Project Title: Potato Breeding and Genetics University of Minnesota
Project leader: Dr. Christian A. Thill

Research Scientist: Jeffrey L. Miller
Assistant Scientist: Kristen John

OBJECTIVES OF THIS RESEARCH
The objective of this research is to develop and release potato varieties adapted to Minnesota and North Dakota. Selection will emphasize lines having superior yield, quality, and host plant resistance to biotic and abiotic stress.

GOALS OF THIS RESEARCH
Breeding efforts focus on state and regional needs as identified by growers at research prioritization meetings.

1. French fry processing lines that fry from the field, fry from 48F or below, have specific gravity >1.085.
2. Fresh market red skin, white flesh lines that retain color at harvest and after storage and do not skin.
3. Potato chipping lines with white skin and white flesh that chip directly from the field and after long term storage without accumulating reducing sugars, and specific gravity > 1.085.
4. Fresh market red skin, yellow flesh lines that retain color at harvest and storage and do not skin.

SELECTIONS FOR RELEASE IN 2012
MN18747 A 80-day maturity, blocky long white, white skin potato for the FF field processing & fresh market.
MN02616R/Y A red skin yellow flesh potato for the fresh market.
MN99380-1Y A white skin yellow flesh potato for chip and fresh market.

SUMMARY
Research emphasized the development, evaluation and release of potato varieties with improved yield, quality, and resistance to biotic and abiotic stress. We field evaluated 53,000 single-hill generation (SH) seedlings from 200 families. New hybrid crosses focused on priority traits determined by Minnesota (MN) and North Dakota (ND) growers in French fry processing, fresh market russet and red skin, and potato chip processing markets. Combined we selected 650 SH lines for these markets. Among SH populations we continue studying environmental influence on selection efficiency. As example, variation in red skin color and degree of color fading is observed across locations; influencing selection decisions. A new, short-season northern MN site with peat soils was added for developing early maturing fresh reds. We observe improved red skin color when growing on peat soils and selected 157 SH clones with bright red color. Conversely, red skin color fades on sandy soils; the predominant soil type in commercial central MN regions. Concern arises though if SH selection occurs in commercial regions due to line contamination with viral pathogens; which, hinders our ability to replant and reevaluate them due to yield and quality declines. The northern seed site facilitates production of virus free seed for subsequent evaluation on sandy soils. We selected 157 SH and 50 generation 1 (G1) red lines for testing on-farm in sandy soils in 2012. Growing for processing also predominates in central MN and we selected 100 SH fry, and 238 SH chip lines. SH selections fill the breeding pipeline for subsequent evaluation over years across MN environments. We continued evaluation of 450 generation 2 (G2) through G3, G4, and G5 or greater lines in MN and ND for yield, grade, internal and external physiological defects, and processing quality at harvest and from low temperature storage. Host plant resistance to common scab, late blight, and viral pathogens was also determined. Promising lines include MN02419Rus, MN18747, and MN02467Rus/Y for fry processing; MN03178-2Rus and MN02467Rus/Y for fresh russet; MN96072-4R/W, MN99460-14R/W, MN03505-3R/W, MN03021-1R/W, MN03027-1R/W, MN06030-1R/W, MN02616R/Y, and MN96013-1 for fresh red; MN02696, MN00467-4, MN02574, MN03339-4, MN02588, and MN99380-1Y for chips; MN02586Y, and MN04844-07Y for fresh
yellow markets. We released MN15620 (MonDak Gold) to growers in 2010. Commercial testing continues exploiting its long-storage fry potential and as a roasted restaurant product. MN18747, MN02419Rus, MN02467Rus/Y, and MonDak Gold are fry lines with low acrylamide (less than 200ppb). Cultivar Russet Burbank had greater than 1000ppb acrylamide. Acrylamide is a known carcinogen found in processed food products, and is a major concern to the industry. Chip potato line MN99380-1Y was selected for fast-track expansion by the US Potato Board due to its high yield and superior quality, and will be grown at 11 US locations in 2012. The red skin yellow flesh line MN02616R/Y is being expanded for commercialization and varietal release in 2012. These clones are maintained in tissue culture as virus free; seed was produced for stakeholder testing.

**BREEDING YIELD & QUALITY TRIALS**

**Yield, Grade and Quality Evaluations** – Selections advancing are compared to commercial cultivars in field trials at irrigated and non-irrigated locations in MN and ND. Plant maturity, yield, grade, and quality information are collected at harvest. Data for the following attributes are collected – US #1 marketable and size distribution yield, percentage of U.S. #1 yield and graded defect weights (malformed tubers, severe growth cracking, etc.), specific gravity, incidence and type of internal and external defects, and processing color. A comprehensive storage/processing/temperature profile (40 & 45F direct and reconditioning) for chip and French fry potato types is performed. Following harvest at each varietal evaluation site, clones are graded and packaged into samples for storage @ 1, 3, 5, 7 & 9 months. At each time point physiological defects, both, internal (hollow heart, internal brown center, vascular discoloration), and external (bruise, skin color) are determined. Additional processing characteristics include FF length distribution, and characterization for sugar end and dark ends. Red-skinned selections are evaluated for color and skin sloughing at harvest and storage.

*Crosses sown 2011: 200*

**Single Hill Population:** 4,000@UMORE Park, 19,000@Nesson Valley (Russet only population), 30,000@PLWR

**Single Hill (G0) Selections:** 31@UMORE Park, 80@Nesson Valley, 539@ PLWR

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<th>Nesson</th>
<th>PLWR</th>
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<td><strong>Total</strong></td>
<td>31</td>
<td>80</td>
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**First Year (G1) Selections:** 135@Becker, 135@Nesson Valley

**Second Year (G2) Selections:** 100@Becker, 100@Nesson Valley, All 3 Disease Trials

**G2 Red Family selection at PLWR**
In 2010 168 red selections from 40 families was made. 2011 selections among the 168 yielded 49 G2 selections.

**Third year (G3) Selections:** 43@Becker, and Nesson Valley, All 3 Disease Trials

**Fourth Year (G4) selections:** 44@Becker and Nesson Valley, All 3 Disease Trials

**Fifth Year and greater Selections:** 17@Becker, 23@Nesson Valley, All 3 Disease Trials

**Strip-trial at Nesson Valley:**
Eight breeding lines were grown in 200-hill, 2-row strip plots to determine commercial handling and adaptation. Processing lines are being evaluated bi-monthly by Ag World Support Systems for grade and quality. Red lines are stored at USDA and are being evaluated monthly for storage quality.

**Processing**
- MonDak Gold
- Russet Fresh MN02467Y
- Red Fresh MN02616R/Y, MN19298R/Y
- Chip MN00467-4, MN03339-4, MN02588,
Yellow MN02586Y

**DISEASE RESISTANCE BREEDING**

Disease screening for foliar and tuber late blight, common scab, PVY and PLRV resistance and PVY symptom expression, are performed on all selections from the 2nd clonal generation.

*Late blight resistance:* The primary focus of this research is to develop new potato varieties and parental germplasm resistant to late blight. Breeding lines are evaluated 3x for % late blight infection after inoculation. Selections will be made advancing the most resistant lines. This work is done at UMORE Park, Rosemount, MN.

Lines evaluated include: MN Breeding lines, NCR lines, National late blight lines, US Potato Board Chip Breeders Trial lines. N=590 clones

*Common scab resistance:* The primary focus of this research is to develop new potato varieties and parental germplasm resistant to common scab. Common scab is a soil-borne disease, which causes significant economic loss by adversely affecting tuber quality with lesions on the tuber periderm. Breeding lines are evaluated for disease incidence (% coverage) and disease severity (surface, raised, and pitted scab; individual or coalesced lesions). This work is done at the Sand Plains Research Farm in Becker, MN.

Lines evaluated include: MN Breeding lines, NCR lines, National C. Scab lines, US Potato Board Chip Breeders Trial lines. N=575 clones

*PVY resistance and PVY symptom expression:* The primary focus of this research is to develop new potato varieties and parental germplasm resistant to PVY. Additionally this research explores the symptom expression of PVY and its relationship to variety. PVY is a viral plant disease that reduces potato plant productivity, marketability, and seed quality. This work is done at UMORE Park, Rosemount, MN.

Lines evaluated include: MN Breeding lines, NCR lines, National breeding lines, US Potato Board Chip Breeders Trial lines, and Flynn MS. Research PVY resistance lines. N=564 clones

**SEED**

*G1 & G2 Seed production; MDA; UM at PLWR* Tissue culture transplant seedlings, Pre nuclear seed, and G1 seed from lines produced G1 and G2 seed.

*Processing* MN02419, MN18747, MonDak Gold

*Russet Fresh* MN02467Y

*Red Fresh* MN03021-1R, MN02616R/Y

*Chip* MN00467-4, MN02574, MN03339-4, MN02588, MN99380-1Y

*Yellow* MN02586Y, MN04844-07Y

*Prenuclear and G1 Hybrid crosses seed; MDA, UM greenhouse, PLWR* Pre nuclear seed of 200 families from 2010 winter crosses was produced in isolated UM greenhouses under MDA guidelines. Lines were grown in 5 pot sizes (second year study) to determine production efficiency.

Additionally the 159 families were transplanted to PLWR@ 150 seedlings / family and selected.

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<th># of Clones Selected</th>
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<td><strong>Chip</strong></td>
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<td><strong>yellow</strong></td>
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<td>11</td>
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<tr>
<td><strong>Other</strong></td>
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*Pre nuclear; Valley Tissue Culture* MonDak Gold MN18747 MN02616R/Y MN99380-1Y MN04844-07Y

**Seed Trials**

MN02616R/Y PLWR G1

MonDak Gold Enander Farms G1

MN02616R/Y K. Mason Prenuclear

MN04844-07Y K. Mason Prenuclear

MN02586Y R. Schmidt G1

MN99380-1 R. Schmidt G1

MN18747 J. Dagen G2

MN02616R/Y J. Dagen G2
Commercial Trials
MN18747  L. Ryman  G2 (flooding)
8 MN lines  Tri-Campbell Farms  G2

TRANSITIONING TO VIRUS FREE
Processing
MN02419Rus  Lt Russet skin, white flesh, long shape FF processing line from 45F

Russet Fresh
MN03178-2Rus  Blocky russet, white flesh, FF processing

Red Fresh
MN96072-4R/W  Red skin, white flesh, Fresh
MN99460-14R/W Red skin, white flesh, Fresh
ATMN03505-3R/W Red skin, white flesh, Fresh; storage red
MN03021-1R/W  Red skin, white flesh, Fresh; storage red
MN03027-1R/W  Red skin, white flesh, Fresh; storage red
MN06030-1R/W  Red skin, white flesh, Fresh; small uniform size, large B market

Chip
MN02696  White skin, white flesh, Chip potato with CIS resistance from 42F

Yellow
MN96013-1R/Y Red skin, yellow flesh, Fresh

POTATO VIRUS ERADICATION STRATEGIES TO ADVANCE MN BREEDING LINES
The primary focus of this laboratory research is continued development of strategies for eradicating virus from potato breeding lines. Viral infection is a major constraint to the production of high yielding potatoes and virus can be transmitted from generation to generation through seed tubers. Cryotherapy is an in vitro technique recently found to eliminate virus from vegetatively propagated plant shoots. Current virus eradication methods in potato are costly and time-consuming factors that minimize the number of clones subjected to virus eradication methods. Potato breeders maintain vegetatively many clones with valuable breeding traits; frequently these clones are infected with one or more viruses. A less expensive, less time consuming procedure for virus eradication would benefit both the research community and the potato industry:
1. Breeders could deploy new varieties with expediency avoiding time consuming protocols (up to 18 months) and high costs (ca. $3-5K / clone) due to limitations imposed by current methods;
2. Lower virus in breeding populations would result in higher quality performance trials;
3. Germplasm lacking virus reduces the risk of moving novel potato diseases across the US while sharing germplasm for national trials.

The goal of this project is to determine the effectiveness, reliability, and efficiency of cryotherapy as a means of eliminating virus from potato.

NEW GRANTS INITIATIVES
North Dakota/ Montana Specialty Crop Block Grant Program: $100,000 (UM $20,000) for research on MonDak Gold, pre nuclear seed production of MonDak Gold, and storage quality and market testing of MonDak Gold and other UM breeding lines. Thill / Bergman

MDA US Farm Bill Grants Funds: $100,000 for research on MN02616R/Y, pre nuclear seed production of MN02616R/Y, and storage quality and market testing of MN02616R/Y lines. Thill / PLWR (Spring 2012)

USDA/ARS/NPC Potato grants:
National common scab (December 2011)
National late blight (December 2011)
Cryotherapy (December 2011)

EXTENSION / COMMUNICATION:
MN Area II: Reporting conference & field @ Becker NPPGA: Reporting conference / Expo & field/shed @ Twilight tour MONDAK: MonDak Irrigation Tour & MonDak Ag Open @ Nesson Valley field

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Principal Research Scientist: Jeffrey L. Miller, University of Minnesota, 311 5th Avenue NE, East Grand Forks, MN 56721. Cell: 701.741.8112, Fax: 218.773.1478, e-mail Mille603@umn.edu
MonDak Gold

University of Minnesota
INVEST IN GOLD
MonDak Gold

(LOW ACRYLAMIDE (< 150ppb, USP9 Fry wash), GOLDEN Fries)

Incentives for production:
The tubers of MonDak Gold have a uniform shape with a smooth skin and light yellow flesh; >92% of the tubers are US No. 1. French fry processing color is excellent from 45P. Tuber set averages 10 tubers/plant with >60% over 6oz. Specific gravity of MonDak Gold ranges 1.080 - 1.085. Smaller tubers may be marketed for fresh market due to their light yellow flesh.

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Tom Rolfstad, Williston Area Ag. Diversification Group
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Phone: (701) 577-8110

Strengths: MonDak Gold has a smooth red to pink color skin, light yellow flesh, oblong tuber shape, and excellent cooking qualities that make it suitable for French fry processing and tablestock use. MonDak Gold has low acrylamide and fries late from storage. Internal quality is excellent. MonDak Gold is resistant to PVY and PLRV, and has moderate field tolerance to CPB, and Verticillium wilt.

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Charles Stadick, Spud Viking Consulting
Email: SpudViking@mn.com
Phone: (208) 230-2410

Culinary Quality: MonDak Gold can be used for processing into fries, fresh market baking, mashing, roasting, and microwave cooking.

Seed availability: Virus-free tissue culture plants of MonDak Gold are available from the University of Minnesota Potato Breeding program. Tissue culture plants are available from the MN. Dept. of Agr. Seed Potato Certification, www.mnseedpotato.org

Chuck Gunnerson, Northern Plains Potato Growers Association
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Potato Research Team
This potato research is a collaborative effort of the potato research programs at the University of Minnesota and the NDSU Williston Research Extension Center; with assistance from the Williston Area Ag. Diversification Group, Spud Viking Consulting, and the Northern Plains Potato Growers Association. These organizations work together conducting potato research and varietal testing for developing cultivars for specific markets and adapted to the MonDak and Northern Plains region.
University of Minnesota
Potato Breeding and Genetics
Potato Seedling  MN 02616 R/Y
MN02616R/Y

Parentage: Minnesota Family #149 x OP

Developers: University of Minnesota, Minnesota Agricultural Experiment Station.

Strengths: MN02616R/Y is a seedling selected by C. Thill having a smooth uniform round to oval shape with dark red skin, deep yellow flesh, and excellent internal quality. Its use is for the Fresh market as baked, boiled, salad, fried or grilled.

Incentives for production: The tubers of MN02616R/Y have a uniform round to oval shape with dark red skin and deep yellow flesh. Culinary characteristics are excellent. Tubers per plant and 43% > 6 oz. and a large proportion of the tubers are US No. 1. MN02616R/Y specific gravity ranges from 1.066 - 1.076. Internal quality is excellent.

Excellent culinary quality

Morphological Characteristics:

Plant: Dark green foliage; vine has an erect to spreading growth habit, medium to tall in height; intermediate stemmy to leafy foliage providing full canopy cover over the bed. Vigor is excellent.

Tubers: Dark red skin, deep yellow flesh, round to oval uniform tuber shape with shallow eyes, and excellent internal quality.

Flower: Red violet.

Agronomic Characteristics:

Foliation: Dark green foliage with medium to large leaflets.

Maturity: Medium to full season.

Yield: Medium to high yield.

Specific gravity: Moderate to low.

Storability: Medium dormancy (January - February).

Culinary quality: MN02616R/Y when prepared for Fresh market use as baked, boiled, salad, fried or grilled - its golden flesh makes appealing culinary products.

Disease reaction: MN02616R/Y expresses normal symptoms of PVY and PLRV, susceptible to common scab and late blight.

Seed availability: Virus-free tissue culture plantlets of MN02616R/Y are available from the University of Minnesota Potato Breeding program as are small amounts of seed. Tissue culture plantlets are available from the Minnesota Department of Agriculture, Seed Potato Certification, www.mnseedpotato.org.

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North Central Potato Breeding Team

The North Central Potato Breeding Team is a cooperative effort of the potato research programs at Michigan State University, the University of Minnesota, North Dakota State University, and the University of Wisconsin. The four states work together conducting breeding and genetic research, disease and pest resistance screening, develop improved cultivars, and enhance germplasm with the potato industry in the North Central Region. Teams of researchers from the four cooperating institutions apply conventional and molecular breeding strategies to develop and test improved cultivars for specific markets.
MN18747
Parentage: ND 2264-7 x MN 47.82-6 (MN 14489)
Developers: University of Minnesota, Minnesota Agricultural Experiment Station.
Strengths: MN18747 is a seedling selected by C. Thill having a bright white skin color, white flesh, and blocky to oblong uniform tubers. Its use is for early French fry processing, it has low acrylamide formation, and excellent internal quality. MN18747 expresses normal symptoms of PVY, and is resistant to common scab.
Incentives for production: The tubers of MN18747 have a uniform blocky shape with a smooth bright skin and white flesh. Tuber set averages 7 tubers/plan with >55% early harvest and >80% late harvest over 6 oz. Early French fry processing color is excellent as is from 48F storage. Specific gravity of MN18747 is 1.080.

(LOW ACRYLAMIDE (<150ppb USPB national testing), EARLY)

Morphological Characteristics:
Plant: Dark green foliage; intermediate to stemmy erect vine and tall in height, large oblong leaflets that provide good bed cover. Vigor is excellent.
Tubers: The tubers are smooth, white color skin, white flesh, and a blocky-oblong uniform tuber shape. MN18747 has excellent internal quality.
Flower: Flowers are red violet with prominent white tips that fade to white.

Agronomic Characteristics:
Foliation: Dark green foliage with large oblong leaflets.
Maturity: Medium to early bulking.
Yield: Tubers bulk early and yield it moderate to high in Minnesota irrigated.
Specific Gravity: Moderate, ranging from 1.077 to 1.081 in Minnesota irrigated.
Storability: Medium dormancy, i.e. slight sprouting at 5 months.
Culinary Quality: MN18747 tubers can be used for fresh market baking, mashing, and microwave cooking and for processing into French fries.
Diseases reaction: Normal symptoms of PVY and PLRV infection, resistant to common scab, susceptibility to CPB, Verticillium wilt, and late blight.
Seed availability: Virus-free tissue culture plantlets of MN18747 are available from the University of Minnesota Potato Breeding program as are small amounts of seed. Tissue culture plantlets are available from the Minnesota Department of Agriculture, Seed Potato Certification, www.mnseedpotato.org

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MN99380-1Y

Parentage: Atlantic x MSA091-1

Developers: University of Minnesota, Minnesota Agricultural Experiment Station.

Strengths: MN99380-1Y is a seedling selected in 1999 having white skin, yellow flesh, smooth uniform tubers, and excellent internal quality. Yield is high. Tubers have moderate specific gravity and good culinary characteristics. MN99380-1Y has low glucose content and chips acceptably from the field and from cold storage.

Incentives for production: The tubers of MN99380-1Y have a uniform shape with a smooth white skin and yellow flesh. Yield is high with ~95% US No.1; and tuber set averages 10 tubers/plant. Attractive chips result after field harvest and late into the storage season.

 Morphological Characteristics:
Plant: Light to medium green foliage; semi-erect vine medium in height; closed canopy with small to medium size leaflets.
Tubers: The tubers are smooth and uniform; white skinned, yellow flesh, and round to oval shape. Internal quality is excellent.
Flower: Pale red violet with prominent white tips - fades to white. Male and female fertile; fruit production is evident in the field.

Agronomic Characteristics:
Foliation: Light to medium green.
Maturity: Medium.
Yield: High yield under irrigated conditions.
Specific gravity: Moderate range 1.078 to 1.085.
Storability: Short to medium dormancy.
Diseases reaction: Low incidence of pink rot, susceptible to Verticillium wilt, CPB, slight resistance to common scab and late blight, Hollow heart is rare.
Seed availability: Virus-free tissue culture plantlets of MN99380-1Y are available from the University of Minnesota Potato Breeding program as are small amounts of seed. Tissue culture plantlets are available from the Minnesota Department of Agriculture, Seed Potato Certification, www.mnseedpotato.org.

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MN02467Rus/Y

Parentage: MN Family #51 x (OP)
Developers: University of Minnesota, Minnesota Agricultural Experiment Station.
Strengths: MN02467Rus/Y is a seedling selected by C. Thill having a smooth russet skin, uniform oblong tuber shape with shallow eyes, yellow flesh, and excellent French fry quality. Its use is for both French fry processing and fresh market.

Incentives for production: The tubers of MN02467Rus/Y have a uniform shape with a russet skin and yellow flesh. Tubers set averages 8 tubers per plant and 64% over 6 oz. and >95% of the tubers are US No. 1. MN02467Rus/Y specific gravity ranges from 1.080 – 1.084. Early French fry processing color is excellent as is from 48F storage. Internal quality is good to excellent; some hollow heart noted.

LOW ACRYLAMIDE (<225ppb, USPB national testing)

Morphological Characteristics:
Plant: Medium to dark green foliage; tall semi-erect vine; intermediate to full canopy with large oblong leaflets providing good bed cover. Vigor is excellent.
Tubers: Russet skin, yellow flesh, oblong uniform tuber shape with shallow eyes, and excellent internal quality. Some hollow heart noted similar to Russet Burbank.
Flower: Red violet with white tips.

Agronomic Characteristics:
Foliage: Medium to dark green foliage with large oblong leaflets.
Maturity: Full season.
Yield: Medium yield, slightly less than Russet Burbank.
Specific gravity: Moderate to high, 1.080 in Minnesota irrigated and 1.084 in Nesson Valley irrigated (Williston, ND).
Storability: Medium long dormancy.
Culinary quality: MN02467Rus/Y tubers can be used for Fresh market baking, and for processing into French fries giving a nice golden colored French fry.
Disease reaction: MN02467Rus/Y expresses normal symptoms of PVY and PLRV, susceptible to common scab and late blight.

Seed availability: Virus-free tissue culture plantlets of MN02467Rus/Y are available from the University of Minnesota Potato Breeding program as are small amounts of seed. Tissue culture plantlets are available from the Minnesota Department of Agriculture, Seed Potato Certification, www.mnseedpotato.org.

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