

MPIC-03-10

**Year 2010 MSU POTATO RESEARCH PROPOSAL**  
**TO THE**  
**MICHIGAN POTATO INDUSTRY COMMISSION**

**TITLE:** Enhancing Potato Quality through Genetic Improvement and  
Variety Development

**INVESTIGATOR:** Dr. D.S. Douches

**COOPERATORS:** J. Coombs, W. Kirk, J. Hao, Z. Szendri, G. Bird, and C. Long

#### **JUSTIFICATION:**

The cultivated potato, *Solanum tuberosum* subsp. *tuberosum* L. ( $2n=4x=48$ ) is the most important vegetable crop and the fourth most important staple food crop in the world. A potato crop produces, on average, more food energy and protein than cereals, and the lysine content of potato complements cereal based diets that are deficient in this amino acid. Potato is highly productive on a per unit area basis and, because of its adaptability, can be grown commercially in any of the 50 states. The potato an important food for the fresh market and it also is the raw material for the french fry, chipping, and starch processing industries. Today, the Michigan potato industry (over \$120 million farmgate value) is dominated by the chip-processing sector that accounts for about 80% of the approximately 45,000 acres in production. The Michigan potato industry ranks as the largest northern supplier of potatoes to the chipping industry. Michigan is one of the few major potato-producing states that are strategically located to ship potatoes to the East Coast market for potato chip processing. The ability to store and supply chip potatoes into June offers expanded market opportunities for the industry. The increasing transportation costs are also offering opportunities for the fresh market. The tablestock market (especially russet types) is expanding with the changes in transportation costs.

New varieties are central to the health and growth of the Michigan potato industry. As a foundation for our breeding program, we are focusing on market limiting traits. In the processing sector, low sugar, high specific gravity, storability, mechanical bruise resistance and tuber shape are market limiting traits. These traits set a minimum standard from which advanced germplasm should be evaluated. Upon this foundation we must add traits that will provide host plant resistance and plant physiological efficiencies that improve environmental quality and provide enhanced consumer nutrition. These key resistance traits are for scab, late blight, PVY, potato early die and Colorado potato beetle.

#### **SPECIFIC OBJECTIVES:**

1. Utilize conventional breeding techniques to generate seedlings for varietal selection and development and also to introgress exotic *Solanum* germplasm for the purposes of variety development.
2. Integrate transformation techniques into the breeding program to introduce genes for insect (*Bt-cry3A*), late blight resistance (RB and MCR-RB), water stress (CBF1) and PVY resistance.
3. Conduct screening procedures to evaluate early generation breeding material and advanced selections for chip-processing, resistance to Colorado potato beetle and diseases such as late blight (foliage and tuber), scab and potato early die.
4. Conduct replicated trials that are designed to evaluate the marketable maturity and adaptability of advanced selections and new releases (from Michigan and other states) with emphasis upon yield, chip-processing, general appearance, dry matter, and blackspot bruise resistance, external and internal defects that affect specific markets. Utilize the Demonstration Storage for season-long chip evaluation of advanced selections.
5. Generate a) virus-free seed for the testing of advanced selections that will be evaluated in production management studies and grower industry trials, and b) virus-free tissue culture plantlets of the superior advanced selections from the MSU breeding program for the industry.
6. Continue to name, commercially release, and intellectually protect new potato varieties that are of value to the potato industry (based on breeder advisory group).

## **PROCEDURE:**

### **Breeding, Selection and Variety Evaluation:**

The MSU Breeding program continues to test MSU-bred lines in replicated trials (over 160 lines) and on grower farms (15 lines). We also enter 3-4 lines in the North Central regional trials, 2-3 lines in the SFA trials and send many of the advanced breeding lines to Ohio, Pennsylvania, Florida, California, North Dakota, Nebraska, Minnesota, North Carolina, Maine, Washington, Wisconsin, Ontario and Quebec Canada and various international sites for testing. Through a cooperative effort of MPIC, commercial growers, seed growers, Chris Long, the MSU breeding program and the processors, we are working together to help move the best lines towards larger scale commercial testing and have chip-processing lines evaluated in the Commercial Demonstration Storage facility (500 cwt bins). At this time, we have many advanced selections that have chipping qualities along with scab or late blight resistance, bruise resistance, etc. with commercial potential. Five of these are in commercial seed production. At least 2 can store at temperatures below 50F and maintain low sugars until June.

In 2010 the MSU breeding program will cross elite germplasm to generate and field evaluate 50,000 seedlings on a single-hill basis for adaptation to Michigan. In the subsequent years these selections are then advanced to 8-hill, 20-hill, 30-hill, and 50-hill plots, with increasing selection pressure for agronomic, quality and disease and/or insect resistance parameters. We now have in place field sites for early generation selection for late blight, scab and Colorado potato beetle resistant lines. Early generation evaluation of these key traits increases our effectiveness in identifying commercially valuable advanced selections. From this 4-year early generation evaluation and selection phase of the breeding program we generate over 100 MSU-bred advanced selections that are then to be tested and evaluated under more intensive replicated trials at the Montcalm Research Farm. We are also producing the FG1 and FG2 level seed of the most promising selections from the MSU breeding program for in-state grower-cooperator trials, out-of-state trials, North Central Regional trials, national USPB/SFA trials and MSU research farm trials.

Elite clones will be tested for at the Montcalm Research Farm for agronomic performance, marketable maturity, chip processing at harvest and in storage, resistance to pitted scab, potato early die and late blight. We place these advanced selections into tissue culture and initiate virus eradication procedures so that virus-free tissue culture plantlets or tuber sources can be made available to the industry. We are moving towards using a commercial NFT mini-tuber production system to produce mini-tubers of our advanced selections

Currently, the breeding program has in tissue culture about 400 clones in the MSU bank and 60 new candidates that are in process for transfer to tissue culture. We want to continue to work closely with the commercial growers and seed industry to test and provide seed for more intensive evaluation. Through this linkage we hope to identify the breeding selections that have merit to achieve varietal status in Michigan.

**Chip-processing:** Chip-processing is the key market trait. *(The Commercial Demonstration Storage facility enhances our ability to characterize advanced breeding lines from our breeding program.)* We screen advanced breeding lines from MRF, the Commercial Demonstration Storage, and on-farm trials for chip-processing out-of-the-field, and 50°F and 45°F storage (about 6-800 samples during the fall and storage season). We also screen early generation breeding material from the single, 8-, 20-, 30-, and 50-hill stages for chip processing out-of-the-field, and 50°F and 45°F storage. About 4,000 samples are processed and this data is computerized and used in the selection and decision making process in the breeding program in the following evaluation phase.

**Potato Scab:** We continue to screen advanced material in the scab nursery and have identified numerous advanced breeding lines with scab resistance. These lines have the potential to advance through the evaluation stages towards varietal naming and/or become parent sources for the crossing block. The scab nursery at MSU is large enough that we have additional space that allows us to screen early generation material from the breeding program. This earlier screening should help us identify and select more scab resistant advanced selections. Scab resistant chip-processing lines are being evaluated in the demo storage trials this storage season. We are also conducting studies to improve the effectiveness to characterize scab resistance. We are also considering additional sites that we identified in 2009 as having high infection levels.

**Foliar Late Blight Resistance:** The trials at the Muck Soils Research Farm have helped us in the evaluation of late blight resistance for breeding purposes (over 400 lines in 2008). 2009 was a loss due to flooding at the Muck Soils Research Farm. Initially we have had a focused breeding effort to combine late blight resistance, chip processing/tablestock and early maturity. We are now pyramiding late blight resistance genes with scab resistance. In the summer of 2010 we will continue to conduct further field trials to evaluate late blight resistance among various lines and germplasm sources. Our greatest priority in crossing is to combine late blight resistance with chip-processing quality and scab resistance. We have at least 20 potential advanced lines of this nature.

**Tuber Storage diseases:** In collaboration with Dr. Kirk's program, post-harvest evaluation of resistance to disease will be for blight tuber rot. The tubers will be inoculated by the application of a block of mycelium and spores onto a small wound on the tuber surface followed by incubation at high relative humidity.

**Marker-based selection for traits:** We have begun to use DNA markers that are linked to traits of interest. We can use the DNA markers for identifying PVY, Verticillium wilt and golden nematode resistance along with transgene markers for late blight and insect resistance. We are developing markers to screen for chip quality at the moment. This area of research will be a focus of our 4-year SolCAP project.

**Use of transgenic potatoes in the breeding program:**

Genetic engineering offers the opportunity to introduce new genes into our cultivated germplasm that otherwise would not be exploited. The production of transgenic potato cultivars carrying the Bt-based insect resistance, RB gene for late blight resistance, and the CBF1 gene for drought resistance represents a valuable source of breeding germplasm. As a result of a USAID-funded project and USDA/ARS funding, the breeding program is integrating genetic engineering and conventional breeding.

We have Colorado potato beetle resistance via the *Bt-cry3A* gene (Lemhi Russet, Yukon Gold, Onaway, MSE018-1, Jacqueline Lee, NY123 and Norwis) and potato tuber moth resistance via the *Bt-cryIIa1* gene (Spunta and Ranger Russet). We have transformed the RB (late blight resistance) into MSE149-5Y, MSG227-2 and Spunta and now we are selecting progeny from crosses that contain the RB gene is segregating along with other late blight resistance genes (a strategy to combine multiple resistance genes). MSE149-5Y was transformed to test the *CBF1* gene for water (drought) stress response. We now have a candidate gene for late blight resistance from *S. microdontum* that is being transformed into MSE149-5Y to test its effectiveness. We are also transforming Silvertop Russet and A95109-1 with a tomato gene for PVY resistance. Through USAID funding we are conducting experiments to generate marker-free transgenic potatoes. We look at this research (combined with conventional breeding) as the most balanced approach to develop improved varieties with long and short-term breeding strategies. These genes will be of value in the breeding program and continue to look for new genes that may have economic and environmental value.

**Diploid Germplasm Enhancement (long-term breeding strategy):**

The *Solanum* germplasm offers opportunities to broaden the genetic base of the tetraploid potato and introduce traits of economic importance. The benefits of germplasm enhancement are not subject to speculation, yet the enhancement time-line is unattractively long. For priority traits, our approach is to determine levels of variation among species, among species plant introductions (PIs), then within PIs to identify candidate germplasm for breeding use. Our breeding programs are using the diploid species and in combination with  $2n$  gametes to accomplish this task. Moreover, the "diploid" breeding program simplifies the genetic system in potato and can exploit more efficient selection of desirable traits. The diploid breeding program germplasm base the North Central region has is a mosaic of numerous species: haploid *S. tuberosum* (adaptation, tuber appearance), *S. phureja* (cold-chipping, specific gravity, PVY immunity), *S. tarijense* and *S. berthaultii* (late blight resistance, verticillium wilt resistance, tuber appearance, insect resistance), *S. microdontum* (late blight resistance, Ca accumulation and cold-chipping), *S. demissum* (silver scurf), *S. albicans* (silver scurf), *S. stoloniferum* (silver scurf), *S. goiurayi* (Ca accumulation, silver scurf), *S. raphanifolium* (cold-chipping), *S. okadae* (cold-chipping) and *S. chacoense* (specific gravity, low sugars, dormancy, insect resistance, silver scurf). We expect to broaden our germplasm base with this genetic material for the purpose of enhancing the long-term progress in variety development.

**Environmental statement:** Improved varieties are a key component to integrated crop management in potato. Through breeding we identify disease/insect resistant (scab, late blight, verticillium, Colorado potato beetle) germplasm and varieties. We must also enhance the nutritional value of this important food staple for consumer benefit. Potential adverse impacts to consumers and the environment must also be minimized through reduced pesticide use, efficient utilization of fertilizer, water and other inputs, continued improvement of potato quality, improved economics of production, and protection of our water resources.

**Economic statement:** The variety chosen for potato production affects market utilization. Improved varieties will promote greater market impact or provide new market niches.

**PROPOSED BUDGET - 2009:**

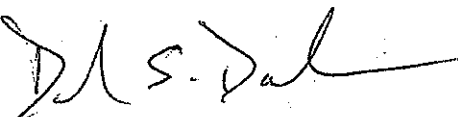
	<u>Federal Grant</u>	<u>MPIC</u>
Personnel/fringe (partial support)	54,500	20,000
Supplies and Materials	6,000	4,000
Travel	7,000	1,000
Publication costs	2,500	
Virus eradication		5,000
<b>TOTAL</b>	<b>70,000</b>	<b>30,000</b>

**Budget Justification**

We are requesting additional funding for Salaries and Wages, Materials and Supplies, and Travel to enhance our 2009 USDA special Potato Grant. The salaries will be used to increase support of potato technician from 50% to full-time and fringe benefit rates. Part of the funding will be used towards student labor in laboratory and chip processing analyses. Additional technical help is also requested during harvest season. To cover the purchase of laboratory and field supplies and seed costs, we are requesting support for materials and supplies. Additional support for travel is requested to cover the field season vehicle lease.

  
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Department Chair

11/30/09  
Date



11/25/09