Potato Variety Development & Improvement in the Northwest

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Jointly funded by USDA-NIFA and Potato Commissions of WA, ID & OR
Overall Goal:

Release & commercialize new potato varieties that will directly benefit all segments of the Northwest potato industry.
Tri-State History

Started in 1985

- Progressive USDA/ARS breeding programs in Aberdeen, ID & Prosser, WA
- Funding & lack of personnel resources limited ARS’s ability to fully evaluate advanced selections, while still providing sufficient quantity of breeding germplasm to satisfy regions needs

Original Intent of Stakeholders

- Create a collaborative Northwest research program that would allow ARS scientists to concentrate on basic genetics & germplasm development, while instituting an applied research effort for smooth delivery of new varieties to the Northwest potato industry

Breeding…Selection…Evaluation…Release…Management
The Northwest program incorporates federal, university, and industry research elements...

...it is a collaborative research effort that crosses state and institutional boundaries in developing new potato varieties...

**USDA-ARS**
- Aberdeen, ID – Rich Novy, Jonathan Whitworth
- Presser, WA – Chuck Brown, Roy Navarre

**University of Idaho**
- Aberdeen, ID – Jeff Stark, Peggy Bain
- Kimberly, WA – Nora Olsen, Sanjay Gupta, Tina Brandt
- Parma, ID – Mike Thornton
- Moscow, ID – Lorie Ewing

**Oregon State University**
- Corvallis, OR – Isabel Vales, Solomon Yilma
- Hermiston, OR – Dan Hane, Phil Hamm, Silvia Rondon, Aymeric Goyer
- Powell Butte, OR – Steve James, Fahrettin Goktepe
- Klamath Falls, OR – Brian Charlton, Darrin Culp
- Ontario, OR – Clint Shock, Erik Feibert

**Washington State University**
- Pullman, WA – Rick Knowles, Mark Pavek, Zach Holden, Nora Fuller

**Potato Commissions** – WA, ID, OR

**Industry** – Simplot, ConAgra, Green Giant, Growers

**Potato Variety Management Institute (PVMI)** – Jeanne Debons
USA Potato Production 2009 (total cwt)

PNW: 56%
North Central: 20%
Southwest: 10%
Eastern: 8%

NASS 2009
Pacific NW Potato Production
(1,000,000 CWT)

Ranger, Umatilla, Alturas, Western
Russet, Modoc, Premier

National Ag. Statistics Service
Why do we need new potato varieties...?

- Worldwide, potatoes rank 4th among all food crops in total production, behind rice, wheat & corn.
- The United Nations has said that by 2050, food production must increase by 70 per cent to feed an estimated world population of 9 billion people, up from today's 6.8 billion.
- Land base for crop production is shrinking; therefore, must achieve drastic increases in efficiency of production (yield/hectare).
- Genetic improvement through breeding is one of the most effective ways to achieve the gains in yield & quality necessary to ensure food security.
What’s wrong with the ‘old’ varieties…?

e.g. Russet Burbank – intensive to grow, requires lots of fertilizer and pesticides, sustainability issues, tuber quality

**Needs**

- Increased N and H₂O-use efficiency
- Tolerance to abiotic stress – heat, drought, salinity
- Resistance to pests & diseases = less pesticides
- Enhanced nutritional attributes
- Low acrylamide forming potential
- Retention of postharvest quality
- Ability to store at low (<7°C) temperature
- More diversity for the consumer
PNWPVDP - Approach

Breeding → USDA-ARS – Research Geneticists

Selection → Land Grant State Universities
Agronomists, physiologists, pathologists, entomologists, extension specialists

Evaluation → USDA-ARS
Industry – growers, processors, packers
Potato Commissions – ID, OR, WA

Release → Potato Variety Management Institute (PVMI)

Management Guidelines → Commercialization
Development of a Potato Variety – PNW Program

Year 1
- Wild species germplasm from Prosser, WA
- Commercial varieties from other breeders

Year 2
- Greenhouse
  - 70,000 TPS seedling tuber production at Corvallis, OR
- Field
  - Tubers from seedlings. Planted at Powell Butte and Klamath Falls, OR

Year 3
- Greenhouse
  - Exchange of seeds and tubers with other States
- Field
  - Tubers from disease resistant and specialty crosses. Prosser, WA

Year 4
- Breeder seed increases Aberdeen, Tetonia, Powell Butte
- Selection for field, storage, processing, and disease resistance performance at 8-10 locations

Yrs 4-5
- Lab and Greenhouses

Yrs 5-8
- Limited generation Foundation seed production UI, OSU

Yrs 9-11
- Limited generation seed production Seed Growers

Yrs 12-15
- Name and release

Conventional & Marker Assisted Selection

Disease Screening

Seed Increase

PVMI Promotion and Marketing
Marker assisted breeding/selection (MAB) enhances the efficiency of selection of the most promising genotypes for evaluation...

- MAB allows selection of parents to increase the probability of progeny containing trait(s) of interest.
- Allows elimination of progeny lacking desirable traits.
- Recent successes of Tri-State breeders include development of genetic markers for:
  - Resistance to Columbia root knot nematode
  - PLRV resistance
  - PVY resistance
  - Carotenoid enhancement
  - Resistance to corky ringspot

PLRV resistance localized to chromosome #4

Higher Carotenoids
Yellow Flesh Color

PVY Resistance Markers
RYSC3
RYSC4
ADG2

Columbia Root Knot Nematode Resistance Markers

100 bp ladder
100 200 300 400 500 600 700

321 bp
145 bp
355 bp

C.R. Brown, USDA-ARS

J.L. Whitworth, USDA-ARS

R.G. Novy, USDA-ARS
Evaluation of Performance

- Early Harvest Tri-State Trial
- Late Harvest Tri-State Trial
- Early Harvest Regional Trial
- Late Harvest Regional Trial
- Regional Red Trial
- Regional Specialty Trial

Tri-State Team - USDA/ARS, WSU, UI, OSU, Potato commissions & industry

Regional Team - WSU, UI, OSU, CO State U., Texas A&M, U.C. Davis, USDA/ARS (Aberdeen, Prosser, Beltsville), Potato commissions & industry.
Primary Traits of Interest

- Total & U.S. #1 yields
- Disease & pest resistance
- Absence of internal & external defects
- Tuber shape & appearance
- Tuber size distribution
- Increased N & H₂O-use efficiency
- Resistance to heat & water stress

- Specific gravity, starch & dry matter
- Low temp sweetening resistance
- Low acrylamide forming potential
- Long dormancy
- Retention of postharvest quality
- Nutritional content – protein, vit C
- Culinary attributes
### 37 Tri-State Releases Since Inception (1985)

<table>
<thead>
<tr>
<th>Russets (dual purpose fry &amp; fresh pack)</th>
<th>Russets (primarily for fresh pack)</th>
<th>Long Whites (Dehydration/Processing)</th>
<th>Red-Skin (fresh pack)</th>
<th>Specialty (fresh pack)</th>
<th>Chippers</th>
</tr>
</thead>
</table>

**Russets (processing for fries, processed potato products)**

- Alpine Russet (2008)
- Highland Russet (2006)
- Blazer Russet (2005)
- Umatilla Russet (1998)
- Ranger Russet (1991)

**Six TS varieties were produced on 1000 or more seed acres in the U.S. in 2009 (out of 20 =30%)**
Impact of Tri-State Potato Varieties on PNW Production

Year
0 to 28%

Percent of Planted Acres

PNW Varieties

Year

Compiled from NASS
Total PNW Potato Acreage has Fallen but Productivity (cwt/A) has Increased

Compiled from NASS

28% higher cwt/A 1991-2009
## National Impact

### Fall Potatoes

#### 2009 Rank Among all Cultivars Planted

<table>
<thead>
<tr>
<th>Tri-State Cultivar</th>
<th>ID</th>
<th>OR</th>
<th>WA</th>
<th>U.S.* Rank</th>
<th>Acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ranger R.</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>79,866</td>
</tr>
<tr>
<td>Premier R.</td>
<td>4</td>
<td>4</td>
<td>7</td>
<td>8</td>
<td>16,269</td>
</tr>
<tr>
<td>Western R.</td>
<td>5</td>
<td>-</td>
<td>-</td>
<td>11</td>
<td>7,395</td>
</tr>
<tr>
<td>Umatilla R.</td>
<td>6</td>
<td>8</td>
<td>4</td>
<td>5</td>
<td>31,059</td>
</tr>
<tr>
<td>Alturas</td>
<td>8</td>
<td>5</td>
<td>5</td>
<td>7</td>
<td>17,748</td>
</tr>
<tr>
<td>*7 state total fall production</td>
<td></td>
<td></td>
<td></td>
<td>Total =</td>
<td>152,337</td>
</tr>
</tbody>
</table>

Tri-State varieties accounted for 21% of U.S. Fall acreage in 2009 (NASS)

Compiled from 2009 NASS

TS varieties: ID = 23%, OR = 35%. WA = 37%
Percent PNW Varieties in USA Certified Seed Acre Categories

<table>
<thead>
<tr>
<th>Acres of Certified Seed (U.S.)</th>
<th>PNW Varieties (% No. U.S. Varieties)</th>
<th>Other Varieties (% No. U.S. Varieties)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;50</td>
<td>9.6% 10/94</td>
<td>2/3</td>
</tr>
<tr>
<td>&gt;100</td>
<td>10% 8/70</td>
<td>3/7</td>
</tr>
<tr>
<td>&gt;500</td>
<td>18% 6/27</td>
<td>4/7</td>
</tr>
<tr>
<td>&gt;1,000</td>
<td>30% 14/11</td>
<td>6/7</td>
</tr>
<tr>
<td>&gt;1,500</td>
<td>35% 11/6</td>
<td>4/7</td>
</tr>
<tr>
<td>&gt;2,000</td>
<td>36% 7/4</td>
<td>4/7</td>
</tr>
<tr>
<td>&gt;3,000</td>
<td>40% 3/2</td>
<td>2/3</td>
</tr>
</tbody>
</table>

National Impact
Reduced Production Inputs

- **Nitrogen (Relative to RB)**
  - Alturas & Bannock Russet: 40% reduction
    - Savings to growers
    - Alleviates groundwater contamination

- **Water Stress Tolerant Varieties**
  - GemStar, Classic, Defender, Premier

- **Pesticides**
  - Fungicides: Defender and Yukon Gem
  - Insecticides: Premier & Yukon Gem
Defender

- Released in 2004
- Primarily Processing
- High Yield & Specific Gravity
- High Vitamin C
- Bulks Rapidly
- Good for Organic Production

- Resistant to Late Blight
  - Foliage
  - Tuber - very
- Also Resistant to:
  - Tuber early blight, PVX, net necrosis and PC Nematode
- Moderate Resistance:
  - Early dying, pink rot, corky ringspot, PVY₀, and soft rot

Weaknesses:
- Blackspot, scab, greening, short dormancy

Late Blight Screening Trial
Bonners Ferry, ID (2004)

- No fungicides
- Late blight inoculated

Late Blight Susceptible: Dead Vines

Defender

Courtesy of Dr. Jeff Miller
Premier Russet
Resistance to Low Temperature Sweetening

Attributes

- High market yields, uniform shape
- Low external and internal defects
- $ Process value > RB, similar to Ranger
- Highly resistant to low temperature sweetening (LTS)
- Fries well out of 42°F (5.5°C) storage temp
- Low acrylamide forming potential
- Resistant to PVY, verticillium, scab, early blight & soft rot
- Industry has shown strong interest for export products

Starch $\xrightarrow{40°F/4°C}$ Sucrose $\xrightarrow{\text{heat} + \text{asparagine}}$ Glu + Fru $\xrightarrow{\text{asparagine}}$ Dark Fries & Acrylamide
Vitamin C:
- 45% of required daily values in medium-sized potato
- Ranger, Defender, GemStar: 30% higher than Burbank

Protein
- Potato: Good balance of amino acids
- Biological value of potato protein = 90-100;
- Whole chicken egg being standard = 100
- Classic and Clearwater Russet: 32% & 38% higher than Burbank

Phytonutrients/Anti-Oxidant Compounds (Navarre)
- Polyphenols, flavonoids, carotenoids
- Yukon Gem, Purple Pelisse
Impacts of PNW Program on the Science of Potato Biology & Improvement

- **PAA 2009**
  - At least 16% of presentations at this conference are using TS varieties or germplasm in their research

- **Interactions with SolCAP**
  - Premier Russet x Rio Grande Russet = tetraploid mapping population to identify genetic markers for phenotypic traits (e.g. CH$_2$O metabolism)
  - PNW is a trial site (with NE & NC region) for collecting phenotypic data for association with genetic markers with CH$_2$O and vitamin biosynthetic pathways
  - SolCAP Potato Germplasm Panel – 25% of clonal entries are Tri-State (40/157)

- **Leveraged & Collaborative Research Efforts**
  - Zebra Chip – USDA/SCRI - TS providing unique germplasm for evaluation for resistance to causal agent
  - State Depts. of Agriculture – sustainability research
  - ARS state partnership program (ARS-NPC)
  - State Potato Commissions
TS varieties now produced on >140,000 A in PNW with value to growers estimated at ~$505 million.
  ✓ This impact is expected to increase
  ✓ Replacement of only half the current RB acreage with TS varieties = $380 million based on average processing contracts.

~21% of U.S. acres planted for fall production in 2009 were TS varieties.

A 2002 economic analysis estimated that TS varieties returned ~$39 to the PNW industry for every dollar invested in the program.

QSR’s have adopted TS varieties.

The program is making substantial contributions to our knowledge of potato biology, agronomy and crop management and is hastening the science of potato improvement.
Newly Released Varieties

- **Classic Russet (2008)**
  - Dual-purpose
  - Early maturing
  - Good culinary qualities & higher protein

- **Clearwater Russet (2008)**
  - Dual-purpose
  - Full-season maturity
  - Cold-sweetening resistant & higher protein

- **Alpine Russet (2008)**
  - Processing
  - Long dormancy
  - Better Processing than Russet Burbank

- **Owhyee Russet (2009)**
  - Dual-purpose
  - Full season maturity
  - High proportion U.S. #1’s
  - Excellent processing out of storage

- **Red Sunset (2009)**
  - Mid-season maturity, round tubers
  - Bright red skin; High percent U.S. #1’s
  - High fresh market merits

- **Crimson Red (2009)**
  - Mid-season maturity, oval tubers
  - White flesh, bright red skin
  - Low internal & external defects
  - Good culinary merits

- **Purple Pelisse (2009)**
  - Mid-season specialty
  - Purple skin, dark purple flesh
  - High set of fingerling-shaped tubers
  - High antioxidant level, good flavor
  - Klamath Basin Fresh Direct exclusive