UW Potato Breeding Program Progress and Update

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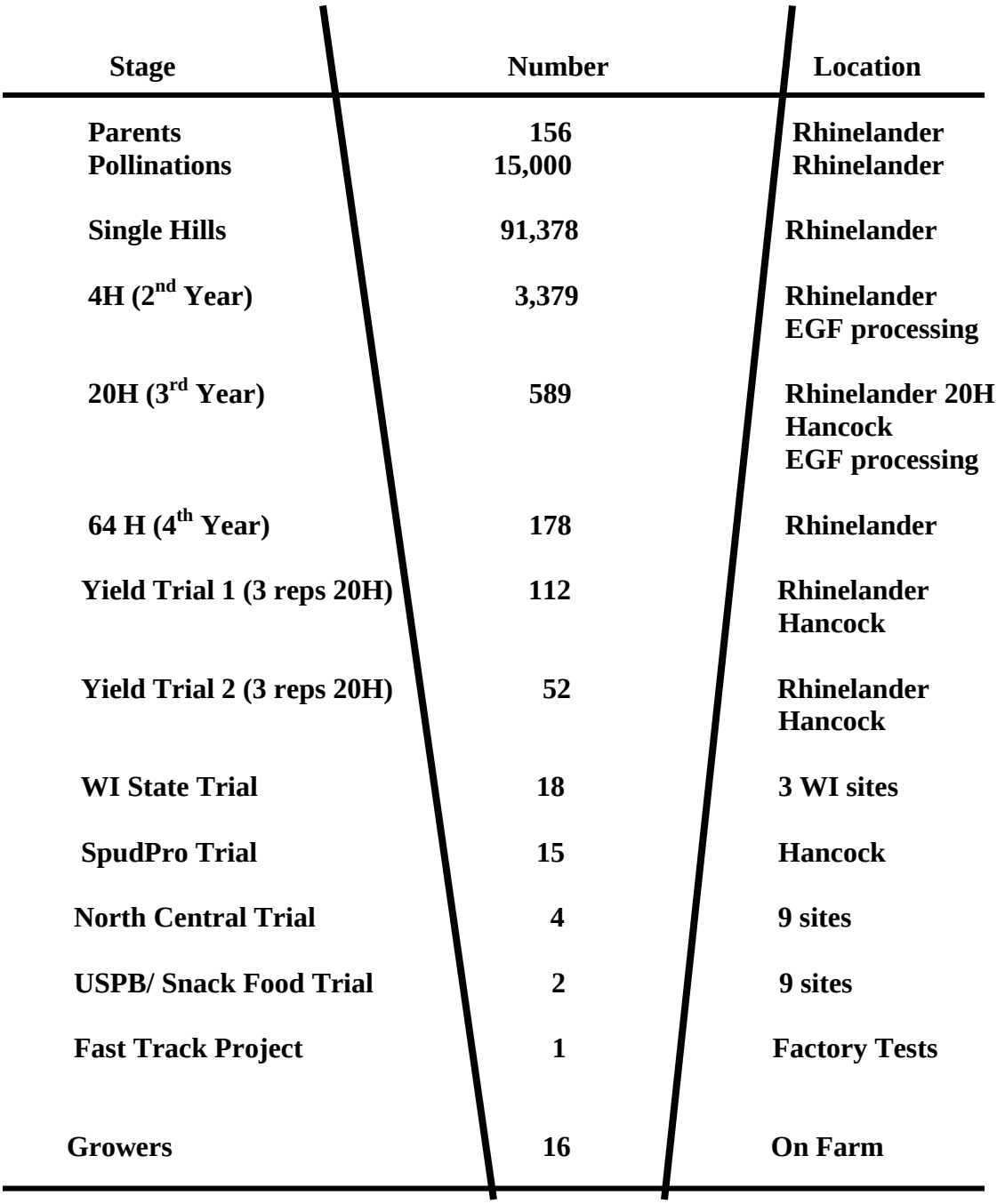
A. Introduction:

The goal of the UW Potato Breeding Program is to develop potato cultivars that are genetically superior for yield and grade as well as for fresh marketing and processing qualities. By selecting under local seed and commercial production practices we aim to release cultivars that are best suited for Wisconsin production environment and possess multiple disease and pest resistances.

Overall scope of the Program Effort:

Every year the potato breeding program initiates a new cycle of selection that include the selection of parents, crosses, maintenance and evaluation of clones at different stages of selection. In this effort, we collaborate with different programs and researchers at UW and throughout the US and Canada. Starting from **15,000 pollinations made** in a given year about 48,000 greenhouse tubers are produced at the end of the following year that will form single hill planting in the following year. With our own 48,000 tubers and similar number of tubers obtained from our collaborators we start with over 90,000 single hills every year (see Fig. 1-4). In the third year of selection we screen these down to less than 750 lines (689 in 2007). These are our early generation lines. With another year of evaluation at Hancock and Rhinelander we usually recover over 100 advance selections that are carried forward into replicated trials at both Rhinelander and Hancock. Following two years of replicated trials we usually recover less than 20 elite lines. These are then evaluated under SpudPro trials at Hancock and on farm evaluations by selected growers. In addition, these lines are also tested in other programs for broad adaptation in potato growing areas in the US and Canada. From further evaluation less than 5 of these lines are selected for entry into NC trials as well as given to the foundation seed farm for cleaning up the seed with intent to give the seed to the seed growers. **In any given year, we are managing 30 acres of research plots at Rhinelander and 5 acres at Hancock.**

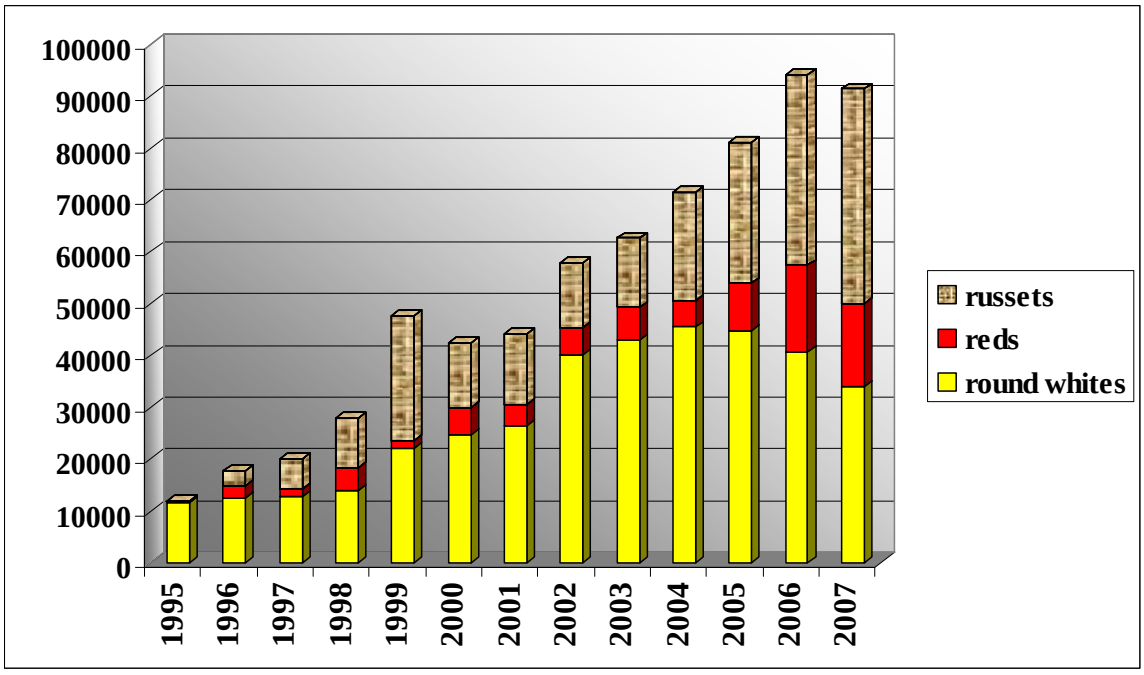
Fig. 1. Selection Scheme and Scope of the Breeding Program Effort (2007)



Changes in program emphasis (meeting the industry needs)

- Historically, the UW-Breeding Program was primarily geared to develop round white potatoes suited for the fresh and chip markets. Over the last 10 years the **program has changed, in response to the demand of WI growers, to incorporate a larger proportion of the russets and reds** to better meet the needs of the Wisconsin industry.
- In 2007, 45% of the single-hills planted were russets, 37% were round white and 18% were red and specialty potatoes. Our program has also increase the emphasis on specialty potatoes in response to consumer demands for novel varieties such as purple, red and yellow skin and flesh colors.
- Also note that the program over the last 10 years has **grown from about 10,000 single hills in 1995 to over 90,000 single hills in 2007**.

Fig. 2. Diversification of market types in Wisconsin breeding lines planted in Year 1 of selection from 1995 to 2007.



The following is a summary of our effort in 2007 referenced in Fig. 1 above.

B. Crossing Strategy and Early Generation Selection:

Crossing Strategy and Greenhouse Year 1 (GY-1): A major objective in the WI crossing strategy of 2007 continues to be the development of high yielding processing and fresh market varieties adapted to WI and other potato growing areas in the US. Pedigree analyses of the last 10 years have been used to help the selection of parents from our own program. This effort has allowed the focusing crossing strategies to parental

materials with higher probability to generate adapted varieties that carry the genes responsible for attributes required by growers and consumers. **In 2007 we tested 91,378 single hills** for variety development. These single hill tubers (about 55%) are derived from seeds generated from approximately 15,000 pollinations made in 2006 by our personnel, using 156 parents, and the remaining 45% of the single hills were received from collaborative effort with six breeding programs outside Wisconsin (Colorado, Idaho, Maine, New York- Cornell, North Dakota, and Alberta).

Parental populations: in 2007, we intentionally reduced the number of parents used in previous years to facilitate the production of higher number of progenies from targeted crosses. In previous years, >500 lines were used for crosses in previous years with relatively small number of individual clones generated by family. Due to the very low percentage of individuals selected in Year 1 of field evaluation (3%), small number of clones per crosses severely limits the number of good lines that can be selected within a cross in a given year. Crosses made in WI emphasized high yield, fresh market and processing potential as well as resistance to scab, late blight, early blight and early dying. Several out of state varieties of outstanding performance were also used in this crossing strategy.

i. **Greenhouse Year 2: Production of Seedling Tubers for 2007:** In 2007, four greenhouses were used for the production of approximately 43,000 greenhouse tubers that will be planted as single hills in 2008.
ii. **Field Year 1 (Single Hills) and Field Year 2 (4H):** In 2007, of the 91,378 single hills were planted; of these 49,883 (55%) corresponded to WI crosses. The remaining 41,495 single hills were planted with seedling tubers obtained through interchanges with the breeding programs from CO, ME, ID, ND, NY and Canada. For 2008, the targeted number of single hills (FY-1) is 75,000; from these, 43,000 from will come from our program and the remaining 32,000 will be obtained from CO, ME, ID, ND, NY and Canada (Fig. 2-4). Tuber exchange with out of state sources is important to strengthen selections for Colorado Potato Beatle, viruses (PVY, PVX and others), scab, late, blight, fresh market red and russets, processing ability in russets and round whites (chippers).The reduction in the number of single hills in 2007 relates to emphasis on only planting adequate sized tubers from out of state sources. In general about 3% of the clones planted in single hills are selected to be planted to be planted in the 2nd Year (4H). In 2007, 2738 lines (43% russet, 43% chipping and 14% red) were planted. Of these, 717 clones were field selected to be evaluated in FY-3. Early evaluation of processing traits (specific gravity and chipping) will occur on 650 of these in collaboration with the USDA East Grand Forks Potato Worksite.
iii. **Field Year 3 (20H):** In 2007, FY-3 was composed of 589 lines that were planted as unreplicated 8 hills plot at the Hancock, WI A.R.S. and 20 hills for evaluation and seed multiplication at the Rhinelander, WI A.R.S. The goal is to select 100-120 lines to be included in the replicated trials-1 of 2008. Line performance for early blight, early dying and tuber aspect were recorded. Evaluation of processing traits (specific gravity and chipping) in collaboration with the USDA East Grand Forks potato facility. Internal and external tuber characteristics are being evaluated in samples held at the Hancock Storage Research Facility.

iv. **Evaluation of Calcium rich populations:** A population of 534 clones from the crosses of Superior to Atlantic and Snowden was evaluated in a replicated trial at Hancock and as unreplicated maintenance plot at Rhinelander using 8 hills plots. Weights, tuber appearance, specific gravity and frying ability and tuber calcium content are being evaluated to help selection for internal and external tuber quality. Tuber appearance indicates a high probability of obtaining competitive lines from these lines. A subset of these lines will be included in the replicated trials of 2008.

Efforts on Early Stage Selection in 2007 (see Fig. 1).

i. A two year reduction within the breeding scheme used to identify Advanced Selections.
ii. Use of the Hancock Agricultural Research Station at earlier stages, targeting adaptation to environment of Central Wisconsin.
iii. Testing at earlier stages for field performance, processing quality (gravity and frying at 45ºF) in collaboration with the USDA facility in East Grand Forks).
iv. Selection at earlier stages for disease resistance (late blight, scab and early dying) through in-State evaluation and collaboration with out of state programs located in OR, MI and ON, and with Dr. Charlie Higgins (Heartland Farms).

The objectives of the crossing strategy and early generation selection are to facilitate a more efficient use of resources through evaluating a larger number of potential varieties under the environments and stresses of the potential areas of production. This will result in a larger number of selectable lines. This approach will increase the opportunities of finding a winner earlier in the selection process. The genetic make-up of a potato line is not expected to change by year of selection; the earlier their value is known the better for a breeding program.

C. Use of Enhanced Germplasm in the Selection of Improved Varieties:

A small, but significant component of **marker assisted selection in early generations for late blight resistance is carried out in collaboration with Dr. Jiming Jiang's lab at UW-Madison.** Several potato programs, especially the UW/USDA Germplasm Enhancement Program led by Dr. Shelley Jansky and the US Potato GeneBank (Bamberg) have identified populations and individual lines that have been used as parents to confer characteristics to improve quality and performance of future varieties. Dr Jansky's program also collaborates in the evaluation of advanced lines for resistance to Verticillium early dying. Highlights of materials that use enhanced germplasm from these sources which are being evaluated in the breeding program are:

i. **Marker Assisted Selection for Resistance to Late Blight:** In 2007, 276 clones that were previously confirmed in Dr. Jiming Jiang's laboratory to carry RB late blight resistance gene were planted in the field and selected for adaptation, maturity and tuber traits. A small percentage of these lines are targeted for additional evaluations for use as parents and potential variety development.

ii. **Selection of Progenies for Late Blight Resistance**: In 2007, one hundred and sixty seven clones of crosses of the MX and LBR were field evaluated for adaptation and screened by detached leaf assays in collaboration with Dr. **Terese Barta (UWSP)** under controlled conditions **Oregon (OR) Field Foliar and Tuber Evaluation of Early Generation Lines*:*** 160 early stage lines of different late blight sources of resistance were submitted for unreplicated evaluations (4 hills) and 40 advanced lines in collaboration with the OR breeding program.

iii. **Selection for Soft Rot resistance:** A group of progenies from lines C297, C31-5-115, C450, and C115 with resistance to tuber and vine rot caused by *Erwinia* spp. were selected from different stages of the breeding program in 2006. Resistance to vine and soft rots will enhance the field and storage performance of future WI varieties. These lines and others derived from different sources of resistance for vine rot and soft rot.

iv. **Selection for Early Dying Resistance:** 2007 field evaluations at Hancock and Rhinelander represented good opportunities to select for early dying resistance at all of the stages of the breeding program due to favorable conditions for the development of this disease

v. **Use of Cold Tolerant Germplasm:** A set of 48 lines selected for vine and tuber frost tolerance have been developed from crosses and backcrosses made by the US Potato Gene Bank between several species were evaluated in replicated trials at Hancock and maintained in unreplicated plots in Rhinelander. Lines derived from these crosses can withstand temperatures up to -5°C (23°F after acclimation). Several of these lines can be used to develop frost tolerant varieties**.**

vi. **Use of High Calcium Germplasm:** The UW breeding program collaborates with the US Potato Gene Bank in the evaluation of calcium content of progenies derived from the crosses of *Solanum tuberosum* and *S. gourlayi* and *S. microdontum.* Some lines can accumulate five times the amount of Ca than regular potato varieties. High calcium content in tubers has been associated with reduction in blackspot bruise in tubers and general tuber health essential for post-harvest handling operations. In 2007, efforts were made to move genes from high calcium parents to more adapted materials by traditional sexual multiplication.

The use of enhanced germplasm is an important part of our breeding strategy. Our collaboration with the USDA Germplasm Enhancement Program (Dr. Shelley Jansky-UW Horticulture) and US Potato Gene Bank (Dr. John Bamberg, UW Horticulture) is critical to achieve this goal.

D. Advanced Selection and Screening for Disease Resistance:

Every year advanced selections are screened in selection, agronomic and disease trials to evaluate their relative performance. Lines are tested against the best available lines from the WI, out of state, and established varieties. Also a number of tests are performed out of state through various collaborators. In 2007, potato lines were evaluated as follows:

i. **Replicated Trials (RT):** selection experiments under the supervision of the plant breeding staff and located in the Rhinelander and Hancock A.R.S. locations. The replicated trial 1 (RT_1) was composed of 112 lines, including 54 chipping, 34 russets and 24 red and yellow flesh. The RT_2 was composed by 52 lines, including the best performing 31, 15 and 6 chipping, russets and reds lines selected from the 2006 RT_1 trial. Evaluations emphasized vigor, maturity, early blight, yield, grade, specific gravity and internal defects. Field and grade results are being analyzed, a set of lines are showing good performance. Frying evaluations will be performed directly from 42 and 47°F storages at 3, 5 and 9 months after harvest. Selections from RT_1 and RT_2 will yield the lines to be evaluated in 2008 (first year Breeder's Seed Multiplication for future on-farm grower exposure, as well as other WI and out of state trials).

ii. **Wisconsin Potato Variety and Advanced Selection Evaluation and SpudPro Trials:** In 2007, 18 lines were submitted to Chuck Kostichka, responsible for this project at the Hancock, WI A.R.S. Data will be available from Chuck's reports to the 2008 WPVGA Grower and Education Meeting. Similarly, 15 lines were evaluated by Kostichka in collaboration with breeding program personnel in the SpudPro variety trial. This trial is geared to provide data to the program and the SpudPro committee to make decisions on variety releases.

iii. **North Central Regional Trial (NCRT):** Two chipping lines (W2133-1, and W2324-1), and two russets (W1879-1rus and W2683-2rus) were included in the NCRT of 2007 along with advanced selections from MI, MN, ND and Canada. This trial is an opportunity to evaluate in five states the WI materials in relation to potential releases from breeding programs of those states. Apart from the WI location, the NCRT was conducted in the MI, MN, ND, NE, OH and Canada (AB, MB and ON). In ND, varieties are also tested for sugar end allocation and metribuzin resistance. This is a collaborative study under the USDA/CSREES Quad State initiative. Results are usually available between December and March each year.

iv. **Selection for Resistance to Scab:** Experiments including 160 advanced lines under heavy disease pressure **at Heartland Farms in collaboration with Dr. Charlie Higgins**, **Alliston, ON in collaboration with Dr. Eugenia Banks**, and Rhinelander WI. Lines of advanced generations represented in RT_1 and RT_2 were evaluated in these trials. Results from these experiments will be key to advancing lines in the breeding program.

v. **OR (Oregon) Late Blight Evaluation:** 40 advanced lines were submitted for evaluation of foliar and tuber late blight in OR. This evaluation is based on in-field inoculation and is collaboration from the OR breeding program. Results are usually available between February and March.

vi. **Pink Rot and Leak:** The lines included in the North Central trial were also submitted for evaluation via inoculation with the causal agents of pink rot (*Phytophthora erythroseptica*) and leak (*Pythium ultimum)*. Pink rot and leak are important causes of tuber decay at harvest and storage. This study was collaboration from ND under the USDA/CREES Quad State initiative. Results are usually available between December and March each year.

vii. **Bacterial Ring Rot (BRR) Screening:** Because of the need to interchange clean seeds with cooperators, the breeding program contracted the evaluation of 128 advanced and 19 elite materials for the presence of *Clavibacter michiganense* subsp. *sepedonicus*, the causal organism of this disease. The results were that the tested lines were free of that pathogen. ***This is a required yearly screening for all materials moving from the US to Canada.***

viii. **Bacterial Ring Rot Expression:** The lines included in the North Central trial were also submitted for evaluation of BRR expression. BRR expression is a critically important criterion for seed certification. Susceptible lines should express symptoms or they will jeopardize the efforts of certification agencies to keep BRR from being transmitted via certified seed. This study was collaboration from ND under the USDA/CSREES Quad State initiative. Results are usually available between December and March each year.

ix. **Virus Screening:** In 2006, advanced and elite lines planted and multiplied in years FY4 and FY5, as well as other collection of lines and germplasm were screened in Rhinelander using ELISA. This screening is conducted previous to planting, through the extraction of sprout sap, to minimize the probability of spreading PVY viruses with the seed. Tests were performed at the Rhinelander, WI A.R.S. Lines that were ELISA positive for PVY were not planted. In addition to a 2006 summer field inspection, provided by the WI Seed Potato Certification Program, seed lots were screened for tuber-borne virus expression in the FL Winter Test (2006/07). Lines from seed lots from the Rhinelander A.R.S. farm will be evaluated in the Seed Certification Winter Test of 2007/08 in FL. The FL tests are collaboration of the UW Potato Seed Certification program.

x. **Virus Expression Test:** A virus expression study including 38 advanced and elite lines was conducted at Hancock by Amy Charkowski and Chuck Kostchiska. Data from this trial will be important for decisions on future releases. Lack of virus expression is a significant problem for seed certification of lines.

E. Evaluation of Elite Lines:

Elite lines were submitted for evaluations by several groups to determine their future potential. These included the following:

i. **Agronomic and Storage Evaluations in WI (Bussan):** In 2007, four W lines (2683-2rus, 2133-1, 2310-3 and 2324-1) were submitted to A.J. Bussan (UW-Madison) to be included in agronomic experiments (density, nitrogen, sugar end, storage and sugar management) to fine tune field and storage management recommendations for these lines in WI. This is a critical stage of evaluation for lines which have the most collective value as potential varieties.

ii. **SPUDPRO Variety Trial (Kostichka):** Fifteen lines were submitted to Chuck Kostichka for the SPUDPRO trial. This experiment included four additional checks and was planted at Hancock, WI ARS. The design of this experiment has been evolving in recent years in order to produce more reliable information used

by the SPUDPRO committed to make decisions about promotion. The experiment included three replications and was harvested at 100 and 130 days after planting. Field evaluation emphasized grade, specific gravity and internal defects. Post-harvest data taken for pressure bruise. Frying ability out of 42°F, 45°F and 48°F will be evaluated at monthly interval from each temperature. Field and grade data is being analyzed and is reported in the Breeding Update section of these proceedings.

iii. **S. Jansky's Verticillium Trial:** Six varieties were submitted to S. Jansky (UW-Madison for evaluation in the National Verticillium trial she conducted.

iv. **Snack Food Association (SFA) Trial:** W2133-1 and W2324-1 were submitted to be trialed in 9 locations in the states of ID, FL, ME, MI, MN, NC, PA, TX and WI. This trial was expanded in 2006 to include the TX and WI locations. Results from the SFA trial will be presented in the "USPB Chip Seminar" in 2007. This is a good opportunity to showcase improvements in variety development to growers and industry.

v. **Evaluation of Lines by McCain Foods Inc**: Six lines are being evaluated by McCain Foods Inc. in the US while three additional UW lines are evaluated by McCain in Canada. In addition, McCain is evaluating the potential of Freedom Russet for the French fry market at the Factory Test level.

vi. **Evaluation of Lines by Frito Lay:** Nine lines were submitted to Frito Lay for WI evaluation in 2007.

vii. **Yield Trials Out of WI:** In 2007, thirty researchers from five US states and five researchers from three Canadian provinces requested and received up to 15 advanced and elite lines from the WI breeding program. These lines were evaluated for field and storage performance to observe the adaptation to the US North East and Canadian provinces.

viii. **2007 On-Farm Evaluation by WI Growers:** In addition to the formal research trial collaborations mentioned above, thirteen commercial growers tested 16 lines and 3 seed growers tested 3 lines (Table 1). These plantings range from 25lb samples to 30cwt depending on the stage of the breeding line and the grower. Some growers received multiple lines totaling 36 variety x location tests. The total seed distributed to growers was 269cwt (Table 1). Exposure of advanced and elite lines to growers has been a very important component of the WI variety development program in the last five years. In particular this has been crucial to the SPUDPRO nomination process where growers have the final say in the advancement and industry investment of elite breeding lines.

Table 1. 2007 Grower Summary for On-Farm Testing

	Number of Growers	Number of Lines tested
Commercial	**13**	**18**
Seed	**3**	**6**

Total seed distributed = 26,890 lbs.

E. Multiplication and Certification of Advanced and Elite Lines

i. **Advanced Lines in FY-4:** Under the current breeding scheme. Selected lines in FY-3 are planted as 64 hills plots at Rhinelander to secure the seed base necessary for in-state and out of state evaluations as well as the first year of seed multiplication. Seed lots of the 64 Hills and field lots from FY-2 were inspected for virus symptoms by the breeding staff. Seed lots from the 64 hills group were sampled, and ELISA will be performed to screen for the presence of PVY and PVS.

ii. **Advanced and Elite Lines in FY-5 and Beyond:** A selected group of 10 to 15 lines are selected according to the results of the replicated trials and are multiplied at the Rhinelander Breeding Farm in a four year scheme (CP3, BK1, BK2 and BK3). Each year lines are dropped from the system or advanced to the next category according to field and processing performance in WI and out of state tests the performance. These seed lots are evaluated and rouged for virus expression in the summer by breeding program staff. WI Seed Certification Program inspectors also conducted two summer field inspections and provide for the Winter Test in FL. As a result, 22 seed lots grown at the Rhinelander Agricultural Station were certified as virus free and correspondingly, seed necessary for expanded, ongoing testing was readily available (Table 2). These included seed for WI trials, out of state trials, on-farm evaluation and continued multiplication of varieties that have been accepted by the SpudPro initiative.

Table 2. Experimental lines planted at the Rhinelander Agricultural Research Station in 2006 that passed the Certification summer of 2006 and Winter tests (2007)

W2133-1	**W2683-2rus**	**W3666-2rus**	**W3957-6R**
W2301-3P	**W2982-1**	**W3730-4rus**	**W5767-1R**
W2309-7	**W3140-3rus**	**W3740-4rus**	**W6153-21Yrus**
W2310-3	**W3160-5LBrus**	**W3743-5rus**	**W6153-6Yrus**
W2324-1	**W3162-3LBrus**	**W3846-4Y**	
W2438-3Y	**W3186-2**	**W3952-3rus**	

G. Collaboration at University of Wisconsin

We actively **collaborate with eleven UW programs**. This collaboration entails exchange of germplasm and screening methodologies developed by the Germplasm Enhancement Program and Potato Gene Bank, screening of advanced lines for Verticillium early dying by the Potato Germplasm Enhancement Program, evaluation of advanced breeding lines in the State and SpudPro trials, agronomic evaluation and storage optimization of SpudPro lines. **An added new activity this year included the evaluation of 38 advanced lines by Dr. Amy Charkowski for PVY expression.**

I. Cooperative effort with other breeding programs:

We cooperate very closely with the other three north central breeding programs in ND, MN and MI. In addition, we have active collaborative effort with **28 other researchers**

in the US and Canada. This cooperation includes **exchange of germplasm for parental use**, as well as **screening and evaluation of advanced materials** among various programs (e.g. NC trials). Over the last few years, as the program has grown, the cooperative efforts have also grown with the program. In 2007, about 44% of the single hill tubers tested in our program came from the seeds obtained form other breeding programs (see Fig. 4). We reciprocated this by sending our germplasm to other breeding programs**. In 2007 we provided over 28,600 genotypes to three other three programs of these breeding programs. In addition, WI varieties evaluated in the North Central variety Trial are tested for sugar profile, bacterial ring rot expression, pink rot and leak.**

Fig. 3. Number of greenhouse tubers received from collaborators in the period from 1995 to 2007.

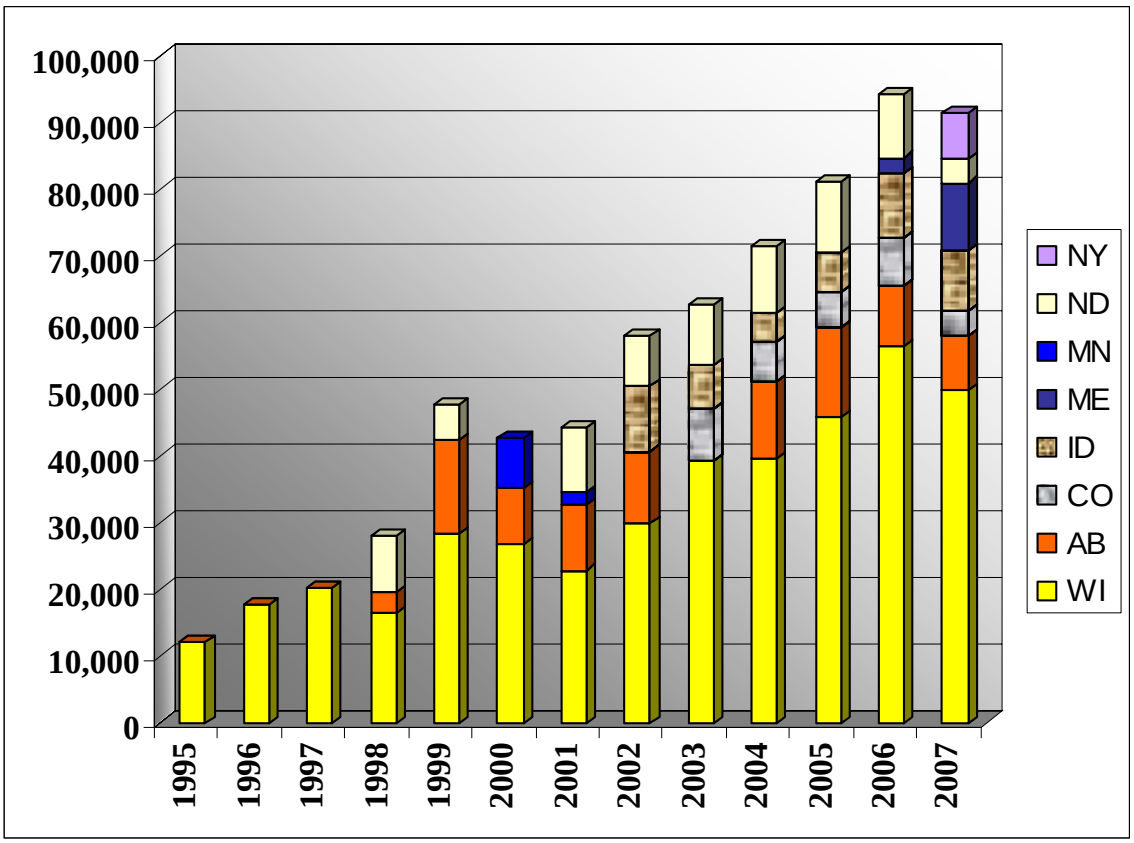
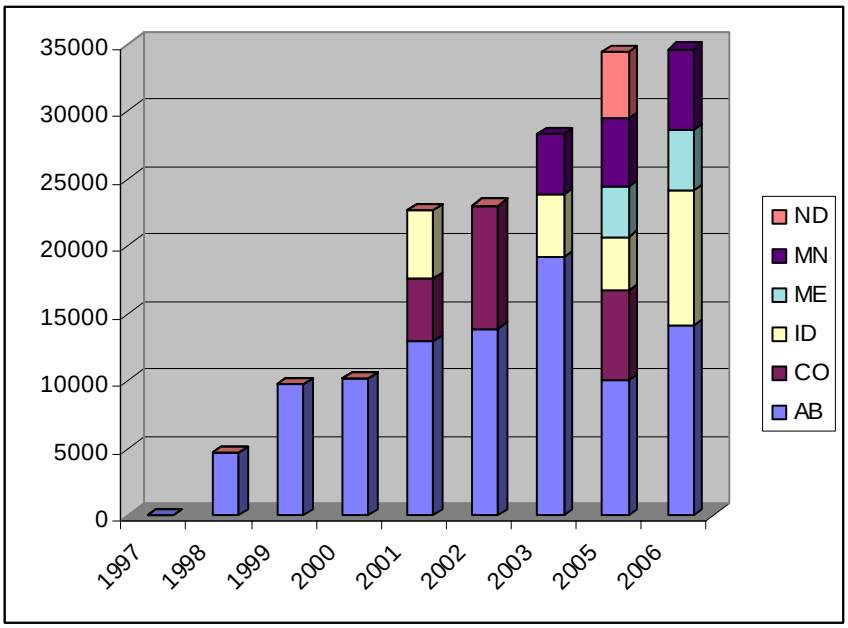


Fig. 4. Number of greenhouse tubers sent to collaborators in the period from 1995 to 2006.



Plant Variety Protection

In 2007, we obtained PVP for Millennium Russet and White Pearl. For this we worked both with the US PVP office in Washington and the Wisconsin Alumni Research Foundation (WARF).

K. Promotion of recent released varieties and advanced breeding lines

Working with the growers and industry committee (SpudPro) we have **recently released five cultivars**. Following activities were pursued in 2007 to promote and protect our new releases:

1. We worked closely with 13 commercial and 3 seed growers to provide on-farm experiences for the potential adoption of recent releases and elite lines. **Total breeder seed produced and distributed to the commercial growers in 2007 was 26,890 lbs**, while 6700 lbs of seeds were distributed to researchers in the US for a total of 33,585 lbs distributed for research and on-farm experiences.
2. In **2007, the recently WI released varieties MegaChip, Freedom Russet, White Pearl, Villetta Rose, Millennium Russet and White Pearl accounted for 449**

certified acres (Table 3). This represents a 46% increase in the amount of certified acreage of WI varieties with respect to 2006. This increase in the area of certified grown in WI is likely due to the consolidation of the SpudPro initiative as a mechanism for the promotion of varieties in WI.

3. In 2007, the **SpudPro committee promoted the chipping line W2310-3 and the russet line W2683-2rus** to be cleaned and multiplied by the Wisconsin Seed Certification Program with the objective of producing 16,000 of seed for further semi-commercial on-farm tests.

4. In 2007, the **chipping line W2133-1 was selected by the Fast Track initiative to be increased in two states**. The primary benefit of this project is a broad exposure of W2133-1 and chipstock testing and evaluation on a commercial and factory scale. The project represents an investment of approximately $54,000 on this variety during the next three years. The SpudPro committee ratified the inclusion of this variety in the Fast Track initiative.

5. We obtained a second year support for a **DATCP grant to promote and develop new specialty potatoes as options for the fresh market**. Through this grant we worked with growers and processors in Wisconsin to **promoting varieties for the fresh market by name**.

6. In cooperation with WPVGA we highlighted our breeding program and recent releases **National Potato Seed Seminar** in Idaho, and at the Central WI field day. In both of these places we displayed our varieties to groups of growers and researcher and extension personnel.

7. Presentations at Potato Growers meetings in Stevens Point.

8. Formal **scientific publication about MegaChip** (W1201) in the July-August issue of the American Journal of Potato Research volume 84 pages 343-350.

Table 3. Certified Seed Acreage of Recent UW- Released Varieties 2006-2007

Variety	2006 Certified Seed Acres	2007 Certified Seed Acres
MegaChip	**133**	**280**
Freedom Russet	**59**	**107**
White Pearl	**24**	**25**
Millennium Russet	**23**	**13**
Villetta Rose	**67**	**18**
W2310-3		**2**
Other WI lines	**Less than 2**	**Less than 2**
Total	**306**	**447**

L. New directions and new approaches taken in 2006: Improving selection to ensure success

In order to assure commercial success of our varieties we implemented a new approach in our breeding program**. In addition to Rhinelander, we have consolidated our early generation selection and evaluation at Hancock.** Since Hancock represents a realistic soil and environmental condition for commercial potato production, we want to be able to evaluate the performance of our lines at early generation in this environment. To achieve this, in 2006:

1. We evaluated 589 early generation lines at Hancock for tuber yield, grade and quality.
2. We are testing the fry quality and specific gravity of these early generation lines in collaboration with the USDA facility in East Ground Forks.
3. At Hancock, we evaluated our early generation lines for disease resistance (late blight, early blight, scab and early dying), maturity type and will evaluate the selected portion for storage and internal qualities. Late blight evaluations have been accomplished in collaboration with the OR breeding program.
4. We have doubled the volume of advanced lines tested in replicated trials both at Hancock and Rhinelander, and special emphasis have been given to select for resistance to scab and tuber internal quality. Charlie Higgins (Heartland Farms) collaborated with the evaluation of these lines (160) in a field with intense scab pressure at Heartland Farms. Additional scab trials of these 160 lines were carried out at Hancock and Alliston, ON. At all three evaluation sites the scab development was from severe to very severe.

New initiatives in 2007:

I took the responsibility to manage the Potato Breeding Program because I believe that the Wisconsin Breeding Program can **lead the nation in the areas of breeding for tuber quality and for resistance to environmental stresses**. Following is a brief description of two new initiatives in our breeding program:

1. Breeding for improved tuber internal and storage quality: Many new releases fail in the commercial setting because of the issues related to tuber bruise incidence and/or tuber internal quality (hollow heart, internal brown spot, brown center). Our research over the past 20 years has demonstrated that tuber quality can be improved by increasing tuber calcium concentration. Several years ago we initiated a collaborative study with John Bamberg to determine the possibility of improving tuber calcium via genetic approaches. Screening of the potato germplasm shown below verified our hypothesis that genetic variation exist for tuber calcium accumulation ability. **Two genetic components were identified for tuber calcium accumulation ability:**

a. Ability to accumulate calcium in the tuber under normal soil conditions

b. Ability to utilize in-season supplied calcium

From several years of intermating we have developed breeding lines with a background containing *S. microdontum* (mcd) and cultivated type. We are using these lines to improve tuber calcium in our breeding program.
In a parallel strategy we are using the genetic variation among cultivars for tuber calcium. **We are using this strategy to improve tuber quality of a major chipping cultivar, Atlantic.**

Cultivar Facts:
Atlantic – Highly desired commercial variety because of yield and chip quality
High incidence of tuber internal defects and bruising
Low tuber calcium (100-250 ppm)
Superior – Poor yield and specific gravity
Low incidence of tuber internal defects and bruising
High tuber calcium (250-300 ppm)
We have created reciprocal hybrids of Atlantic and Superior with a goal of developing a chipping cultivar with low incidence of internal defect and bruising. We have now screened a progeny of 600 and identified elite material that combines high specific gravity, yield and tuber calcium.

2. Breeding for improved cold tolerance: The cultivated potato species *S. tuberosum* is very sensitive to frost. However, many wild potato species, such as *S. commersonii*, are frost hardy and able to cold acclimate.

About 15 years ago we initiated a systematic collaborative study with John Bamberg aimed at understanding the genetics of frost hardiness of potato with a goal of transferring frost hardiness from the wild *S. commersonii* to cultivated potatoes. **With two successful USDA NRI grants we have made substantial progress.** Initial studies utilized inter-specific crosses between two diploid potato species exhibiting the extremes in frost hardiness traits. Precise evaluation of F1 and the segregating backcross populations demonstrated that frost hardiness consists of several components which are inherited independently. These studies demonstrated that frost hardiness of cultivated potatoes could be improved by precisely selecting for all independent components of frost hardiness. **Advanced breeding lines, with substantial improvement in frost hardiness and agronomic traits with tuber yield comparable or better than the cultivated parent were identified six years ago.**

With further inter-mating with cultivars we have now developed and selected elite lines. These lines have doubled the frost hardiness of our present cultivars. These elite lines also have a yield comparable to or better than present cultivars. We are now utilizing these materials in our breeding program.

In 2007, our elite cold hardy lines were evaluated at Hancock. We also performed laboratory tests to determine precise freeze tolerance of these lines. The data are summarized in Fig. 5.

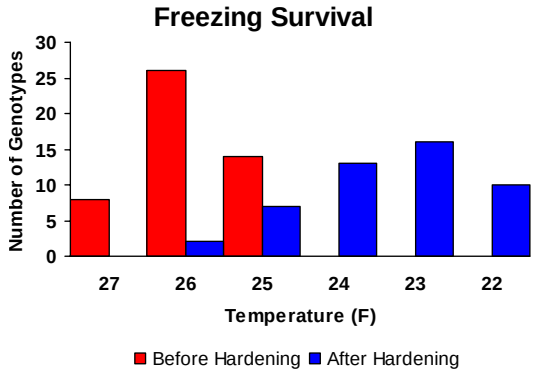


Figure 5. Frequency distribution of cold hardy lines, evaluated for freezing tolerance, before and after cold acclimation The freezing survival of standard cultivars is 28 °F. Some of our lines are hardy down to 22°F.

We have also initiated collaborative studies with the International Potato Center in Peru (CIP). Two types of studies have been jointly conducted:
1. Evaluation of our cold hardy breeding material in the highlands where cultivated potatoes cannot be grown (over 4000m in elevation).
2. Improving yield and quality of native potatoes by calcium nutrition.

Figure 6: Evaluation of native potatoes for their response to calcium application in the Peruvian highlands (collaborative studies with J. Bamberg, A. Del Rio and CIP).