The Importance of Plant Improvement to Sustainable Specialty Crop Systems

Jim McFerson
Washington Tree Fruit Research Commission

www.usda.gov/oe/forum
Horticulture & Plant Breeding

UW-Madison --- BS, PhD
Texas A&M --- MS

Petoseed: Plant breeder

USDA-ARS Geneva: Geneticist

WTFRC: Manager, Researcher
Born Mt. Pleasant IA

Cascade Garlic

small farm <$10k
research focus

established by State Legislature in 1969

per-ton assessment on Washington producers

annual budget $4M
Plant improvement
Sustainable
Specialty crop
Systems
Plant improvement

Sustainable

Specialty crop

Systems
Plant improvement

Classical plant breeding uses deliberate interbreeding (crossing) of closely or distantly related individuals to produce new crop cultivars with desirable properties.

Modern plant breeding uses techniques of molecular biology to select, or in the case of genetic modification, to insert, desirable traits into plants.

For many specialty crops, plant improvement includes clonal selection, compound plants, and application of exogenous plant growth regulators.
Sustainable Agriculture

An integrated system of plant and animal production practices having site-specific application that will, over the long term:

• Satisfy human food and fiber needs
• Enhance environmental quality and the natural resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls
• Sustain the economic viability of farm operations
• Enhance the quality of life for farmers and society as a whole

-- Public Law 101-624, Title XVI, Subtitle A, Section 1603
Stakeholders
“Living in material comfort and peacefully with each other within the means of nature.”

- Wackernagel & Rees
Stakeholders
THE TRIPLE BOTTOM LINE

People

Planet

Profits

Sustainable Agriculture

Courtesy Molly Jahn
Plant improvement
Sustainable
Specialty crop
Systems
The Specialty Crop Industry

- Fruits, nuts, vegetables, nursery and landscape crops
- >$50B annual US production value
- Diverse
  - cropping systems
  - processing systems
  - location
  - everything
- High-value, labor-intensive, high-risk
Specialty Crop Industries

- Fruits, nuts, vegetables, nursery and landscape crops
- $50B annual US production value
- Diverse
  - cropping systems
  - processing systems
  - location
  - everything
- High-value, high-risk, labor- and management-intensive

Percent
Less than 1
1 - 24
25 - 49
50 - 74
75 or more

United States
20.6 Percent

U.S. Department of Agriculture, National Agricultural Statistics Service
Plant improvement
Sustainable
Specialty crop
Systems
Typical apple production and harvest costs

Clark Seavert, OSU

- Labor: pruning & thinning: 10%
- Labor: harvest: 27%
- Labor: other: 3%
- Machine: fuel & repairs: 16%
- Machine: replacement cost: 15%
- Chemical: general: 10%
- Chemical: fertilizer: 13%
- Other costs: 6%
Citrus mechanical harvester
Genetic technologies

Engineering technologies
Predictable & accessible systems
Genetics and Engineering

Measure, model, and manage the best genetics
To be profitable in a globally competitive marketplace, the U.S. tree fruit industry must deliver the highest quality fruit and reduce production costs 30% by 2010.
Plant Improvement

Fundamental for sustainability by any definition

• Utilize natural resources efficiently
• Optimize inputs
• Improve yield, quality, nutrition
• Maximize local adaptation
• Expedite regulatory compliance

Courtesy Molly Jahn
Plant breeding as a share of total agricultural R&D expenditures

The Seed Industry in U.S.
Agriculture / AIB-786
Economic Research Service/USDA

Courtesy Molly Jahn
Use of a Delphi Study offers a proven mechanism for bringing together a group of experts (breeders) and other stakeholders to develop a comprehensive list of the most important educational, competency, and experiential components for graduate level training in plant breeding. All results from this study will be made publically available for use internationally.
2008 Farm Bill

- **International Market Access ($1.1 billion)**
  - Market Access Program
  - Technical Assistance for Specialty Crops

- **Nutrition Investment ($1.1 billion)**
  - Expands Fresh Fruit & Vegetable Snack Program to all 50 states
  - Provides a free fresh fruit and vegetable snack to >3M children

- **Specialty Crop Block Grant Program ($466 million)**
  - State targeted programs addressing infrastructure needs
  - Prioritizes marketing, food safety, quality, handling, labor

- **Pest and Disease Programs ($377 million)**
  - Prioritize pest and disease threats to production of specialty crops
  - Develop action plans and targets federal resources to emergencies

- **Specialty Crop Research Initiative ($230 million)**
  - Specialty Crop Research Initiative: Plant breeding, production efficiency, precision ag, product quality
Specialty Crop Research Initiative

- $230 million over 5 yrs
- competitive basis
- matching funding
- significant extension component
- transdisciplinary
- Stakeholder priorities
  - plant genomics genetics, and breeding
  - precision agriculture
  - production efficiency
  - product quality
Carrot breeding stocks with superior resistance to root knot nematodes

Courtesy Phil Simon
Improving Carotene Content of Carrot in the U.S. Crop

- Result of classical plant breeding
  - 1950’s – 60 ppm
  - 1970’s – 90 ppm
  - 1990’s – 130 ppm

- 2010 - 2/3 of typical carrot contains enough provitamin A to fully satisfy daily adult vit A requirements

Courtesy Phil Simon

www.ars.usda.gov
Beta III
270 ppm

HCM
450 ppm

Progenitor
140 ppm

Courtesy Phil Simon
Increasing the Farm and Consumer Value of Carrots

- **Uniform appearance and size**
  - Impetus for developing hybrid varieties

- **Freedom of defects and disease**
  - Leaf blight
  - Nematodes

- **Culinary Quality**
  - Sweet
  - Not harsh (turpentiney, bitter)
  - Succulent

- **Orange Color**

- **Convenience**
  - “cut and peel”

- **Nutritional Quality**

Courtesy Phil Simon

www.ars.usda.gov
RosBREED Mission Statement

We will develop and apply marker-assisted breeding, based on improved knowledge of industry value and consumer preferences, to accelerate and increase the efficiency of rosaceous cultivar release and successful cultivar adoption.

4 yrs
$7M federal
$7M matching

Amy Iezzoni, Michigan State Univ
Cameron Peace, WA State Univ

Specialty Crop Research Initiative

United States Department of Agriculture
National Institute of Food and Agriculture
The Rosaceae family of horticultural crops

STONE FRUIT

POME FRUIT

BERRIES

ROSE

Heirloom and modern cultivars
Honeycrisp: a breakthrough cultivar

- Honeycrisp apple - introduced 1991 by the Univ of Minn.

- Dramatic attention and U.S. market share this decade.

- An ultra-crisp juicy texture and pleasing flavor

- 30 years from crossing to commercialization.
Apple, peach & diploid strawberry genome sequences will be available in 2010

(Arabidopsis = 157 Mb/C)

750 Mb/C  
280 Mb/C  
206 Mb/C
The same major gene is believed to be responsible for red core & foliage in apple, and skin & flesh color in cherry.

Chagne et al. 2007. BMC Genomics 8:212

Photo: USDA-ARS

Sooriyapathirana et al. (in review)
How will RosBREED help breed cherry leaf spot resistant tart cherry cultivars?
RosBREED will generate knowledge of the genetic control of fruit size & enable the use of this information to more efficiently achieve the desired fruit size while retaining the CLS resistance.

12 grams

We are identifying the genetic changes that are responsible for this increase in fruit size.

2 grams

Sweet cherry cultivar

Wild forest cherry
In sweet cherry, 3 linkage group regions have been identified that contain genes that control fruit size.
RosBREED Stakeholder Advisory Panel

Josefina Alcala
Jim Allen
Phil Baugher
Henry Bierlink
Chalmers Carr III
Robert Curtis
Bill Dodd
Chrislyn Particka
Bruce Grim
Rick Harrison
Philip Korson
Kevin Moffitt
Tom Stokes
Gary van Sickle
Genetic technologies

Engineering technologies
Comprehensive Automation for Specialty Crops (CASC)

Welcome  Motivation  Partners  Publications  Events  Trip Reports  Commercialization  Advisory Board  Press  Contact

CASC is a multi-institutional initiative led by Carnegie Mellon Robotics Institute to comprehensively address the needs of specialty agriculture focusing on apples and horticultural stock. CASC will develop methods to improve production efficiency, identify threats from pests and diseases, and detect, monitor and respond to food safety hazards. We expect advances from the integration of robotics technology and plant science.

CASC is funded by the USDA Cooperative State Research, Education & Extension Service with matching support from industry and the Pennsylvania Infrastructure Technology Alliance.

Sanjiv Singh, Carnegie Mellon Univ

Specialty Crop Research Initiative

USDA United States Department of Agriculture
National Institute of Food and Agriculture
Thanks
Stakeholders
Production Systems
Crop health
Crop Quality Management
Vision Robotics
orchard scout
prototype

Quincy 2008

PictureCourtesy of Geraldine Warner, Good Fruit Grower
Oxbo/ Picker Technologies
mechanical assist prototype
August 2009
Pasco WA
Future Technology