia Trade Promotion Agreement, at an aggregate

Appendix 2. List of Attendees

Janet Aardema
Virginia Association for Biological Farming
janet@vabf.org

IsauraAndaluz
AC-21
c4puertas@yahoo.com

James Bing
Entomological Society of America
JWBing@dow.com

Joe Bischoff
American Nursery and Landscape Association
jbischoff@anla.org

Mark Brick
Crop Science Society
Mark.Brick@ColoState.EDU

Meryl Broussard
USDA – NIFA
MBROUSSARD@nifa.usda.gov

Doug Buhler
Michigan State University
buhler@anr.msu.edu

Tom Byram
Western Gulf Forest Tree Improvement Program
t-byram@tamu.edu

Saharah Chapotin
USAID
schapotin@usaid.gov

Andrew David
Minnesota Tree Improvement Cooperative
adavid@umn.edu

Kelly Day-Rubenstein
USDA – ERS
kday@ers.usda.gov

Jane DeMarchi
American Seed Trade Association
jdemarchi@amseed.org

Jane Dever
Texas A & M University
jdever@ag.tamu.edu

Bill Doley
USDA – APHIS
william.p.doley@aphis.usda.gov

Pat Donahue
Mondelez International
pat.donahue@mdlz.com

Ann Dorrance
American Phytopathological Society
dorrance.1@osu.edu

Nancy Jo Ehlke
University of Minnesota
nancy@umn.edu

John Englert
USDA – NRCS
John.Englert@wdc.usda.gov

Steve Etka
National Organic Coalition
steveetka@gmail.com

Kellye Eversole
Eversole Associates
kellye.eversole@gmail.com

Wendy Fink
Association of Public & Land Grant Universities
wfink@aplu.org

Caron Gala
C-FARE
CGala@cfare.org

David Gammel
Entomological Society of America
dgammel@entsoc.org
Kris Giles
Entomological Society of America
kris.giles@okstate.edu

Walter Goldstein
Mandaamin Institute
wgoldstein@mandaamin.org

Major Goodman
North Carolina State University
goodman@ncsu.edu

Robin Groose
Wyoming Agricultural Experiment Station
Groose@uwyo.edu

Rob Gropp
American Institute of Biological Sciences
rgropp@aibs.org

Doug Gurian-Sherman
Union of Concerned Scientists
DGurian-Sherman@ucsusa.org

Dave Gwaze
USDA Forest Service
dgwaze@fs.fed.us

Paul Heisey
USDA – ERS
PHEISEY@ers.usda.gov

Neil Hoffman
USDA – APHIS
Neil.E.Hoffman@aphis.usda.gov

Liana Hoodes
National Organic Coalition
liana@hvc.rr.com

Joy Hought
Native Seed Search
jhought@nativeseeds.org

Donna House
Native Seed Search
daturamonet@gmail.com

Kristina Hubbard
Organic Seed Alliance
kristina@seedalliance.org

Jenna Jadin
USDA – OCS
Jenna.jadin@osec.usda.gov

Randy Johnson
USDA Forest Service
randyjohnson@fs.fed.us

Richard Joost
United Soybean Board
RJoost@smithbucklin.com

Ed Kaleikau
USDA – NIFA
EKALEIKAU@nifa.usda.gov

Esther Kibbe
Driscoll's
esther.kibbe@driscolls.com

Shing Kwok
USDA – NIFA
skwok@nifa.usda.gov

Andy LaVigne
American Seed Trade Association
alavigne@amseed.org

Liang Lin
USDA – NIFA
LLIN@nifa.usda.gov

Vern Long
USAID
jlong@usaid.gov

Ariane Lotti
National Sustainable Agriculture Coalition
alotti@sustainableagriculture.net

Michael Mazourek
Cornell University
mm284@cornell.edu

Bill McDorman
Native Seed Search
bmcdorman@nativeseeds.org

Steve McKeand
North Carolina State University Cooperative Tree Improvement Program
semckean@unity.ncsu.edu

Ray Miller
Michigan State University
rmiller@anr.msu.edu

Mathieu Ngouajoi
USDA – NIFA
mngouajoi@nifa.usda.gov

Charles Onwulata
USDA – OCS
charles.onwulata@osec.usda.gov

Peggy Ozias-Akins
The University of Georgia-Tifton
pozias@uga.edu

Vince Pantalone
University of Tennessee
vpantalo@utk.edu

Ram Perumal
Kansas State University
perumal@k-state.edu

Gary Peter
The Cooperative Forest Genetics Research Program
gfpeter@ufl.edu

William Randle
North Carolina A & T State University
wrandle@ncat.edu

Catherine Ronning
Department of Energy
Catherine.Ronning@science.doe.gov

Ray Schnell
Mars, Inc.
Ray.Schnell@effem.com

Todd Scholz
USA Dry Pea and Lentil Council
scholz@pea-lentil.com

Roy Scott
USDA – ARS
Roy.Scott@ars.usda.gov

Jessica Shade
The Organic Center
jshade@organic-center.org

Sharon Perron
Center for Food Safety
sharon@centerforfoodsafety.org

Deborah Sheely
USDA – NIFA
DSHEELY@nifa.usda.gov

Michael Sligh
Rural Advancement Fund International
msligh@rafiusa.org

Steve Smith
American Seed Trade Association
stephen.smith@pioneer.com

Crispin Taylor
American Society of Plant Biologists
ctaylor@aspb.org

Tesfaye Tesso
Kansa State University
ttesso@k-state.edu

Ann Marie Thro
USDA – NIFA
ATHRO@nifa.usda.gov

William Tracy
University of Wisconsin
tracywf1@gmail.com

John Turner
USDA –APHIS
John.T.Turner@aphis.usda.gov

Allen Van Deynze
Plant Breeding Coordinating Committee
avandeynze@ucdavis.edu

Richard Vierling
National Corn Growers Association
vierling@ncga.com

Gail Wisler
USDA – ARS
Gail.Wisler@ars.usda.gov

Keith Woeste
Hardwood Tree Improvement and Regeneration Center
woeste@purdue.edu

Appendix 3. Agenda

USDA Plant Breeding Listening Session, August 15, 2013
Room 107-A Whitten

AGENDA

8:00 AM Meet and greet/coffee/poster display browsing in Patio

8:30 AM Welcome from REE Under Secretary and Chief Scientist Catherine Woteki

8:45 AM USDA Plant Breeding Portfolio Overview (PBWG Representatives from USDA agencies)

9:45 AM Stakeholder Presentations (Moderator: Jenna Jadin)
- North Carolina State University, Cooperative Tree Improvement Program (Steve McKeand)
- Virginia Association for Biological Farming (Janet Aardema)
- American Nursery and Landscape Association (Joe Bischoff)

10:25 AM Break

10:40 AM Stakeholder Presentations (Moderator: Randy Johnson)
- Crop Science Society (Mark Brick)
- American Phytopathological Society (Ann Dorrance)
- Michael Fields Institute (Walter Goldstein)
- Wyoming Agricultural Experiment Station (Robin Groose)
- United Soybean Board (Richard Joost)
- Vern Long (USAID)

12:00 PM Lunch on Patio (Keynote from Sonny Ramaswamy, Director of the National Institute of Food and Agriculture)

12:45 PM Stakeholder presentations (Moderator: Roy Scott)
- Cornell Plant Breeding (Michael Mazourek)
- University of Florida Plant Breeding (Ed Osborne)
- University of Tennessee Plant Breeding (Vince Pantalone)
- The Cooperative Forest Genetics Research Program (Gary Peter)
- North Carolina A & T, School of Agriculture and Environmental Sciences (William Randle)
- USA Dry Pea and Lentil Council (Todd Scholtz)
- Rural Advancement Fund International (Michael Sligh)

2:15 PM Break

2:30 PM Stakeholder presentation (Moderator: Ed Kaleikau)
- National Association of Plant Breeders (Allen Van Deynze)
- American Seed Trade Association (Steve Smith)
- Organic Seed Alliance (Kristina Hubbard)

3:10 PM	Breakout Session (see topics on included sheet)
4:15 PM	Report out from breakouts and open discussion
5:20 PM	Summary of Day (Charles Onwulata, Director of the Office of the Chief Scientist)
5:30 PM	Adjourn

Optional: Informal dinner at area restaurant

Appendix 4. Breakout Group Questions

1. Are current plant breeding efforts fulfilling the needs of agency stakeholders? If not, what is missing?

2. How can we better track and evaluate success in plant breeding, and what are the tools that will enable us to do this?

3. How can we improve connections between plant breeders and end users?

4. How can we better develop the prioritization process for responding to needs?

5. How can we improve connections among Federal programs, community colleges and 4-year institutions to provide more entry points into plant breeding?

6. What should our national strategy be for training a plant breeding workforce?

Appendix 5. Glossary of Acronyms

Acronym	Definition
AAAS	American Association for the Advancement of Science
AFRI	Agriculture and Food Research Initiative, USDA NIFA
APLU	Association of Public Land-Grant Universities
ARS	Agricultural Research Service, USDA
ASTA	American Seed Trade Association
BRDI	Biomass Research and Development Initiative, USDA NIFA
CAP	Coordinated Agricultural Project, USDA
CREES	Cooperative Research, Extension, and Education Service
CRIS	Current Research Information System, USDA NIFA
CSA	Community supported agriculture
CSAW	Coalition for a Sustainable Agricultural Workforce
DOE	Department of Energy
ERS	Economic Research Service, USDA
FS	Forest Service
GEM	Germplasm Enhancement of Maize , NPGS
GMO	Genetically modified organism
GRIN	Germplasm Resources Information Network, USDA ARS
IFPRI	International Food Policy Research Institute
IPBC	Illinois Plant Breeding Center, University of Illinois
LGU	Land Grant University
NAPB	National Association of Plant Breeders
NCCPB	National Council of Commercial Plant Breeders
NGO	Non-governmental organization
NGRAC	National Genetic Resources Advisory Council, USDA ARS
NIFA	National Institute of Food and Agriculture, USDA
NIH	National Institute of Health
NMGP	National Microbial Germplasm Program, USDA ARS
NOVIC	Northern Organic Vegetable Improvement Cooperative
NP301	National Program 301- Plant Genetic Resources, Genomics, and Genetic Improvement, USDA ARS
NPGS	National Plant Germplasm System, USDA ARS
NPL	National Program Leader, NIFA
NRCS	Natural Resources Conservation Service, USDA
NSF	National Science Foundation

OREI	Organic Agriculture Research and Extension Initiative, USDA NIFA
PBCC	Plant Breeding Coordinating Committee
PBTN	Plant Breeding Training Network
PBWG	Plant Breeding Working Group, USDA
PGBCoP	Plant Breeding and Genomics Community of Practice
PVP	Plant Variety Protection Act
REE	Research, Education, and Economics Mission Area, USDA
RFP	Request for proposal
SARE	Sustainable Agriculture Research and Education, USDA NIFA
SBIR	Small Business Innovation Research, USDA NIFA
SCRI	Specialty Crop Research Initiative, USDA NIFA
TGCR	Tomato Genetics Research Center, University of California at Davis
UIUC	University of Illinois, Urbana-Champaign
USDA	United States Department of Agriculture

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