

Coordinating Committee: Imagining the Future of Plant Breeding

Duration: October 01, 2020 to September 30, 2025

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Statement of Issues and Justification:

The science of plant breeding was formalized as a discipline in the early 20th century and has tremendous capability to help improve agriculture, food security, and human health and well-being. While it has been a scientific discipline for a brief time, plant breeding has been conducted by almost all societies from the beginnings of agriculture. Plant breeding has made contributions to and been helped by many allied disciplines (e.g., genetics, statistics, microbiology, agronomy). Plant breeding is conducted in the private and public sectors, and has the potential to generate revenue for both. A coordinating committee (CC) provides an opportunity to create a shared community vision and develop goals that connect disparate geographies. The CC also has the ability to present a plant breeding perspective to public policy entities as it relates to broader societal and agricultural goals.

Ensuring the long-term sustainability of agriculture to supply a growing global population with food, feed, fiber, fuel, shelter, recreation, and ecosystem services presents an unprecedented challenge. Climate change and heightened competition for diminishing land, water, and nutrient resources add to that challenge. New cultivars having greater economic value with better quality/nutritional profiles and resistance to varied biotic and abiotic stresses are an essential and proven component for meeting the human demands for a sustainable supply of plant products.

The recent integration of plant breeding and ‘omics’ technologies has revolutionized the field, resulting in increased breeding efficiency and potential. Capitalizing on new technology at all scales requires continued investment in human capacity and access to enabling knowledge, germplasm, infrastructure, and programmatic support (Miller et al., 2010; Tester and Langridge, 2010). There is a primary role for public sector investment in this capacity and infrastructure, as the time-scale of plant breeding efforts related to germplasm conservation, evaluation, and selection (Pardey et al., 2016; Carter et al., 2014) falls outside of the shorter timeframes under which businesses operate. Deficits in capacity can severely limit the success of plant breeding, whether in the public or private sector. Continual knowledge of the current national plant breeding capacity, therefore, is essential to identify needs, opportunities, or emergencies where plant breeding efforts are below capacity to meet future challenges.

Genetic diversity serves as the basis for development of cultivars that are critical for providing livelihood resilience and food security. Therefore, it is essential that the U.S. and international communities conserve, characterize, and provide access to diverse germplasm for plant breeding.

Agreements such as the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) govern the transfer and flow of germplasm and can either help or hinder cultivar development. There is cause for concern over the status of USDA germplasm collections with the impending retirement of up to one-third of the curatorial and scientific staff of the National Plant Germplasm System (NPGS) within the next five years. Scientists in the private sector and NGO communities have also expressed a need for expanded continuing education opportunities on conservation and use of plant genetic resources. All of these are imminent issues that need addressing since germplasm collections represent the raw material necessary to maintain and improve genetic gain for yield potential and other heritable traits. In addition to conserving and accessing germplasm, it is important to explore new methods for efficiently integrating and maintaining genetic diversity, which will allow breeders to take advantage of valuable alleles without compromising future genetic gain.

Public and private sector plant breeders have a long history of working together in education and research to meet common goals, but this collaboration can be enhanced. Plant breeding companies are concerned about maintaining the supply of graduates from U.S. universities with proper education and training (Gepts and Hancock, 2006; Guner and Wehner, 2003; Repinski et al., 2011). This concern relates to both the quantity and quality of plant breeding students. Public-private collaborations also provide a mechanism to foster innovation of new tools for plant breeding that are essential to the evolution of this science for providing a safe, reliable and sustainable supply of human-driven plant products.

It is important for the new technologies to be vetted and trialed at multiple different scales. The public sector has a responsibility to help inform policy makers about all of the potential benefits and challenges of using different types of technology, ranging from genome editing to robotic harvesters. The PBCC creates a community that has the capacity to carefully explore and communicate the reasons for using different types of technology available for plant improvement.

Science is not complete until it is communicated and there are many audiences that public plant breeders need to reach including federal agencies, farmers, city planners, and those interested in plants. Breeders speak on a wide variety of issues including public policy, emerging threats to food security, and the new technologies impacting plant breeding. There is a need for clear, scientifically sound communication to be integrated into the normal activities of plant breeders. Academics tend to focus communication on a narrow set of fellow professionals with whom the work is most relevant. However, communication tools that help breeders reach broader audiences are key to combating misinformation and pseudoscience, and attracting outstanding students into this highly satisfying and important discipline.

Previous work:

The Plant Breeding Coordinating Committee (PBCC) was established in 2006 as the Southern Region Coordinating Committee 80 (SCC80). A CC is an approved coordinating committee within the federal-state partnership established to work cooperatively “to solve problems that concern more than one state” (SAES Directors et al., 2006). The initial purposes of the PBCC were to raise awareness of plant breeding’s contributions to the U.S. economy and to strengthen plant breeding infrastructure and education capacity. Subsequently, and in response to the need for an advocacy capability rather than just a public outreach capacity, the National Association of Plant Breeders (NAPB) was created in 2008 as an initiative of PBCC. In 2010, NAPB became an independent entity. Whereas NAPB embraces the entire economic spectrum of plant breeding, including both private and public sectors, **the mission of PBCC is to focus on issues facing public plant breeding and plant breeders at land-grant universities while serving and addressing plant breeding issues affecting all organizations utilizing or served by the discipline.** The core membership of PBCC consists of representatives of State Agricultural Experiment Stations (SAES) that have plant breeding programs.

The PBCC has issued several ‘white papers’ that analyzed topics of concern to plant breeding, including ‘Breeding Crops for a Healthier Population’, ‘A Safe and Secure Food Supply’, ‘Plant Breeding and Rural Development in the United States’, and ‘Intellectual Property Rights and Public Plant Breeding Recommendations’, and the proceedings of a conference on best practices for intellectual property protection of publically developed plant germplasm. The PBCC has provided input to the USDA Listening Session on Plant Breeding and compiled and distributed public plant breeding success stories that demonstrate the impact of federal funding. The PBCC has been instrumental in the development of peer reviewed publications on the current capacity of United States Plant Breeding (Coe et al., 2020), plant genetic resources (Byrne et al., 2018; Volk et al., 2019a, 2019b), intellectual property standards (Dawson et al., 2018), and science communication (Khoury et al., 2019). The PBCC organized a symposium entitled ‘Unlocking Plant Genetic Diversity for Food and Nutritional Security’ at the 2016 annual meeting of AAAS.

This renewal proposal is based on the continuing need for an organized group focused on imagining the future of SAES plant breeding programs. As public programs within the land-grant university system, they (1) are essential providers of plant breeding education; (2) make invaluable contributions to breeding methodologies and germplasm enhancement; and (3) are especially critical for specialty crops having little or no private sector investment. In addition, as a coordinating committee, the PBCC fills a unique role in communicating with USDA and other federal agencies on issues of national importance concerning plant breeding, particularly concerning issues with the public sector. PBCC leadership disseminates information and generates discussion on relevant plant breeding issues with LGU and other entities through its state representatives. The need for this role in coordination and dissemination of information is a continual challenge, given the complexity of the issues discussed above, and, no doubt, issues yet

to come. The PBCC also provides an opportunity for public breeders to have an SAES- and USDA-recognized platform to participate in community activities as part of their appointments to facilitate increased participation in breeding community research and outreach.

The first-line stakeholders for this committee are all plant-breeding organizations and the growers that they serve. Ultimate beneficiaries are domestic and international consumers of food and other plant products, who will benefit from increased quantity, quality, and sustainability of supplies. The work of this coordinating committee is particularly important in a world where a growing human population, a finite amount of land available for agricultural production, and the right of every person to expect food security are recognized and can be addressed by plant breeding.

Objectives:

1. **Resource Analyses:** Collect, analyze, and disseminate data about U.S. public and private plant breeding efforts, including human capacity and access to enabling knowledge, technologies, germplasm, and infrastructure
2. **Genetic Resources Conservation and Utilization:** Promote the conservation, characterization, and utilization of plant genetic resources and access to those resources for plant breeding purposes
3. **Education:** Explore the U.S. plant breeding education capacity across universities and identify potential gaps and ways of achieving more uniform teaching capacity
4. **Communication:** Improve communication [1] among public plant breeders and federal-state-local agencies on plant breeding policy issues, including alerts to existing and emerging threats to agricultural security that are relevant to plant breeding; [2] among public plant breeding programs and university administrators through enhancing the mission and impact of PBCC state representatives; and [3] between the plant breeding community and public audiences.

Procedures and Activities:

Annual meetings will be held to exchange information, plan and coordinate activities, and review progress towards meeting the committee's objectives. Between annual meetings, communication will take place through email, online discussion groups, and conference calls, as needed. Since all PBCC activities depend on voluntary member contributions, progress toward achieving the objectives will depend on the level of input from participants. It is envisioned that for each of the objectives a subcommittee or task force will be formed to focus on the following activities:

Strategies

Objective 1: Resource Analyses: Collect, analyze, and disseminate information about U.S. public and private plant breeding efforts, including human capacity and access to enabling knowledge, technologies, germplasm, and infrastructure

Strategy: During the last cycle, PBCC initiated a partnership with the NAPB, CSSA, ASHS, ASTA, and the Seed Science Foundation (see External Linkages for acronym definitions) to survey U.S. public plant breeding capacity with regard to human capital and access to enabling knowledge, technologies, germplasm, and infrastructure. The study was designed to include components that allowed comparison with the comprehensive study of Frey (1996) and to have a methodology that is reproducible to document capacity changes over time. The instrument that was developed currently has a database of ~350 public plant breeders and continues to grow. The survey design allows for adding new breeding programs and deleting closed programs, making it repeatable over time in order to understand capacity changes. During the next five-year period, in addition to gaining additional data points on the public sector, data will be collected to create similar information from the private sector.

While it may not be possible to generate the same level of data as with the public sector, knowing the number of private breeders, plus other demographics will be informative to understand the gaps in education. To assess private sector capacity, there are several potential mechanisms, 1) tracking the number of students who take jobs in industry 2) reaching out to research directors and asking for summary statistics of the breeding companies and 3) working with published reports on R&D.

Objective 2: Genetic Resources Conservation and Utilization: Promote the conservation, characterization, and utilization of plant genetic resources and access to those resources for plant breeding purposes

Strategy: PBCC will continue to coordinate with partner organizations to promote robust plant germplasm systems and initiatives, encompassing all cultivated plants within the United States; review and communicate new methods for unlocking the potential of genetic resources for crop improvement, including the use of non-elite germplasm and practices for managing data; and provide guidance on germplasm access and benefit sharing under international treaties. Coordination will be through online discussion groups where successful strategies can be shared and knowledge gaps identified. Knowledge gained from these discussion groups can be shared more broadly through white papers and co-sponsoring symposia on exploiting genetic diversity in crop improvement with organizations such as AAAS, CSSA, NAPB, ASPB, and ASHS, and/or PAG.

Potential strategic initiatives are:

- Continue to document and distribute success stories on the use of plant genetic resources
- Evaluate new curriculum supports including eBooks, infographics, videos, best practices, and course lists for germplasm curators and those who utilize plant genetic resources

- Determine educational requirements of the NPGS, botanical gardens, university, and private germplasm collections and identify gaps in coverage
- Organize a symposium on using genetic diversity in crop improvement, co-sponsored at the annual meeting of one or more scientific organizations such as AAAS, CSSA, NAPB, ASPB, ASHS, or Plant and Animal Genome

Objective 3: Explore and improve the U.S. plant breeding education capacity across 1862, 1890 and 1994 LGU and other agricultural Universities

Strategy 3a—Education-formal: Plant breeding is central to agriculture, yet there is uneven ability of land grant universities to teach all aspects of the discipline. Efforts will be made to help facilitate the development of digital courses on plant breeding relative to emerging topics such as remote phenotyping and Bayesian analysis of breeding trials. Initiatives may include:

- Analyze and develop recommendations on core competencies for plant breeding students.
 - Survey PBCC reps to see how the core competencies are represented across agricultural universities
 - Identify need areas and establish plant breeding digital courses to address these needs
 - Recommendations on making courses etc. better available across universities (in particular those with limited capacities)
 - Develop a web tool for these competencies; white paper
 - Non-formal education options: workshops, short courses – survey; need analysis; recommendations

Strategy 3b—Education-Enhance Graduate Student Training: Promote collaborative models of graduate education in plant breeding, e.g., internships at private companies or increased private support for graduate assistantships with required visits to a company site/function.

Potential activities are:

- Develop guidelines for navigating the sometimes conflicting needs of the graduate student to publish and the private sector to protect proprietary intellectual property
- Develop a white paper addressing the research needs of the public and private sector
 - Develop priority breeding and breeding research needs that each sector thinks the other sector should cover
 - Develop a list of projects that can be conducted in public sector but would not be pursued in the private sector which could be basis for a new set of RFPs. Examples include germplasm screening and characterization, Compositional and nutritional quality, crop breeding for food safety, etc.

Strategy 3c—Education-Supporting Disciplines: Creating effective breeding teams depend on a number of scientific disciplines working collaboratively with plant breeders. While there has been a decrease in plant breeders, there has been a concomitant and sometimes larger decrease in plant breeding support (e.g. physiologists, nematologists, entomologists, statisticians) and there is an emerging need for additional data scientists. To parallel the other components of this objective, we need to encourage more interaction between allied disciplines

- Raising awareness other disciplines among Plant Breeders and University/Experiment station administrators
- Identify and establish a working relationship with other Coordinating Committees from allied disciplines
 - Share programs, make meeting time available, and share research products with allied disciplines

Objective 4: Communication: Improve communication [1] among public plant breeders and federal-state-local agencies on plant breeding policy issues, including alerts to existing and emerging threats to agricultural security that are relevant to plant breeding; and [2] among public plant breeding programs and university administrators through enhancing the mission and impact of PBCC state representatives.

Strategy: Provide input to USDA representatives, SAES Directors, and other officials on key policy issues related to plant breeding. This will include advising on funding mechanisms and competitive grants programs, and alerting officials to emerging threats to agricultural security that are relevant to plant breeding. There is a need to develop internal communication between PBCC state reps to rapidly communicate and solicit feedback and understanding on technical and policy issues related to plant breeding. As PBCC outputs become more useful to plant breeders, there will be more interest and incentive to participate in communication efforts.

- Collaborate with NAPB to share information with multiple audiences on the value of public plant breeding programs.
- Help create tools for communication in different mediums (podcasting, video, visual) and different audiences (Administrators, Students, Farmers, Master Gardeners) for the plant breeding community
- Develop templates for popular press articles, magazines
- Develop podcasting material
- Develop Video making training
- Make a PBCC NIMSS project summaries available on the NAPB website
- Develop an official PBCC letterhead with documents that are specifically directed to different audiences

- There is a need to for PBCC to have a science editor for specific objectives that need to be communicated within and between institutions and scientific societies such as CSSA, NAPB, etc.

Expected Outcomes and Impacts:

Objective 1: Resource Analyses

- Re-issuing and updating of the survey on public plant breeding results disseminated on U.S. plant breeding capacity, which will result in a peer reviewed article
- Development of survey on private plant breeding and disseminate results
 - Increased awareness of national opportunities, needs or emergencies where plant breeding effort is below the needed capacity

Objective 2: Genetic Resources Conservation

- Organize a symposium on using genetic diversity in crop improvement. This may be co-sponsored at the annual meeting of one or more scientific organizations such as AAAS, CSSA, NAPB, ASPB, ASHS, or Plant and Animal Genome
- Develop materials such as digital short courses to provide continuing education for training a new generation of plant germplasm curators and breeders

Objective 3: Education

- Courses or modules featuring leading plant breeding educators, both public and within private industry, that can be used in formal class room undergraduate and graduate education. These should be available at no or minimal cost to the user by 2022.
- Beta test short term internships for PhD plant breeding graduate students with selected private plant breeding companies in 2021 and 2022 with expanded opportunities by 2023.
- PBCC state reps will establish communication with university leadership and provide PBCC developed literature/data on the need for education/research positions in plant breeding and in supporting disciplines
- Development of a national plant breeding teaching award within NAPB and explore same with CSSA by 2021
- Development of digital courses on emerging issues in plant breeding by 2021
- Develop a white paper or journal publication produced on core competencies for plant breeding students by 2022

Objective 4: Communication

- Establish protocol by 2021 for PBCC state reps to provide information to SAES Directors and University Deans periodic information from the PBCC. This may be white papers, NAPB newsletters, etc.

- Generate materials that can be published in both popular press (e.g. AAAS, CAST blogs) and scientific journals
- Establish SOP for PBCC to communicate through the USDA CC coordinator and NIFA rep Edward Kaleikau with information regarding progress on the objectives of this CC
- Establish a subcommittee by 2021 within PBCC to regularly meet and review emerging strengths, weaknesses, and threats to agricultural security and propose action by PBCC
 - Subcommittees will be established to explore each individual strength, weakness, or threat and prepare written response suggestions as appropriate, e.g.
 - Genome editing
 - Remote sensing
 - Plant breeding literacy for urban K-12, 4H, FFA, etc.
 - e.g., public school level lesson plans
 - intersection of plant breeding and other technologies

Project Participation:

In addition to designated representatives from SAES (Appendix E; table 1), who are the voting members of the committee, we will invite participation from anyone interested in furthering the objectives of this committee. This will include persons from public (e.g., USDA-ARS), private, and non-governmental organizations. We will especially reach out to plant breeders at 1890 Land Grant Universities.

Table 1. Participants in the PBCC

Member	email	University Affiliation
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Educational Plan:

Information obtained or generated through this project will be shared regularly through presentations and discussions at the annual meeting, peer-reviewed publications, and white papers written on selected topics. Information will also be communicated with USDA via interaction with the NIFA representative. We will also make all materials available on the PBCC portion of the NAPB website (<https://www.plantbreeding.org/content/pbcc>).

Governance:

Standard governance for multistate research activities will be followed. Officers will include a Chair, Vice-Chair, and Secretary. Each year at the annual meeting the Vice-Chair will become the Chair for the coming year, and the Secretary will become the Vice-Chair. Prior to the annual meeting, nominations for Secretary will be solicited and an election held by email to ensure broad participation. Sub-committees or working groups will likely be needed to achieve some of the objectives while distributing the workload among a larger number of participants. Administrative guidance will be provided by an assigned Administrative Advisor and a NIFA Representative.

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Attachments:

None

Internal Linkages:

State Agricultural Experiment Station Directors
State reps appointed by SAES Directors

External Linkages:

American Association for the Advancement of Science (AAAS)

American Seed Trade Association (ASTA)

American Society for Horticultural Science (ASHS)

Crop Science Society of America (CSSA)

National Association of Plant Breeders (NAPB)

Seed Science Foundation (SSF)

National Plant Germplasm Coordinating Committee (NPGCC)

Regional Germplasm Coordinating Committees, such as NC7, NE 9, S9, W6, NRSP 6 (potatoes); NRSP 10

European Association for Research on Plant Breeding (EUCARPIA)

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