The Discipline of Plant Breeding

First Workshop in "Advancements in Plant Breeding Symposium Series"

On February 19th, 2020 the first set of seminars in what is planned to become a series of "advancements in plant breeding symposia" was held in Washington DC. The event was jointly sponsored by the National Association of Plant Breeders (NAPB), Plant Breeding Coordinating Committee (PBCC), and the University of California, Davis Seed Biotechnology Center. The purpose of the workshop was to provide presentations on the sciences contributing to plant breeding to open a dialog with the federal agencies, such as the EPA, FDA, USDA, and USTR. This public workshop on a range of topics in plant breeding from the public sector had the specific intent to improve communication between the public and private sectors of the plant breeding community with these federal agencies.

The forum provided a fundamental grounding in the scientific disciplines contributing to plant breeding, with the morning session around the topics of breeding food and feed crops and the afternoon session focused on applications of genetic diversity to improve productivity, efficiency and rate of crop improvement. All of the presentations can be accessed and are a public record at the following NAPB web site link: https://www.plantbreeding.org/content/plant-breeding-research.

All presentations at the link above provide excellent overviews of research and ideas for each topic. The countless contributions of plant breeding through the ages and many opportunities applicable for today and the future are represented in these talks. They provide an excellent public record of what has been accomplished and what is possible through the many scientific disciplines that contribute to effective plant breeding programs.

The workshop provided a forum among attendees to have a dialogue about opportunities and countless global consumer benefits in the future. We believe it is imperative to tell the great success story of plant breeding and contributions to the world.

Here is a brief summary of the agenda and key points:

Opening Remarks - Advancing Plant Breeding and Crop Improvement for Meeting Future Challenges, Peggy Ozias-Akins, National Association of Plant Breeders, Michael Kantar, Plant Breeding Coordinating Committee

Symposium Objectives - Allen Van Deynze University of California Seed Biotechnology Center

Session 1 - Breeding Programs for Food and Feed Crops: Chair - Peggy Ozias-Akins, Professor, University of Georgia and President NAPB

Crop Domestication and Genetic Diversity: Contributions to the Food Supply: Wayne Parrott, University of Georgia

Dr. Parrott creatively presented the irony of the 'paleo' diet and shared how early domestication and selection from wild relatives led to modern domesticated and cultivated food/feed species, using

numerous examples such as tomatoes, Brassicas, and maize. He highlighted a key point: USDA reports that over the last 70 years, 250% in output per unit input have been achieved through breeding improvements and improvements to production practices. He further highlighted tools plant breeders have used, such as mutation breeding or leveraging natural mutations to select beneficial changes to food/feed species, such as pink grapefruit or numerous oil quality improvements.

Breeding Process Framework: A Powerful Tool for Enhancing Desirable Traits in Potato: David Douches, Natalie Kirkwyland, Michigan State University

Dr. Douches provided a comprehensive review of the challenges in breeding potato, a tetraploid crop that is largely clonally propagated and has faced numerous technical challenges limiting improvement. He stated that for 100 years, potato yield increase was mostly due to improvement of production and management techniques. He noted that genetic engineering, self-compatibility mechanisms enabling breeding in diploid, utilizing true potato seed, genomic information and gene editing will provide opportunities for future improvement, and highlighted numerous examples of specific traits that could be improved in the future.

Birth of Canola Oil: Overcoming Palatability and Nutritional Barriers Through Breeding: Larry Sernyk Dow AgroSciences (retired)

Larry Sernyk provided a comprehensive history of the birth of canola oil, truly a remarkable accomplishment of modern plant breeding. Canola was derived from breeding in rapeseed to accomplish a target of oil that contains less than 2% erucic acid and the solid component contains less than 30 micromoles of any mixture of glucosinolates. The accomplishment of hybrid systems in canola was also noted as leveraging CMS (cytoplasmic male sterility) systems first used in commercial hybrids in 1989-90.

Breeding Peanuts Resistant to Preharvest Aflatoxin Contamination: Peggy Ozias-Akins University of Georgia

Dr. Ozias-Akins' talk was focused on one example of a mycotoxin that occurs in peanuts and numerous other food sources and how plant breeding can be a tool to make our food safer. She noted that 4.5 billion people in developing countries consume foods contaminated with aflatoxin from various food sources noting that numerous health concerns are at issue: chronic and acute hepatocellular injury and child stunting; liver cancer from aflatoxin exposure, particularly in immunocompromised individuals; example from Kenya in 2004 where 317 cases of aflatoxin poisoning were reported with 125 deaths due to contaminated maize. She noted multiple approaches in plant breeding that could reduce the pre-harvest disposition of peanuts to aflatoxin.

Breeding Crops for Enhanced Food Safety: Allen Van Deynze, Michelle Jay-Russell, Marilyn Warburton, Maria Brandl, Shirley Micallef, Maeli Melott

Dr. Allen Van Deynze in a second day of seminars reaching out to seed industry stakeholders, provided a seminar on crop breeding for enhanced food safety. He touched on numerous aspects of food safety including mycotoxins, bacteria, heavy metals, nitrates and allergens impacting human and animal health. He described how plant breeding can positively impact food safety through use of plant-based trait selection and how innovations in plant breeding can contribute to safe food production.

Session 2 - Applying Genetic Diversity to Improve the Productivity, Efficiency and Rate of Crop Improvement - Chair: Allen Van Deynze, Professor, University of California Davis

Maintaining and Utilizing Genetic Diversity for Crop Improvement: Shilpa Swarup, Bayer Crop Sciences

Dr. Swarup provided an overview of plant breeders' need to focus on maintenance and utilization of genetic diversity to achieve crop improvement. She provided an overview of how plant genomes have substantially more plasticity compared to mammalian genomes. She introduced three fundamental concepts used to leverage genetic diversity: backcrossing, cell division and selection, noting that multiple breeding methods are used to improve traits with technology.

Plant Breeding Tools and Technologies for Variety Development: Katy Rainey, Purdue University

Dr. Rainey provided a comprehensive overview of the basic tools utilized by the plant breeder. She noted the fundamentals of the plant breeder's equation, noting that genetic gain for any trait is a function of a standardized selection differential, selection accuracy, the variance for the trait of interest, as well as the length of time required to complete one breeding cycle. She highlighted the importance of running uniform field trials for selection, the ability to phenotype or measure traits accurately, as well as the use of remote sensing or drones to collect data reflecting traits of interest.

Breeding to Increase Fruit Quality and Disease Resistance in Sour Cherry: Amy Iezzoni, Michigan State University

As a global expert in breeding sour cherries, Dr. Iezzoni provided an insightful review of some of the most significant challenges to improvement of fruit quality, disease resistance and avoidance of or resistance to late spring frost damage, all while managing the difficulty of long breeding cycles with fruit

tree species. Fruit color and disease resistance were also highlighted as breeding opportunities in her presentation.

Overcoming Negative Epistasis on Yield in Tomato Imposed by a Domestication Gene: Zachary Lippman, Cold Springs Harbor

Dr. Lippman provided an excellent and practical example of genome editing in tomatoes, such as the "jointless" trait. Via genome editing, he described how it is possible to utilize jointless traits in tomatoes, which enable commercial harvest of tomatoes that entirely remove the stem, preventing post-harvest damage during the shipping process of tomatoes. He further explored the opportunities to leverage qualitative versus quantitative variation, using the example in cherry tomatoes of creating determinate dwarf types to provide improved varieties for vertical farming environments.

The Potential for Genome Editing to Improve the Efficiency and Rate of Crop Improvement: Aaron Hummel, Pairwise

Aaron Hummel from Pairwise provided an overview of his company's endeavors in genome editing, first describing the process of genome editing in crops followed by examples of how genome editing can accelerate crop breeding. He concluded with ideas on how "genetic optimization" has driven crop performance in some crops but is untapped in others.