# 2012 POTATO BREEDING AND GENETICS RESEARCH REPORT

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## INTRODUCTION

At Michigan State University, we are dedicated to developing improved potato varieties for the chip-processing and tablestock markets. The program is one of four integrated breeding programs in the North Central region supported through the Potato Special Grant. At MSU, we conduct a multi-disciplinary program for potato breeding and variety development that integrates traditional and biotechnological approaches to breed for disease and insect resistance. In Michigan, it requires that we primarily develop high yielding round white potatoes with excellent chip-processing from the field and/or storage. In addition, there is a need for table varieties (russet, red, yellow, and round white). We conduct variety trials of advanced selections and field experiments at MSU research locations (Montcalm Research Center, Lake City Experiment Station, Clarksville Research Center, and MSU Soils Farm), we ship seed to other states and Canadian provinces for variety trials, and we cooperate with Chris Long on grower trials throughout Michigan. Through conventional crosses in the greenhouse, we develop new genetic combinations in the breeding program, and also screen and identify exotic germplasm that will enhance the varietal breeding efforts. With each cycle of crossing and selection we are seeing directed improvement towards improved varieties (e.g. combining chip-processing, scab resistance, and late blight resistance, beetle resistance, specific gravity). The SolCAP project has developed a new set of genetic markers (8,303) called SNPs that are located in the 39,000 genes of potato. This USDA-funded SolCAP translational genomics project is finally giving us the opportunity to link genetic markers to important traits (reducing sugars, starch and scab resistance) in the cultivated potato lines and then breed them into elite germplasm. In addition, our program has been utilizing genetic engineering as a tool to introduce new genes to improve varieties and advanced germplasm for traits such as insect resistance, late blight and PVY resistance, lower reducing sugar, nitrogen use efficiency and drought. Furthermore, the USPB is supporting national early generation trials called the National Coordinated Breeder Trial (NCBT) which will feed lines into the SFA trial and also fast track lines into commercial testing. We are also funded through the USDA/SCRI Acrylamide project to link genetic markers with lower acrylamide traits. We feel that these in-house capacities (both conventional and biotechnological) put us in a unique position to respond to and focus on the most promising directions for variety development and effectively integrate the breeding of improved chip-processing and tablestock potatoes.

The breeding goals at MSU are based upon current and future needs of the Michigan potato industry. Traits of importance include yield potential, disease resistance (scab, late blight, early die, and PVY), insect (Colorado potato beetle) resistance, chipping (out-of-the-field, storage, and extended cold storage) and cooking quality, bruise resistance, storability, along with shape, internal quality, and appearance. We are also developing potato tuber moth resistant lines as a component of our international research project. If these goals can be met, we will be able to reduce production input costs as well as the reliance on chemical inputs such as insecticides, fungicides and sprout inhibitors, and improve overall agronomic performance with new potato varieties.

Over the years, key infrastructure changes have been established for the breeding program to make sound assessments of the breeding selections moving through the program. These include the establishment and expansion of the scab nursery, the development of the Clarksville Research Center for late blight testing, the incorporation of no-choice caged studies for Colorado potato beetle assessment, the Michigan Potato Industry Commission (MPIC)-funded construction of the B.F. (Burt) Cargill Demonstration Storage adjacent to the Montcalm Research Center, new land at the Lake City Experiment Station along with a well for irrigation and expanded land at the Montcalm Research Center and Lake City Experiment Station, the new plot harvester, the development of the grading line at the MSU campus facility, and expansion of the tissue culture operation so that small amounts certified seed of minitubers can be produced. In 2012 we relocated our research lab in the new Molecular Plant Sciences addition on the MSU campus.

## PROCEDURE

### I. Varietal Development

#### Breeding, Selection and Variety Evaluation:

The MSU breeding program has been operating for over 20 years and we feel that we have advanced the germplasm so that we can breed scab and late blight resistant varieties for Michigan. We have the genetic variation to combine tuber shape, skin type, scab resistance and low sugars, yield and storability as well as late blight, PVY and golden nematode resistances. Secondly, we have been improved the efficiency of the breeding cycle by defining more precisely the commercial needs of the new varieties and make better decisions more quickly in the first three years of the breeding program cycle. Third, we have raised our standards for what we consider a commercial selection for testing. Fourth, we have been able to increase our efficiency because we are conducting an integrated selection based upon our disease nurseries, post-harvest evaluations for specific gravity and chip quality and DNA tests. Furthermore, we have also revised the selection scheme so that we have reduced a year from the early generation cycle. The MSU Breeding program continues to test MSU-bred lines in replicated trials (over 160 lines) and on grower farms (15 lines). We also annually enter 3-4 lines in the North Central regional trials, 2-4 lines in the USPB/SFA trials and send many of the advanced breeding lines to other states, Canada and various international sites for testing. The NCBT in 2012 allowed us to test the over 50 MSU lines at 11 locations around the country. 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. Six of these are in the fast track commercial seed production (MSL007-B, MSJ126-9Y, MSH228-6, MSL292-A, MSR061-1 and MSK061-4). MSL292-A and MSJ126-9Y can store at temperatures below 50F and maintain low sugars until June.

In 2013 the MSU breeding program will cross elite germplasm to generate and evaluate 60,000 new seedlings for adaptation to Michigan. In the subsequent years these selections are then advanced to 12-hill (year 2), 30-hill (year 3), 50-hill, and 100-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 3-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 Center. 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 Center for agronomic performance, marketable maturity, chip processing at harvest and in storage, resistance to pitted scab, potato early die and late blight. We place the 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. Part of our greenhouse is now approved to produce certified greenhouse minitubers. We are moving towards using a commercial NFT mini-tuber production system to produce mini-tubers of our advanced selections. We have also been developing a new cryotherapy procedure for virus eradication.

Currently, the breeding program has in tissue culture about 1000 clones in the MSU bank and 80 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.

There is a need to find a russet table potato that will be profitable and produce quality russets for the eastern market. Currently, the three most desirable potatoes for production and type in Michigan are GoldRush, Russet Norkotah and Silverton Russet. The latter two potatoes suffer as symptomless carriers of PVY. Norkotah also has a weak vine and susceptibility to potato early die. We need a PVY resistant Silverton Russet potato. We are continuing to make more russet crosses and selections in the breeding program to support this new russet market.

**Evaluation of Advanced Selections for Extended Storage**

With the Demonstration Storage facility adjacent to the Montcalm Research Center, we are positioned to evaluate advanced selections from the breeding program for chip-processing over the whole extended storage season (October-June). Tuber samples of our elite chip-processing selections are placed in the demonstration storage facility in October and are sampled monthly to determine their ability to chip-process from colder (42-48°F) and/or 50°F storage. In addition, Chris Long evaluates the more advanced selections in the 10 cwt. box bins and manages the 500 cwt. storage bins which may have MSU-developed lines.

**II. Germplasm Enhancement**

To supplement the genetic base of the varietal breeding program, we have a "diploid" (2x = 24 chromosomes) breeding program in an effort to simplify the genetic system in potato (which normally has 48 chromosomes) and exploit more efficient selection of desirable traits. This added approach to breeding represents a large source of valuable germplasm, which can broaden the genetic base of the cultivated potato. The diploid breeding program germplasm base at MSU is a synthesis of seven species: *S. tuberosum* (adaptation, tuber appearance), *S. raphanifolium* (cold chipping), *S. phureja* (cold-chipping, specific gravity, PVY resistance, self-compatability), *S. tarijense* and *S. berthaultii* (tuber appearance, insect resistance, late blight resistance, verticillium wilt resistance), *S. microdontum* (late blight resistance) and *S. chacoense* (specific gravity, low sugars, dormancy and leptine-based insect resistance). Even though these potatoes have only half the chromosomes of the varieties in the U.S., we can cross these potatoes to transfer the desirable genes by conventional crossing methods via 2n pollen. We are redirecting the diploid breeding by introducing a self compatability (SLi) gene. The ability to self pollinate diploid potato lines will allow us to think of diploid potato breeding more like corn breeding.

**III. Integration of Genetic Engineering with Potato Breeding**

Through transgenic approaches we have the opportunity to introduce new genes into our cultivated germplasm that otherwise would not be exploited. It has been used in potato as a tool to improve commercially acceptable cultivars for specific traits. Our laboratory has now 17 years experience in *Agrobacterium*-mediated transformation to introduce genes into important potato cultivars and advanced breeding lines. We are presently using genes in vector constructs that confer resistance to Colorado potato beetle and potato tuber moth (*Bt-cry3A* and *Bt-cry1Ia1*), late blight resistance via the *RB* gene (from the wild potato species *S. bulbocastanum*) and also a late blight resistance gene we cloned from *S. microdontum*, drought resistance (*CBF1, IPT*), PVY, and lower reducing sugars with acid invertase gene silencing, and nitrogen use efficiency from a barley alanine aminotransferase gene.

**RESULTS AND DISCUSSION**

**I. Varietal Development**

**Breeding**

The MSU potato breeding and genetics program is actively producing new germplasm and advanced seedlings that are improved for cold chipping, and resistance to scab, late blight, and Colorado potato beetle. For the 2012 field season, progeny from about

600 crosses were planted and evaluated. Of those, the majority were crosses to select for round whites (chip-processing and tablestock), with the remainder to select for yellow flesh, long/russet types, red-skin, and novelty market classes. During the 2012 harvest, over 1,400 selections were made from the 60,000 seedlings produced. In addition, about 400 selections from elite chip-processing crosses were made in a commercial field with high scab pressure. All potential chip-processing selections will be tested in January and April 2012 directly out of 45°F (7.2°C) and 50°F (10°C) storages. Atlantic, Pike (50°F chipper) and Snowden (45°F chipper) are chip-processed as check cultivars. Selections have been identified at each stage of the selection cycle that have desirable agronomic characteristics and chip-processing potential. At the 12-hill and 30-hill evaluation state, about 190 and 80 selections were made, respectively, based upon chip quality, specific gravity, scab resistance, late blight resistance and DNA markers. Selection in the early generation stages has been enhanced by the incorporation of the Colorado potato beetle, scab and late blight evaluations of the early generation material. We are pushing our early generation selections from the 30-hill stage into tissue culture to minimize PVY issues in our breeding and seed stock. We have also been experimenting with a cryotherapy method to remove viruses. If perfected, we will be able to more predictably remove virus from tissue culture stocks. Preliminary results show that we are able to remove both PVY and PVS from lines. We are continuing these evaluations.

**Chip-Processing**

Over 80% of the single hill selections have a chip-processing parent in their pedigree. Our most promising chip-processing lines are MSJ126-9Y (scab resistant), MSL007-B (scab resistance), MSR169-8Y (scab resistant), MSQ086-3, (late blight resistant), MSL292-A and MSR061-1 (scab, late blight and PVY resistant). Our most promising new line is MSR127-2 (scab resistant). We are fast-tracking this line as we remove PVS from the tissue culture stock. We have some newer lines to consider, but we are removing virus from those lines. We are using the NCPT trials to more effectively identify promising new selections.

**Tablestock**

Efforts have been made to identify lines with good appearance, low internal defects, good cooking quality, high marketable yield and resistance to scab, late blight and PVY. Our current tablestock development goals now are to continue to improve the frequency of scab resistant lines, incorporate resistance to late blight along with marketable maturity and excellent tuber quality, and select more russet and yellow-fleshed lines. We have also been spinning off some pigmented skin and tuber flesh lines that may fit some specialty markets. We released three lines for the specialty market: MSN215-2P (Colonial Purple), MSR226-1RR (Raspberry) and MSQ425-4PY (Spartan Splash). We have interest from some western specialty potato growers to test and possibly commercial these lines. From our breeding efforts we have identified mostly round white lines, but we also have a number of yellow-fleshed and red-skinned lines, as well as some purple skin selections that carry many of the characteristics mentioned above. We are also selecting for a dual-purpose russet, round white, red-skin, and improved Yukon Gold-type yellow-fleshed potatoes. Some of the tablestock lines were tested in on-farm trials in 2012, while others were tested under replicated conditions at the Montcalm Research Center. Promising tablestock lines include

MSL211-3, MSQ440-2, MSM288-2Y, MSL268-D and MSQ176-5. We have a number of tablestock selections with late blight resistance (MSQ176-5, MSM182-1, and MSL268-D). MSL211-3 has earliness and a bright skin. We are using russets as parents in the breeding program to combine the late blight and scab resistance. MSM288-2Y is a bright yellow flesh selection similar in type to Yukon Gold. Some new specialty pigmented lines are MSS576-05SPL (red splash) and Michigan Red and Purple Heart. MSQ558-2RR and MSR226-1RR are red-fleshed chippers. We will be increasing seed of Missuakee for international markets due to its late blight resistance.

**Early harvest breeding material screen**

In 2012, we continued our early harvest observation trial of our breeding lines to learn about the potential to replace Atlantic as an early harvest variety. We harvested the plots at 89 days and observed the yield, tuber size and tuber shape/ appearance. In addition, we measured specific gravity and made chips out of the field. From this trial of over 140 lines, we were able to identify some promising early breeding lines for the out-of-the-field chipping use (MSL292-A, MSS297-1 and MSN190-2) and table use (MSL211-3, MSS576-05SPL and MSW123-3). **Table 1** summarizes these results of the lines with the highest merit ratings. Some of these lines are also characterized to have some scab resistance and late blight resistance along with the desirable chipping traits. We will continue to test many of these lines and other selections in 2013.

**Disease and Insect Resistance Breeding**

**Scab**: In 2012 we had two locations to evaluate scab resistance: a commercial field with a history of severe scab infection and a highly infected site at the Montcalm Research Center in the commercial production area. The commercial site and the new site at the Montcalm Research Center both gave us the high infection levels. Some of results are summarized in **Table 2**. The susceptible checks of Snowden and Atlantic were highly infected with pitted scab. Promising resistant selections were MSJ126-9Y, MSL007-B, MSR061-1, MSR169-8Y, MSP270-1, MSR127-2, MSS165-2Y, U383-1 and MSQ440-2. The high level of scab infection at the on-farm site with a history of scab infection and MRC has significantly helped with our discrimination of resistance and susceptibility of our lines. In 2013 we are planning to use the commercial site for primary trait selection of our 12-hill (year 2) lines in elite chip-processing crosses. The MRC scab site was used for assessing scab susceptibility in our advanced breeding lines and early generation material and is summarized below. All susceptible checks were scored as susceptible.

**Table 1 Early Observation Trial: Most promising lines.**

| Line | Plot Yield (cwt/a) | Specific Gravity | OTF 8/7/12 SFA Chip Score | Merit[1] | Pedigree | |
|---|---|---|---|---|---|---|
| *Chip-processing* | | | | | **Female** | **Male** |
| **Atlantic** | **240** | **1.078** | **1.0** | **1** | | |
| **Atlantic** | **219** | **1.075** | **1.5** | **1** | | |
| Lamoka | 244 | 1.073 | 1.0 | 1 | | |
| MSL292-A | 245 | 1.071 | 1.0 | 1 | Snowden | MSH098-2 |
| MSN190-2 | 261 | 1.081 | 1.0 | 1 | MSI234-6Y | MSG227-2 |
| MSQ035-3 | 264 | 1.070 | 1.0 | 1 | MSG227-2 | Missaukee |
| MSQ086-3 | 261 | 1.059 | 1.5 | 1 | Onaway | Missuakee |
| MSR061-1 | 182 | 1.070 | 1.0 | 1 | MegaChip | NY121 |
| MSS297-1 | 226 | 1.076 | 1.5 | 1 | MSJ147-1 | MSM066-4 |
| MSW138-2 | 202 | 1.077 | 1.0 | 2 | MegaChip | Eva |
| MSW140-3 | 207 | 1.076 | 1.5 | 2 | MegaChip | Missuakee |
| MSW501-5 | 282 | 1.065 | 1.5 | 1 | Boulder | White Pearl |
| **Pike** | **133** | **1.066** | **1.0** | **1** | | |
| **Pike** | **175** | **1.068** | **1.5** | **1** | | |
| **Snowden** | **167** | **1.065** | **1.0** | **1** | | |
| **Snowden** | **255** | **1.069** | **1.0** | **1** | | |
| *Tablestock* | | | | | | |
| MSL211-3 | 266 | 1.059 | - | 1 | MSG301-9 | Jacqueline Lee |
| MSS576-05SPL | 278 | 1.059 | - | 1 | MSI005-20Y | MSL211-3 |
| MSW027-1 | 269 | 1.063 | - | 1 | Eva | MSQ176-5 |
| MSW123-3 | 337 | 1.059 | - | 1 | MSM171-A | Dakota Diamond |
| MSW125-3 | 275 | 1.051 | - | 1 | MSM171-A | MSL211-3 |
| MSW273-3R | 310 | 1.061 | - | 1 | NDTX4271-5R | MSN105-1 |
| MSW500-4 | 185 | 1.068 | - | 2 | Boulder | MSP516-A |
| **Onaway** | **379** | **1.059** | **-** | **1** | | |
| **Onaway** | **326** | **1.058** | **-** | **1** | | |
| **Reba** | **246** | **1.055** | **-** | **1** | | |
| **Reba** | **154** | **1.054** | **-** | **1** | | |

[1]Merit Rating: 1-Great, 2-Keep, 3-Marginal, 4-Drop

Planted 5/9/12; Harvested 8/6/12. 89 DAP. 10-hill plots planted in 10 ft plots.

Fig. 1. Scab Disease Nursery Ratings in Early Generation Lines

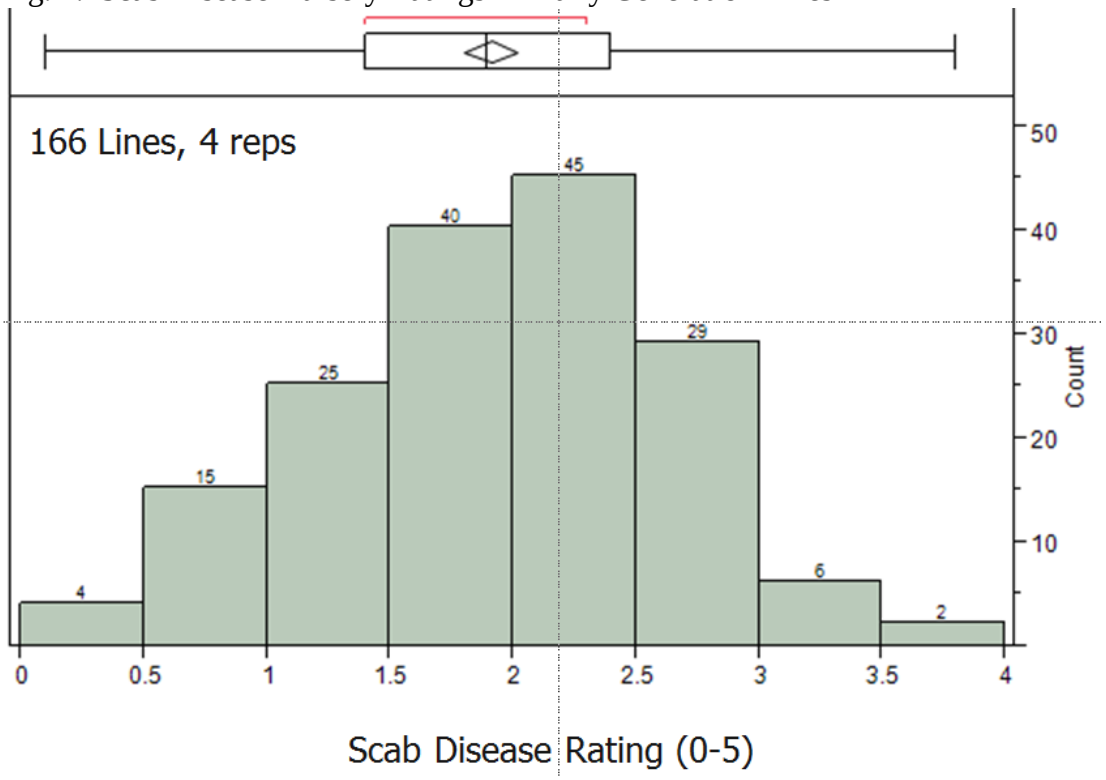
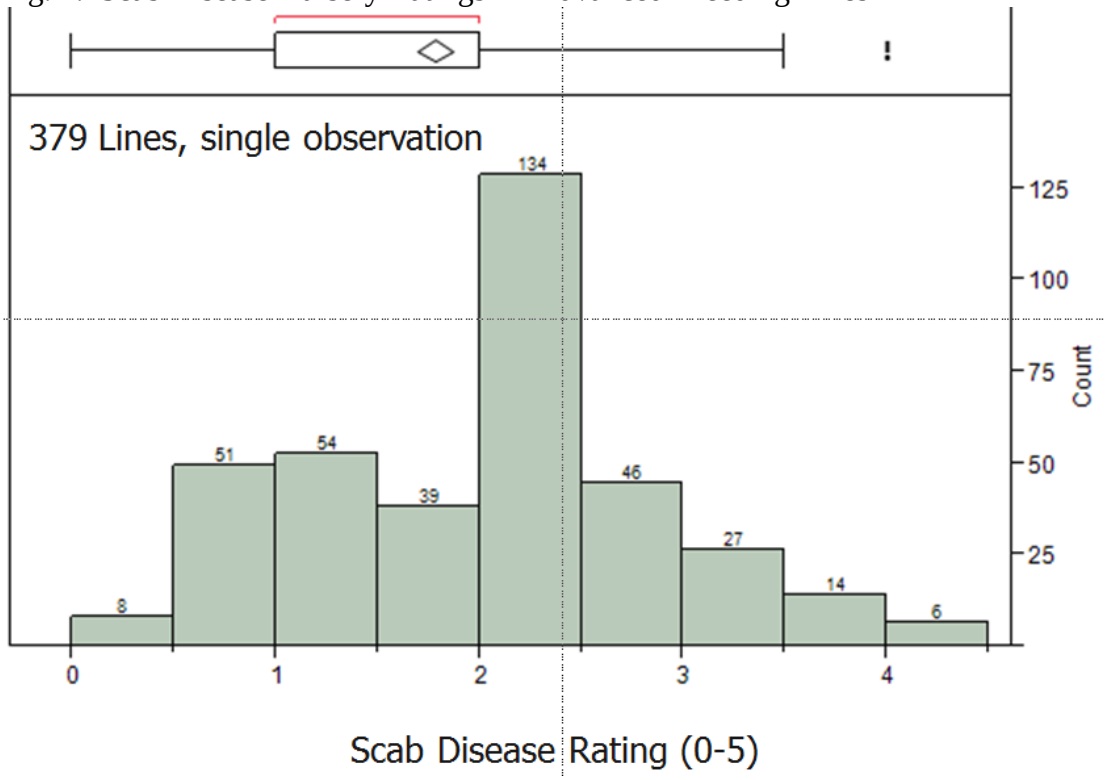



Fig. 2. Scab Disease Nursery Ratings in Advanced Breeding Lines



Based upon this data, scab resistance is increasing in the breeding program. These data were also incorporated into the early generation selection evaluation process at Lake City. We are seeing that this expanded effort is leading to more scab resistant lines advancing through the breeding program. MSU is now being recognized by peer programs for its scab resistant advanced breeding lines.

In 2012 we collected replicated (4 times) scab infection data from our Montcalm Research Center scab field on 200 progeny from a cross between resistant and susceptible varieties Of the 200 progeny, about 40% were highly to moderately resistant. Most importantly, we are also using this field data to conduct genome wide QTL analysis with the SolCAP 8300 Potato SNP data in search of genetic markers linked to scab resistance. The data collected from this trial has led us to identify some genetic markers linked to scab resistance.

**Table 2. *Streptomyces* Scab Trial Results from On-Farm trial location.**

| Line | | | | | | | | | | | Scab Rating | OTF Chip |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MSP270-1 | | | | | | | | | | J | 0.5 | 1.5 |
| MSV383-1 | | | | | | | | | I | J | 1.0 | 1.0 |
| MSQ440-2 | | | | | | | | H | I | J | 1.3 | - |
| MSR058-1 | | | | | | | G | H | I | J | 1.4 | 1.0 |
| Kalkaska | | | | | | | G | H | I | J | 1.4 | 1.0 |
| Liberator | | | | | | F | G | H | I | | 1.8 | 1.0 |
| MSS297-3 | | | | | E | F | G | H | I | | 1.9 | 1.0 |
| Pike | | | | | E | F | G | H | I | | 2.0 | 1.0 |
| Colonial Purple | | | | | E | F | G | H | I | | 2.1 | - |
| Dakota Diamond | | | | | E | F | G | H | I | | 2.1 | 1.5 |
| MSR169-8Y | | | | | E | F | G | H | I | | 2.1 | 1.0 |
| MSL007-B | | | | | E | F | G | H | | | 2.3 | 1.5 |
| MSQ341-BY | | | | | E | F | G | H | | | 2.3 | 1.0 |
| MSR061-1 | | | | | E | F | G | H | | | 2.3 | 1.0 |
| MSQ035-3 | | | | D | E | F | G | | | | 2.5 | 1.0 |
| MSS165-2Y | | | | D | E | F | G | | | | 2.5 | 1.0 |
| MSR148-4 | | | C | D | E | F | | | | | 2.8 | 1.5 |
| MSR128-4Y | | B | C | D | E | | | | | | 3.0 | 1.0 |
| MSS544-1R | | B | C | D | E | | | | | | 3.0 | - |
| MSQ131-A | A | B | C | D | | | | | | | 3.6 | - |
| Atlantic | A | B | C | | | | | | | | 3.9 | 1.0 |
| MSL292-A | A | B | | | | | | | | | 4.0 | 1.0 |
| Snowden | A | B | | | | | | | | | 4.1 | 1.0 |
| Purple Heart | A | | | | | | | | | | 4.4 | - |

HSD=1.18

Scab Rating (0: No Scab – 5: Severly pitted scab)

**Late Blight:** Our specific objective is to breed improved cultivars for the industry that have foliar and tuber resistance to late blight using a combination of conventional breeding, marker-assisted strategies and transgenic approaches. Through conventional breeding approaches, the MSU potato breeding and genetics program has developed a series of late blight resistant advanced breeding lines and cultivars that have diverse sources of resistance to late blight. This is a GREEEN-funded project. In 2012 we conducted late blight trials at the Clarksville Research Center. We inoculated with the US22 genotype the past two years, but the foliar reaction to the *Phytophthora infestans* has been different from all previous years using US8. In some cases lines that were classified as resistant were susceptible. On the other hand, some of the lines with moderate resistance in previous years were highly resistant in 2011 and 2012. In the 2012 trials, about over 50% of the 152 early generation lines were resistant to late blight comprised of 12 sources of late blight resistance (Fig. 1). Of the 162 advanced breeding lines and varieties tested, over 40% were classified as resistant (Fig. 2). Fourteen sources of resistance can be traced in the pedigrees of these resistant lines. This data infers that we have a broad genetic base to combine resistance genes and also should be able to respond to changes in the pathogen. This observation has been supported by a field trial in Honduras. Missaukee, Jacqueline Lee, MSL211-3, MSQ176-5, MSM182-1, MSR061-1 showed resistance to late blight under natural infection. Susceptible varieties did not survive the trial.

An inoculated field trial was conducted at the Clarksville Research Center using a US22 isolate common to the US and Michigan. Sets of three progeny (Spunta-RB x susceptible; Spunta-RB x moderate resistance; Spunta-RB x resistance) were planted in a randomized complete block design with two replications. The progeny were separated in RB+ vs RB- progeny by cross (see figures below). Visual ratings of percent defoliation due to late blight were recorded at least weekly after inoculation occurred and RAUDPCs were calculated for each line. The RB+ progeny from all three crosses had, on average; lower levels of late blight infection. Secondly, the most resistant progeny were found in the crosses to parents with late blight resistance, while the most susceptible progeny were observed within the RB- progeny. This study was conducted in 2010 and repeated in 2011 and 2012. The results of three years suggest that combining the RB gene with current resistance genes in parents may lead to higher levels of late blight resistance. We selected 50 of the most resistant lines from these crosses that contain the RB gene. These will be further tested against more *P. infestans* isolates and are candidates for effector testing. We are hoping that with a combination of conventional crossing and transgenic approaches we can create cultivars that can be commercialized by the North American potato industry that have a stronger resistance.

Fig. 1. Foliar Late Blight Reaction in Early Generation Lines

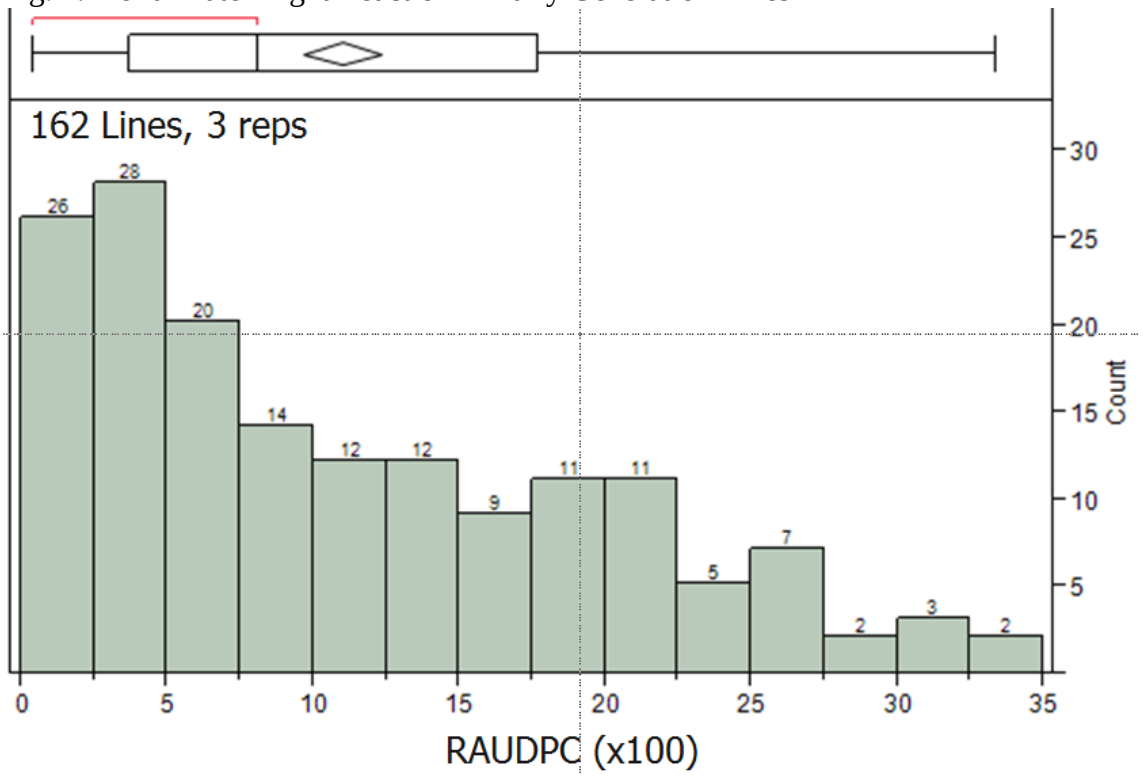



Fig. 2. Foliar Late Blight Reaction in Advanced Breeding Lines

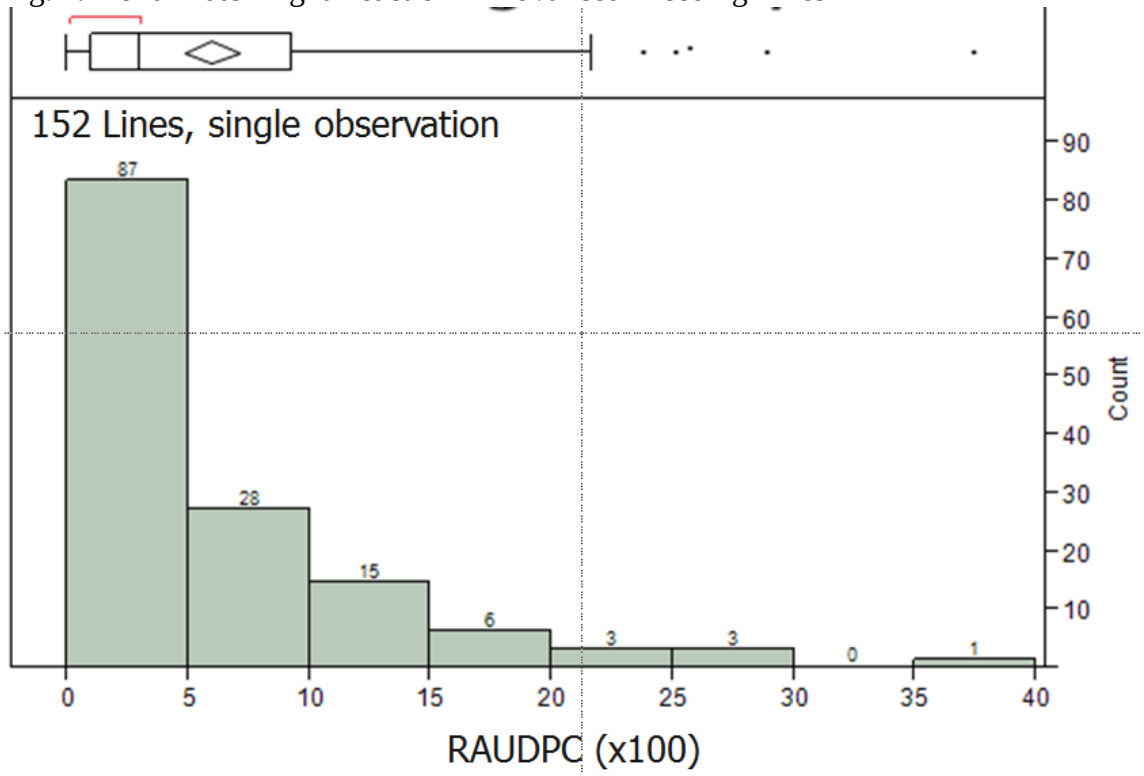
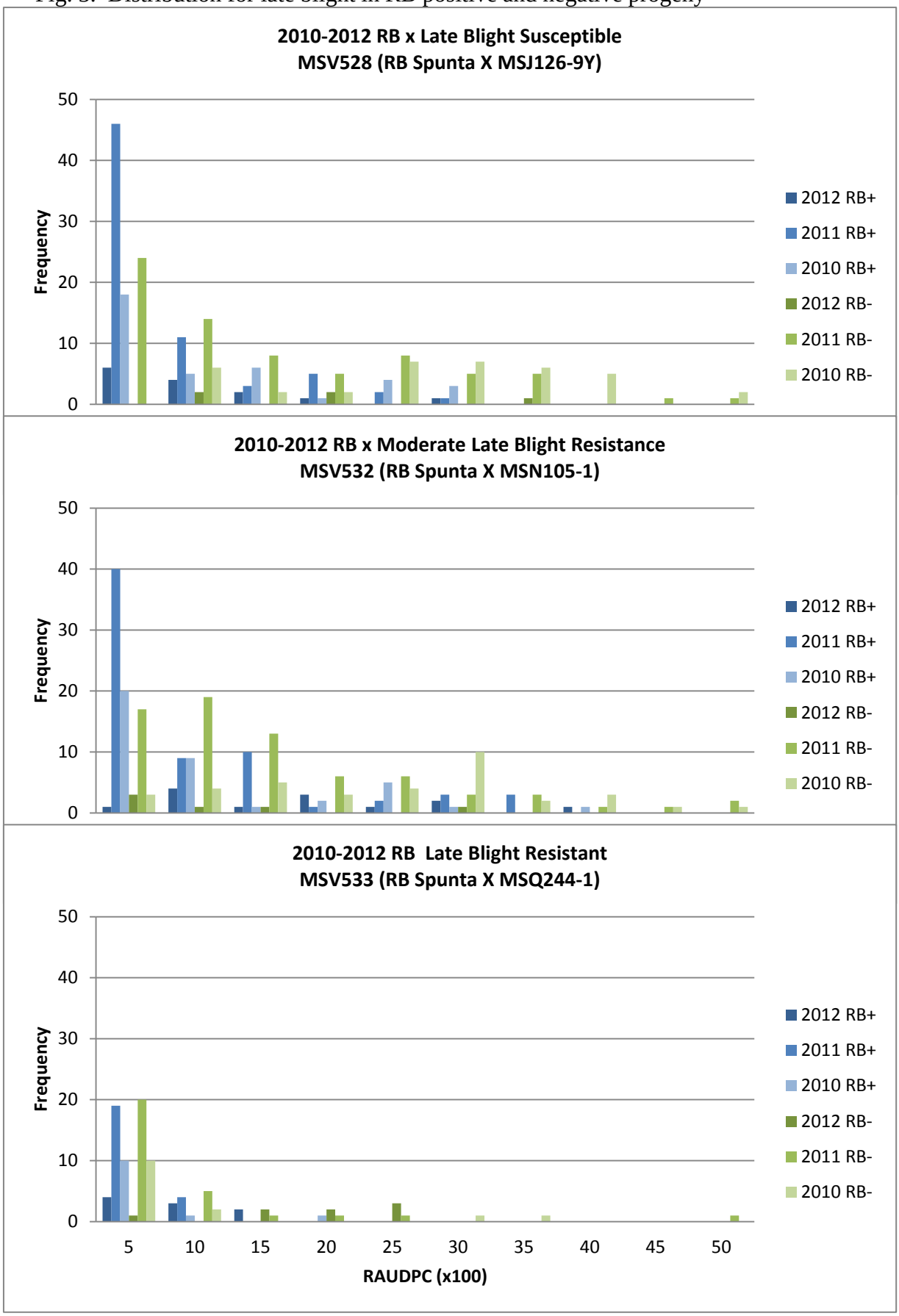


Fig. 3. Distribution for late blight in RB positive and negative progeny



**Colorado potato beetle:** With support from project GREEEN we evaluated advanced breeding lines from the breeding program for field defoliation by the Colorado potato beetle. Using the Montcalm Research Center beetle nursery, 40 lines with pedigrees of insect resistance germplasm were evaluated in replicated trials. Five lines showed significant reduction to defoliation. These lines are being used to make further crosses to advance this beetle resistance trait. We feel after 3 rounds of crossing this tetraploid germplasm we are starting to see some advancement in resistance introgressed from the wild species. However, much value would be gained if we could combine resistance mechanisms. For that reason, we need to identify additional sources of beetle resistance. Combining host plant resistance to insects in a commercially acceptable line is a great challenge.

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**Russet Table Varieties for Michigan**

Our breeding strategy has been to make selected crosses that have a high probability of selecting Norkotah types. We grew out large progenies over the past three years to further increase the probability of finding desirable selections. We will continue to use Silverton, Russet Norkotah, MSE192-8RUS, A95109-1RUS, etc. as parents. Single hill selections were made in the past three years. These early generation selections will be evaluated in 2013 as well as a new set of crosses will be evaluated at Lake City.

**Sugar Profile Analysis of Early Generation Selections for Extended Storage: Chip-processing Results From the MPIC Demonstration Commercial Storage (October 2011 - June 2012)**

The MSU Potato Breeding Program has been conducting chip-processing evaluations each year on potato lines from the MSU breeding program and from other states. For 13 years we have been conducting a long-term storage study to evaluate advanced breeding lines with chip-processing potential in the Dr. B. F. (Burt) Cargill Potato Demonstration Storage facility directly adjacent to the MSU Montcalm Research Farm to identify extended storage chippers. We evaluated advanced selections from the MSU breeding program for chip-processing over the whole extended storage season (October-June). Tuber samples of our elite chip-processing selections were placed in the demonstration storage facility in October and were sampled 9 times to determine their ability to chip-process from storage.

In October 2011, tuber samples from 14 MSU lines from the Montcalm Research Center and Lake City Experiment Station trials were placed in the bins along with three check varieties. The first samples were chip-processed in October and then 8 more times until June 2012. Samples were evaluated for chip-processing color and defects. **Table 3** summarizes the chip-processing color and scab rating of 20 lines and four check varieties (FL1879, Pike and Snowden) over the 8-month storage season. Most lines chip-processed well from the storage until April as Snowden color was increasing. Over half the lines tested chip processed well until June. These lines are highlighted in the last three months of the table. We are also showing that some of the lines with good chip quality also have scab resistance and/or late blight resistance.

**2011-2012 Demonstration Storage Chip Results of Elite MSU Breeding Lines**

| | | 11/22/11 | 12/21/11 | 1/31/12 | 2/28/12 | 3/27/12 | 4/20/12 | 5/17/12 | 6/6/12 |
|---|---|---|---|---|---|---|---|---|---|
| | | SFA Chip Score Rating Scale 1-5 | | | | | | | |
| **Line** | **Resistance** | 54.8 F | 49.8 F | 48.2F | 47.2F | 48.0F | 49.4F | 49.4F | 49.4F |
| **Atlantic** | | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 2.0 | 1.5 | 2.0 |
| **FL1879** | | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.5 | 1.0 |
| **Pike** | **ScabR** | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.5 | 1.5 |
| **Snowden** | | 1.0 | 1.0 | 1.0! | 1.5 | 1.0 | 1.5 | 2.5 | 3.0 |
| Beacon Chipper | ScabMR | 1.0 | 1.0 | 1.0 | 1.0 | 1.5 | 1.0 | 2.5 | 1.5 |
| Kalkaska | ScabR | 1.5 | 1.5 | 1.0 | 1.0 | 1.5 | 1.5 | 2.0 | 2.5 |
| Lamoka | | 1.0 | 1.0 | 1.0 | 1.0 | 1.5 | 1.5 | 1.0 | 1.0 |
| MSH228-6 | ScabR | 1.0 | 1.5 | 1.0 | 1.5 | 1.0 | 1.5 | 1.5 | 2.0 |
| MSJ126-9Y | ScabR | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.5 |
| MSJ147-1 | | | 1.0 | 1.0 | 1.0 | 1.0 | 1.5 | 1.0 | 1.5 |
| MSL007-B | ScabR | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 2.0 | 1.5 | 2.0 |
| MSL292-A | | 1.0 | 1.0 | 1.0 | 1.0 | 1.5 | 1.0 | 1.5 | 1.5 |
| MSQ035-3 | MR ScabR LBR | 2.0 | 1.0 | 1.5 | 1.5 | 1.0 | 2.0 | 2.5 | 2.0 |
| MSQ070-1 | ScabR-LBR | 1.0 | 1.0 | 1.0 | 1.0 | 1.5 | 1.5 | 1.5 | 1.5 |
| MSQ086-3 | LBR | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| MSQ089-1 | | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.5 | 1.5 | 2.0 |
| MSQ279-1 | ScabR | 1.0 | 1.0 | 1.0 | 1.5 | 1.0 | 1.5 | 1.0 | 1.0 |
| MSR036-5 | ScabR-LBR | 1.5 | 1.5 | 1.5 | 1.5 | 1.0 | 1.5 | 2.0 | 1.5 |
| MSR061-1 | ScabR | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.5 | 1.0 | 1.0 |
| MSR127-2 | | 1.0 | 1.0 | 1.0! | 1.0 | 1.0 | 1.5 | 1.5 | 2.5 |
| MSR159-02 | ScabMR | 1.5 | 1.5 | 1.5 | 1.5 | 1.0 | 2.0 | 1.5 | 2.0 |
| MSR169-8Y | ScabR | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| MSS165-2Y | ScabR | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| NYE106-4 | | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |

**National Coordinated Breeder Trial (NCBT)**

2012 was the third year of the NCBT. The purpose of the trial is to evaluate early generation breeding lines from the US public breeding programs for their use in chip-processing. The NCBT has 10 sites (North: NY, MI, WI, ND, OR and over 200 lines were tested as 15-hill plots with best performing lines of the previous year being replicated in 2012. The lines were evaluated for tuber type and appearance, yield, specific gravity, chip color and chip defects. Some of the lines are being fast tracked for SFA and commercial trialing. The data is being prepared to be posted on a website database for the public to use. The lines with the best performance will be retested in 2013 and new early generation lines will be added. The MSU lines were more scab resistant than the lines from the programs. Some of the promising lines are MSK061-4, MSM246-B, MSL292-A, MSR061-1, MSL007-B, MSR169-8Y, MSR058-1 and MSR127-2.

| NCPT Trial | No. of Entries | | | | | |
|---|---|---|---|---|---|---|
| | 2010 | | 2011 | | 2012 | |
| | North | South | North | South | North | South |
| Tier 1 | 220 | 220 | 167 | 194 | 107 | 139 |
| Tier 2 | N/A | N/A | 38 | 32 | 60 | 66 |
| Total | 220 | 220 | 205 | 226 | 167 | 205 |

**Variety Release**

We are proposing to release MSJ126-9Y and MSL292-A in 2013. There is commercial interest in MSH228-6, Colonial Purple and Spartan Splash. We are continuing to promote the seed production and testing of Beacon Chipper, a 2005 release. In addition, we are also continuing to promote Michigan Purple, Jacqueline Lee for the tablestock specialty markets. Lastly, commercial seed of MSJ126-9Y, MSR061-1, MSQ086-3, MSL292-A and MSL007-B are being produced (mostly through the USPB fast-track process) and we will continue to seek commercial testing of these lines. We also have a focused ribavirin-based virus eradication system to generate virus-free tissue culture lines for the industry. We are also developing the cryotherapy technique to remove virus from tissue culture plants. About 60 lines are in ribaviran treatment at this time to remove PVS and/or PVY. This year, about 80 new MSU breeding lines are being put into tissue culture.

**MSU Lines with Commercial Tracking:**

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**MSJ126-9Y (Posen)**

**Parentage:** Penta x OP
**Developers:** Michigan State University and the Michigan Agricultural Experiment Station
**Plant Variety Protection:** To Be Applied For.

**Strengths:** MSJ126-9Y is a chip-processing potato with an attractive round appearance with shallow eyes. MSJ126-9Y has a medium vine and an early to mid-season maturity. This variety has resistance to *Streptomyces scabies* (common scab) stronger than Pike. MSJ126-9Y also has excellent chip-processing long-term storage characteristics and better tolerance to blackspot bruise than Snowden.

**Incentives for production:** Excellent chip-processing quality with long-term storage characteristics, common scab resistance superior to Pike, and good tuber type.

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**MSH228-6**

**Parentage:** MSC127-3 x OP
**Developers:** Michigan State University and the Michigan Agricultural Experiment Station
**Plant Variety Protection:** no

**Strengths:** MSH228-6 is a chip-processing potato with moderate resistance to *Streptomyces scabies* (common scab). MSH228-6 also has a promising storage sugar profile and good chip-processing long-term storage characteristics.

**Incentives for production:** Chip-processing quality with long-term storage characteristics, and moderate common scab resistance with good tuber type.

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**MSL292-A (Manistee)**

**Parentage:** Snowden x MSH098-2
**Developers:** Michigan State University and the Michigan Agricultural Experiment Station
**Plant Variety Protection:** Will be applied for.

**Strengths:** MSL292-A is a chip-processing potato with an attractive round appearance with shallow eyes. MSL292-A has a full-sized vine and an early to mid-season maturity. MSL292-A has above average yield potential and specific gravity similar to Snowden. This variety has excellent chip-processing long-term storage characteristics and a similar to better tolerance to blackspot bruise than Snowden.

**Incentives for production:** Excellent chip-processing quality with long-term storage characteristics, above average yield, specific gravity similar to Snowden, and good tuber type.

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**MSL007-B**

**Parentage:** MSA105-1 x MSG227-2
**Developers:** Michigan State University and the Michigan Agricultural Experiment Station
**Plant Variety Protection:** Will be considered.

**Strengths:** MSL007-B is a chip-processing potato with an attractive, uniform round appearance with shallow eyes. This variety has

resistance to *Streptomyces scabies* (common scab) stronger than Pike, with a strong, netted skin. MSL007-B was the most highly merit rated line in the National Chip Processing Trial across eight locations in 2010.

**Incentives for production: C**hip-processing quality with common scab resistance superior to Pike, and a uniform, round tuber type.

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**MSR061-1**

**Parentage:** MegaChip x NY121
**Developers:** Michigan State University and the Michigan Agricultural Experiment Station
**Plant Variety Protection:** Will be considered.

**Strengths:** MSR061-1 is a chip-processing potato with resistance to common scab (*Streptomyces scabies*) and moderate foliar late blight (*Phytophthora infestans*) resistance. This variety has medium yield similar to Pike and a 1.079 (average) specific gravity and an attractive, uniform, round appearance. MSR061-1 has a medium vine and an early to mid-season maturity.

**Incentives for production:** Chip-processing quality with common scab resistance similar to Pike, moderate foliar late blight resistance (US8 genotype), and uniform, round tuber type.

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**MSR127-2**

**Parentage:** MSJ167-1 x MSG227-2
**Developers:** Michigan State University and the MSU AgBioResearch.
**Plant Variety Protection:** To Be Applied For.

**Strengths:** MSR127-2 is a chip-processing potato with resistance to common scab (*Streptomyces scabies*). This variety yields greater than Atlantic and Snowden, has a 1.086 (average) specific gravity, and an attractive, uniform, round appearance. MSR127-2 has a strong vine and a full-season maturity, and has demonstrated excellent long-term storage chip-processing quality.

**Incentives for production:** Long-term chip-processing quality with common scab resistance similar to Pike, and uniform, round tuber type.

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## II. Germplasm Enhancement

In 2010 we developed genetic mapping populations (both at diploid and tetraploid levels) for late blight resistance, beetle resistance, scab resistance and also for tuber quality traits. We have started to characterize these populations in 2011 and conduct the linkage analysis studies using the SNP genotyping. The mapping populations will be a major research focus for us over the next two years as we try to correlate the field data with the genetic markers. The diploid genetic material represent material from South American potato species and other countries around the world that are potential sources of resistance to Colorado potato beetle, late blight, potato early die, and ability to cold-chip process. We have used lines with Verticillium wilt resistance, PVY resistance, and cold chip-processing. We are monitoring the introgression of this germplasm through marker assisted selection. Through GREEEN funding, we were able to continue a breeding effort to introgress leptine-based insect resistance using new material selected from USDA/ARS material developed in Wisconsin. We will continue conducting extensive field screening for resistance to Colorado potato beetle at the Montcalm Research Farm and in cages at the Michigan State University Horticulture Farm. We made crosses with late blight resistant diploid lines derived from *Solanum microdontum* to our tetraploid lines. We have conducted lab-based detached leaf bioassays and have identified resistant lines. These lines are being used crosses to further transmit resistance. In the summer of 2012 we screened 75 accessions of wild species looking for drought resistance. Five different species are showing drought resistance. We are also using some inbred lines of *S. chacoense* that have fertility and vigor to initiate our efforts to develop inbred lines with our own diploid germplasm.

## III. Integration of Genetic Engineering with Potato Breeding

PVY resistance to three PVY strains (O, N and NTN) of the MSE149-5Y, Classic Russet, Silverton Russet and Russet Norkotah lines were evaluated by Jonathan Whitworth over the past three years. A number of lines with PVY resistance were identified. These lines have been increased for seed production so that field studies can be conducted in 2013. We have over 50 lbs. of seed for those trials. We are focusing on greenhouse minituber increase for these PVY resistant lines this winter. We identified a number of Silverton Russet lines with increased PVY resistance but none with complete resistance to all three PVY strains. Regarding late blight resistance, we have many lines with the RB gene for late blight resistance transformed into MSU lines. In many case the transformed parent line is a late blight resistance source. The addition of the RB gene allows us to test the effect of multiple resistance genes on the durability of resistance. Greenhouse tests are being conducted and field trials in 2013 are planned. We have also generated over 50 lines with the gene for nitrogen use efficiency. Greenhouse tests are in progress. We also have over 50 lines with the IPT gene for water use efficiency. Eight lines with the best results from the first greenhouse test are being re-evaluated. Lastly, we have some lines with the vacuolar acid invertase silencing. We are producing tubers so we can study the tuber sugar levels.