Potato Breeding and Cultivar Development for the Northern Plains
North Dakota State University
2010 Summary

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Potato continues to be the most important vegetable and horticultural crop grown in North Dakota and the Northern Plains. Traditionally, North Dakota State University (NDSU) potato cultivar releases have been widely adapted and accepted, thus significantly impacting production in North Dakota, Minnesota, the Northern Plains, and often throughout North America.

Potato research has been conducted at NDSU since the late 1800s. Early work was mainly in regard to production practices such as plant population and planting depth. The potato breeding program was initiated in 1930 by the North Dakota Agricultural Experiment Station (NDAES). Potato breeders have included Dr. A. F. Yaeger, Mr. H. Mattson, Dr. Robert H. Johansen (1948), Dr. Rich Novy (1995), and Dr. Asunta (Susie) Thompson (2001). Recent interim breeders (circa 1998-2001) included Dr. Gary Secor (Department of Plant Pathology, NDSU) and Dr. Jim Lorenzen (University of Idaho). Potato breeding is a long, arduous process, partly due to the complex genetic nature of the highly heterozygous and tetraploid *Solanum tuberosum* L., but also because producers, industry, and consumers are very discerning, and in order to remain economically sustainable must know information about a myriad of traits including agronomic characteristics, yield and grade, cultivar specific management information, resistances to pests and stress, and processing and culinary qualities. Our basic breeding schematic is presented in Table 1.

Since 1930, 24 cultivars have been named and released by the NDAES, in cooperation with the USDA-ARS, and others (please see Table 2). Many additional collaborative releases with state Agricultural Experiment Stations, the USDA-ARS, and Agriculture Canada have also occurred. As a leader in potato breeding, selection, and cultivar development, our goal is to identify and release superior, multi-purpose cultivars that are high yielding, possess multiple resistances to diseases, insect pests, and environmental stresses, have excellent processing and/or culinary quality, and that are adapted to production in North Dakota, Minnesota, and the Northern Plains.

Our program emphasizes late blight, cold-sweetening, Colorado potato beetle, pink rot and *Pythium* leak, silver scurf, sugar end, and aphid and virus resistance breeding. In order to develop durable and long-term resistance to pests and stresses, breeding efforts continue to include germplasm enhancement to incorporate important pest resistances and improved quality traits via exploitation of wild species and wild species hybrids, in addition to the use of released cultivars and advanced germplasm from around the globe. Breeding, evaluation, and screening efforts are successful because of the cooperative and interdisciplinary efforts amongst the NDSU

potato improvement team, the North Dakota State Seed Department (NDSSD), Minnesota Department of Agriculture, and with potato producers, research and industry personnel in North Dakota, Minnesota, the Northern Plains, and beyond.

In order to meet the needs of producers and industry, we have established the following research objectives:
1) Develop potato (*Solanum tuberosum* Group Tuberosum L.) cultivars for North Dakota, Minnesota, the Northern Plains, and beyond, using traditional hybridization that are genetically superior for yield, market-limiting traits, and processing quality.

2) Identify and introgress into adapted potato germplasm, genetic resistance to major disease, insect, and nematode pests causing economic losses in potato production in North Dakota and the Northern Plains.

3) Identify and develop enhanced germplasm with resistance to environmental stresses and improved quality characteristics for adoption by consumers and the potato industry.

Potato Breeding, Selection, Cultivar Development, and Germplasm Enhancement

The NDSU potato improvement team concentrates on breeding and evaluation for important traits to our industry, including cold processing ability (both chip and frozen products), late blight, Colorado potato beetle, sugar end, *Verticillium* wilt, pink rot and *Pythium* leak, aphid, and *Fusarium* dry rot resistance. In hybridizing, the breeding program utilizes germplasm enhancement in an effort to develop durable and long-term resistance to pests and stresses and to improve quality attributes, exploiting wild species, wild species hybrids, and cultivars and advanced selections from cooperators around the globe. In 2010, 626 new families were created in the greenhouse using 174 parental genotypes. Of these families, 417 (67%) included late blight resistance breeding, 289 (46%) Colorado potato beetle (CPB) resistance breeding, 129 (21%) aphid resistance breeding, 46 (7%) *Verticillium* wilt resistance breeding, and 213 (34%) chip selections with cold sweetening resistance breeding. In the summer and fall greenhouse crops, 530 families from (true) botanical seed were grown; of these families, 340 (64%) included late blight resistance breeding, 248 (47%) CPB resistance breeding, 190 (36%) aphid resistance breeding, 22 (4%) *Verticillium* wilt resistance breeding, 192 (36%) chip selections with cold sweetening resistance breeding, 19 (4%) corky ringspot resistance breeding, and 20 (4%) tuber moth resistance breeding. Harvest both crops are complete.

At Langdon, 78,020 North Dakota (ND) seedlings, representing 565 families, were evaluated; 770 selections were retained. Unselected seedling tubers from cooperating programs in Idaho, Texas and Maine were grown at Larimore, Hoople and Crystal, ND. Unselected seedlings (totaling 45,702 tubers) were shared with breeding programs in Idaho (18, 569), Maine (6,820), Colorado (8,697), and Texas (11,616). In 2010, 757 second, 158 third year, and 302 fourth year and older selections, were produced in seed maintenance and increase lots at Absaraka and Wyndmere; 176, 81, and 240 second, third, and fourth year and older selections were retained, respectively. Additional selections with late blight resistance and for several genetic studies were also maintained and/or increased at Wyndmere.

Yield and evaluation trials were grown at six locations in North Dakota, four irrigated (Larimore,

Oakes, Inkster and Williston) and two non-irrigated locations (Hoople and Crystal). Twenty-six entries were grown in the chip trial at Hoople, including 15 advancing selections from the NDSU program, four lines from Frito-Lay, and seven named cultivars. A new trial in 2010 was the National Chip Breeders Trial, initiated by the USPB and regional chip processors; 219 entries were included in the unreplicated trial. The goals are to rapidly identify and develop clones to replace Atlantic for southern production areas, and Snowden from storage. At Crystal, 20 entries were grown in the fresh market trial, including 13 advancing selections and seven named cultivars. In the preliminary fresh market trial, 31 entries were evaluated, including 27 advanced selections and four named cultivars. The purpose of the preliminary fresh market trial is to help us discard lines that do not have commercial potential and to more quickly identify those that should be increased and moved to the fresh market trial. Twenty selections and commercially acceptable cultivars were grown in the Oakes processing trial, 20 in the Larimore processing trial, and 16 in the Williston processing trial. A new trial in 2010 at Larimore was a trial aimed at identifying suitable genotypes for dehydration; in this initial year, 20 entries including four check genotypes (Alturas, Ranger Russet, Russet Burbank and Dakota Trailblazer) were evaluated. Additionally at Larimore, the NDSU potato breeding program cooperated with Simplot Plant Sciences, Boise, ID, in conducting three trials evaluating improved lines of Ranger Russet, Russet Burbank and Atlantic. Trials at Inkster ranged from the chip processing yield trial with 21 entries, evaluation of genotypes for resistance to Verticillium wilt, Fusarium sp., sugar end/anti-sweetening, and cultural management trials including work with 2,4-D and metribuzin sensitivity. The trials were in collaboration with Drs. Nick David, Neil Gudmestad, Harlene Hatterman-Valenti, Gary Secor and Joe Sowokinos.

Four entries from NDSU were evaluated in the North Central Regional Potato Variety Trial (NCRPVT), including ND8314-1R and ND8555-8R, bright red skinned selections suitable for the fresh market, ND8307C-3 a chip processing selection, and ND8229-3 a dual-purpose russet. NCRPVT locations are Crystal (fresh market), Hoople (chip processing), Larimore (processing), and Inkster (fresh market, chip and processing).

Our efforts continue to identify processing (both chip and frozen) germplasm that will reliably and consistently process from long-term cold storage. As we grade, chip processing selections are sampled, and stored at 42F and 38F (5.5C and 3.3C) for eight weeks; a second set is evaluated the following June. French fry/fozen processing selections are evaluated predominantly from 45F (7.2C) storage after eight weeks storage and again the following June. All trial entries are evaluated for blackspot and shatter bruise potential.

In 2010, Dr. Gary Secor's program evaluated seedling families using a detached leaf assay in the greenhouse. Resistant selections were retained for field evaluation in 2011. Collaborative field trials included late blight foliar and tuber evaluation trials with Dr. Secor, in addition to evaluation for resistance to tuber blemish diseases. Bacterial ring rot expression and resistance to Verticillium wilt, pink rot and Pythium leak is a collaborative effort with Dr. Neil Gudmestad's program. Dr. Deirdre Prischmann-Voldseth's program conducted Colorado potato beetle resistance screening. Sucrose rating, invertase/ugpase analysis, and serial chipping of chip and French fry/frozen processing selections is conducted by Marty Glynn (USDA-ARS), and Drs. Joseph Sowokinos (UMN) and Sonu at the USDA-ARS Potato Worksite in East Grand Forks, MN. We also submitted entries in many cooperative trials with various producers,

industry, and research groups around North America.

The most promising advancing red fresh market selections include ND4659-5R, ND8555-8R, AND00272-1R, ND6002-1R, and ND7132-1R. All are beautiful, bright red skinned, white fleshed selections. Release committee meetings may convene for ND8555-8R and ND4659-5R in 2011. Dual-purpose russet selections, ND8229-3, ND8068-5Russ and several hybrids between Dakota Trialblazer and ND8229-3, possess excellent appearance, yield and grade, and processing qualities. ND8068-5Russ has early maturity, about seven days earlier than Russet Norkotah. Unlike Russet Norkotah, it processes from the field and 45F storage. ND7519-1 and ND8304-2, advancing chip processing selections, possess excellent appearance and cold sweetening resistance. Characteristics of Dakota Trailblazer and superior advancing selections for all market types including three specialty types are summarized in the pages following Table 2.

A highlight for 2010 was being the first project to move into the new NDSU greenhouse complex. In our first crop, several families of seedlings were grown, in addition to several advancing clones for minituber production. This crop was tremendous in terms of size of tubers and number of tubers per pot. We currently have two additional crops for minituber production in two separate pods (chambers). This state-of-art facility is allowing the potato breeding program to produce seedlings and minitubers with reduced fear of insect pests that vector diseases such as tomato spotted wilt and impatiens necrotic spot viruses, which are present in other ranges on campus. The precise environmental controls allow us to define strict production parameters, which were evident in the high yield and quality of our first crop.

Goals for 2011 continue to include developing improved potato cultivars for ND, MN, the Northern Plains, and beyond, using traditional hybridization, and utilizing early generation selection techniques such as marker assisted selection and greenhouse screening procedures when possible for rapid identification of genetically superior germplasm. Our objectives for identifying and developing resistance to major insect, disease and nematode pests, and to environmental stresses, with an emphasis on improved quality characteristics will continue as major concentrations. Finally, working with the North Dakota State Seed Department and the Minnesota Department of Agriculture, we will strive to streamline and improve our seed maintenance and increase efforts in order to produce high quality certified seed. New efforts in participatory plant breeding and sustainable production practices will also be initiated.

We are grateful for the opportunity to conduct cooperative and interdisciplinary research with members of the NDSU potato improvement team, the USDA-ARS programs in Fargo and East Grand Forks, the North Central group and other research programs across the globe. Our sincere thanks to our many grower, industry, and research cooperators in North Dakota, Minnesota, and beyond. Your support of our research program is amazing, making our work exciting and a joy.

Table 1. Potato Breeding and Cultivar Development Breeding, Selection and Development Schematic, North Dakota State University

Year	Procedure
1	Parental selection, crossing and true seed production in the greenhouse. Produce seedling tubers from true seed in the greenhouse. Initiate late blight screening of seedling families in the greenhouse using a detached leaf assay.
2	About 100,000 North Dakota seedlings are planted in the field (Langdon, ND) as single hills. Up to 50,000 from out-of state programs are also planted at ND locations. Initial selection takes place at harvest; 1,000-1,500 genotypes are typically retained. This is the first cycle of field selection. Decisions regarding seed increase are initiated.
3	Two-four hill units are planted at Absaraka for seed maintenance. Typically 200-250 selections are retained at harvest based primarily on phenotypic selection. This is the second cycle of field selection. Colorado potato beetle (CPB) resistant (potential) selections are entered into replicated trials and evaluated for defoliation. Selections are evaluated for specific gravity and internal defects. Chipping and processing russet selections are evaluated for sucrose rating and are chipped from storage (5.5 and 7.2 C). Replicated late blight resistance screening field evaluations begin. Preliminary yield trials begin. Cleanup and micropropagation are initiated for exceptional genotypes.
4 and/or 5	Two-four hill units are planted at Absaraka and 10 hills are planted at Wyndmere for seed maintenance. Decisions regarding increase are made at harvest and following quality evaluations during the winter. This is the third cycle of field selection. Selections are evaluated for specific gravity and internal defects. Chipping evaluations, late blight and CPB resistance screenings continue. Selected lines are increased for trial seed. Additional selections may be entered into micropropagation. Entry into state yield trials for up to three years may occur. Sensory evaluations are initiated. Decision is made following grading, or during the winter evaluations, determining which selections to continue with.
6	Second year of state trials. Promising selections continue to be increased. Cultural management and disease/pest (field and post-harvest reaction) evaluation trials begin. Promising selections continue to be increased. To growers for evaluation and increase.
7	Third year in state trials or exceptional selections to North Central Regional Potato Variety Trial. Cultural management and disease/pest evaluation trials continue. Processing selections are evaluated for flake production.
8-11	Enter in North Central Regional Trial for up to 3 years and USPB/Snack Food Association Trial if it is a chipper. Grower evaluation and increase continue. Cultural management and disease/pest reaction evaluations continue.
10-15+	Consider for release as a named cultivar.

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Table 2. Cultivar releases from the North Dakota State University Potato Breeding Program, as part of the North Dakota Agricultural Experiment Station, from its inception in 1930 through 2010.

Cultivar	Year	Type	Seed Acreage 2010[1]
Nordak	1957	Tablestock, round-oval white	
Norgleam	1957	Tablestock, round-oval white	
Norland	1957	Tablestock, round-oval red	3021.36[2]
Snowflake	1961	Tablestock, round-oval white	
Viking	1963	Tablestock, oblong-round red	125.40
Norgold Russet	1964	Tablestock, russet	
Norchip	1968	Chip processing, round white	
Norchief	1968	Tablestock, round-oblong red	
Bison	1974	Tablestock, round-oblong red	
Dakchip	1979	Chip processing, round-oval white	
Crystal	1980	Chip processing, oval	
Redsen	1983	Tablestock, round-oval red	
NorKing Russet	1985	Tablestock, russet	
Russet Norkotah	1987	Tablestock, russet	397.26[3]
Goldrush	1992	Tablestock, russet	149.40
Norqueen Russet	1992	Tablestock, russet	
NorDonna	1995	Tablestock, round-oval red	
NorValley	1997	Chip processing, round-oval white	92.40
Dakota Pearl	1999	Chip processing, round white	1,196.14
Dakota Rose	2000	Tablestock, round-oblong red	23.21
Dakota Jewel	2004	Tablestock, round-oblong red	36.00
Dakota Crisp	2005	Chip processing, round white	270.11
Dakota Diamond	2005	Chip processing, round white	3.50
Dakota Trailblazer	2009	Dual-purpose[4], russet	19.00

[1] North Dakota Certified Seed Potato Acreage Summary, acreage eligible.
[2] Includes all selections
[3] Standard Russet Norkotah, does not include lines, strains or selections from CO, TX, or NE
[4] Dual-purpose – suitable for French fry processing and tablestock. Evaluated (also listed in seed directory) as AOND95249-1Russ.

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Dakota Trailblazer

- A89163-3LS x A8914-4
- Medium-late maturity
- High yield potential
- Good storability and low sugar accumulation in storage.
- High specific gravity
- Resistance to *Vertillium* wilt, pink rot, sugar ends, and late blight (foliar) in field evaluations. Hollow heart and blackspot bruise are occasionally noted.
- Tolerant of metribuzin applications. Requires reduced applications of nitrogen.

ND8229-3

- Marcy x AH66-4
- Medium maturity
- Medium vine size
- High yield potential
- Good storability and excellent fry color from 45F storage
- High specific gravity
- Resistance to sugar ends
- Tolerant of metribuzin applications

ND8068-5Russ

- ND2667-9Russ x ND4233-1Russ
- Medium vine size
- Early vine maturity
- Medium to high yield potential
- Dual-purpose
- High specific gravity
- Good storability with low sugar accumulation

ND4659-5R

- NorDonna x ND2842-3R
- Suited for the fresh market
- Medium vine with red-purple flowers
- Medium maturity
- Medium yield potential
- Bright red, round, smooth tubers with white flesh and shallow eyes
- Medium specific gravity
- No outstanding disease or pest susceptibilities
- Stores well

ND8555-8R

- ND7188-4R x ND5256-7R
- Suited for the fresh market
- Medium maturity
- Medium-large vine size
- High yield potential
- Bright red, round, smooth tubers with white flesh and shallow eyes
- Very uniform tuber size profile
- Medium specific gravity
- Stores well

AND00272-1R

- MN17922 x A92653-6R
- Suited for the fresh market
- Medium vine with red-purple flowers
- Medium-late maturity
- Medium yield potential
- Bright red, round to oval, tubers with white flesh, shallow eyes and smooth tuber type.
- Low to medium specific gravity
- No outstanding disease or pest susceptibilities
- Stores well

ND6002-1R

- NorDonna x Bison
- Medium sized vine
- Medium-late vine maturity
- Medium yield potential
- Round, smooth, bright red tubers with smooth eyes and bright white flesh
- Low to medium specific gravity
- Early in evaluation process

ND7132-1R

- ND5002-3R x ND5438-1R
- Medium maturity
- Medium yield potential
- Bright red skinned, oval to oblong tubers with white flesh
- Early in evaluation process

ND8314-1R

- Dakota Jewel x ND5261-3R
- Medium vine size
- Medium maturity
- High yield potential
- Bright red skin, oval to oblong tubers with white flesh
- Early in evaluation process

ND7519-1

- ND3828-15 x W1353
- Medium sized vine
- Medium-late maturity
- High yield potential
- High specific gravity (+1.090 average in ND)
- Chips from 42F storage

ND8304-2

- ND860-2 x ND7083-1
- Medium early maturity
- Small to medium sized vine
- Medium yield potential
  - Nice tuber type, smaller size profile
- High specific gravity
- Chips from 42F storage
  - Excellent cold chipping selection

ND7799c-1

- Dakota Pearl x Dakota Diamond
- Medium vine size
- Medium-late maturity
- High yield potential
  - Nice tuber type and tuber size profile
- Medium to high specific gravity (1.086 average)
- Chips from 42F storage

ATND98459-1RY

- ATD252-5R x T4845
- Medium to large vine size
- Medium maturity
- High yield potential
- Round, smooth, red tubers with shallow eyes and yellow flesh
- Medium to high specific gravity

ND7834-2P

- NorDonna x ND5554-1R
- Medium vine size
- Medium maturity
- Medium to high yield potential
- Oval and blocky tubers, smooth, dark purple (blue) color, with very shallow eyes and marbled flesh
- Medium to high specific gravity

ND7818-1Y

- Morene x Marcy
- Medium vine size
- Medium maturity
- Medium to high yield potential
- Oval, smooth, yellow skinned tubers with yellow flesh
- Medium to high specific gravity
- Excellent cold chipping selection
- 'European' type