Michigan State University
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In Cooperation With
Michigan Potato Industry Commission

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Michigan Potato Industry Commission

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To All Michigan Potato Growers & Shippers:

The Michigan Potato Industry Commission, Michigan State University's AgBioResearch and Cooperative Extension Service are pleased to provide you with a copy of the results from the 2010 potato research projects.

This report includes research projects funded by the Michigan Potato Industry Commission, the USDA Special Grant and special allocations by the Commission. Additionally, the Commission expresses appreciation to suppliers of products for research purposes and special grants to the Commission and researchers.

Providing research funding and direction to principal investigators at MSU is a function of the Michigan Potato Industry Commission's Research Committee.

Best wishes for a prosperous 2011 season.

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2010 MICHIGAN POTATO RESEARCH REPORT

C. M. Long, Coordinator

INTRODUCTION AND ACKNOWLEDGMENTS

The 2010 Potato Research Report contains reports of the many potato research projects conducted by MSU potato researchers at several locations. The 2010 report is the 42nd volume, which has been prepared annually since 1969. This volume includes research projects funded by the Potato Special Federal Grant, the Michigan Potato Industry Commission (MPIC), GREEEN and numerous other sources. The principal source of funding for each project has been noted at the beginning of each report.

We wish to acknowledge the excellent cooperation of the Michigan potato industry and the MPIC for their continued support of the MSU potato research program. We also want to acknowledge the significant impact that the funds from the Potato Special Federal Grant have had on the scope and magnitude of potato related research in Michigan.

Many other contributions to MSU potato research have been made in the form of fertilizers, pesticides, seed, supplies and monetary grants. We also recognize the tremendous cooperation of individual producers who participate in the numerous on-farm projects. It is this dedicated support and cooperation that makes for a productive research program for the betterment of the Michigan potato industry.

We further acknowledge the professionalism of the MPIC Research Committee. The Michigan potato industry should be proud of the dedication of this committee and the keen interest they take in determining the needs and direction of Michigan's potato research.
Special thanks go to Bruce Sackett for the management of the MSU Montcalm Research Farm (MRF) and the many details which are a part of its operation. We also want to recognize Barb Smith at MPIC for helping with the details of this final draft.

WEATHER

The overall 6-month average maximum temperature during the 2010 growing season was three degrees higher than the 6-month average maximum temperature for the 2009 season and was two degrees higher than the 15-year average (Table 1). The 6-month average minimum temperature for 2010 was three degrees higher than the 15-year average. There were no recorded temperature readings of 90 °F or above in 2010. There were 220 hours of 70 °F temperatures between the hours of 10 PM and 8 AM which occurred over 43 different days, April to September (Data not shown). There were two days in May that the air temperature was below 32 °F. This occurred on May 9th and 10th. The average maximum temperatures for July and August, 2010, were two and three degrees higher than the 15-year average, respectively (Table 1). In October 2010, there were 8 days with measureable rainfall and two daytime highs below 50 °F.

Rainfall for April through September was 15.13 inches, which was 3.81 inches below the 15-year average (Table 2). In October 2010, 1.45 inches of rain were recorded. Irrigation at MRF was applied 11 times from June 16th to August 16th, averaging 0.77 inches for each application. The total amount of irrigation water applied during this time period was 8.45 inches.

Table 1. The 15-year summary of average maximum and minimum temperatures (°F) during the growing season at the Montcalm Research Farm.

Year	April		May		June		July		August		September		6-Month Average	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1996	50	31	64	44	75	57	76	55	80	59	70	51	69	50
1997	54	31	59	39	79	56	80	57	73	55	69	50	69	48
1998	60	37	75	51	77	56	82	58	81	60	76	52	75	52
1999	59	37	71	48	77	55	84	62	76	56	73	48	73	51
2000	56	34	70	49	75	57	77	56	79	57	70	49	71	50
2001	61	37	70	49	78	57	83	58	72	70	69	48	72	53
2002	56	36	63	42	79	58	85	62	81	58	77	52	73	51
2003	56	33	64	44	77	52	81	58	82	58	72	48	72	49
2004	62	37	67	46	74	54	79	57	76	53	78	49	73	49
2005	62	36	65	41	82	60	82	58	81	58	77	51	75	51
2006	62	36	61	46	78	54	83	61	80	58	68	48	72	51
2007	53	33	73	47	82	54	81	56	80	58	76	50	74	50
2008	61	37	67	40	77	56	80	58	80	54	73	50	73	49
2009	56	34	67	45	76	54	75	53	76	56	74	49	71	49
2010	**64**	**38**	**70**	**49**	**77**	**57**	**83**	**62**	**82**	**61**	**69**	**50**	**74**	**53**
15-Year Average	58	35	67	45	78	56	81	58	79	58	73	50	72	50

Table 2. The 15-year summary of precipitation (inches per month) recorded during the growing season at the Montcalm Research Farm.

Year	April	May	June	July	August	September	Total
1996	2.46	3.99	6.28	3.39	3.69	2.96	22.77
1997	2.02	3.13	3.54	2.80	2.71	1.46	15.66
1998	2.40	2.21	1.82	0.40	2.22	3.05	12.10
1999	5.49	5.07	5.82	4.29	5.46	4.03	30.16
2000	3.18	6.46	4.50	3.79	5.28	5.25	28.46
2001	3.28	6.74	2.90	2.49	5.71	4.43	25.55
2002	2.88	4.16	3.28	3.62	7.12	1.59	22.65
2003	0.70	3.44	1.85	2.60	2.60	2.06	13.25
2004	1.79	8.18	3.13	1.72	1.99	0.32	17.13
2005	0.69	1.39	3.57	3.65	1.85	3.90	15.05
2006	2.73	4.45	2.18	5.55	2.25	3.15	20.31
2007	2.64	1.60	1.58	2.43	2.34	1.18	11.77
2008	1.59	1.69	2.95	3.07	3.03	5.03	17.36
2009	3.94	2.15	2.43	2.07	4.74	1.49	16.82
2010	**1.59**	**3.68**	**3.21**	**2.14**	**2.63**	**1.88**	**15.13**
15-Year Average	2.49	3.89	3.27	2.93	3.57	2.79	18.94

GROWING DEGREE DAYS

Tables 3 and 4 summarize the cumulative growing degree days (GDD) for 2010. Growing degree days base 50 for May through September, 2010, are in (Table 3) and growing degree days base 40 for May through September, 2010, are in (Table 4). The total GDD base 50 for 2010 was 2531 (Table 3), which is over 200 degree days higher than the 10-year average. The total GDD base 40 for 2010 was 3979 (Table 4).

Table 3. Growing Degree Days* - Base 50°F.

	Cumulative Monthly Totals				
Year	May	June	July	August	September
2001	317	808	1441	2079	2379
2002	319	903	1646	2214	2613
2003	330	762	1302	1922	2256
2004	245	662	1200	1639	2060
2005	195	826	1449	2035	2458
2006	283	765	1444	2016	2271
2007	358	926	1494	2084	2495
2008	205	700	1298	1816	2152
2009	247	700	1133	1622	1963
2010	**352**	**857**	**1561**	**2231**	**2531**
10-Year Average	285	791	1397	1966	2318

Table 4. Growing Degree Days* - Base 40°F.

	Cumulative Monthly Totals				
Year	May	June	July	August	September
2006	532	1310	2298	3180	3707
2007	639	1503	2379	3277	3966
2008	447	1240	2147	2973	3596
2009	519	1264	2004	2800	3420
2010	**610**	**1411**	**2424**	**3402**	**3979**
2011					
2012					
2013					
2014					
2015					
10-Year Average	549	1346	2250	3126	3734

*2001-2010 data from the weather station at MSU Montcalm Research Farm (Michigan Automated Weather Network System Entrican, MI.)

PREVIOUS CROPS, SOIL TESTS AND FERTILIZERS

The general potato research area utilized in 2010 was rented from Steve Comden, directly to the West of the Montcalm Research Farm. This acreage was planted to a field corn crop in the spring of 2009 and harvested fall 2009 with crop residue disked into the soil. In the spring of 2010, the recommended rate of potash was applied in addition to 2 tons/A of dried chicken litter. These products were disked into the remaining corn residue. The chicken litter nutrient analysis was 4-3-2-8%Ca with a carbon to nitrogen ratio of 6.9:1. The ground was deep chiseled, disked and direct planted to potatoes. The area was not fumigated with Vapam prior to potato planting, but Vydate was applied in-furrow at planting. Early potato vine senescence was not an issue in 2010.

The soil test analysis for the general crop area was as follows:

	lbs/A			
pH	P_2O_5	K_2O	Ca	Mg
6.1	274 (137 ppm)	302 (151 ppm)	796 (398 ppm)	132 (66 ppm)

The fertilizers used in the general plot area are as follows. (Variances in fertilizers used for specific research projects are included in the individual project reports.)

Application	Analysis	Rate	Nutrients (N-P_20_5-K_20-Mg)
Broadcast at plow down	0-0-21-10	200 lbs/A	0-0-42-20
	10%B	10 lbs/A	1 lbs B
At planting	28-0-0	23 gpa	71-0-0
	10-34-0	5 gpa	6-20-0
At cultivation	28-0-0	25 gpa	77-0-0
At hilling	46-0-0	150 lbs/A	69-0-0
Late side dress (late varieties)	46-0-0	100 lbs/A	46-0-0

Magnesium and Sulfur were applied on July 14 in the form of Magnesium Sulfate (with an analysis of 9.8% Mg and 12.9% S) for a total application of 10 lbs/A. The composite nutrient value resulted in 1 lb actual Mg and 1.3 lbs of S being applied per acre on the potato production area.

Calcium and Nitrogen were applied July 20th and 26th in the form of liquid Calcium Nitrate (with an analysis of 30% Ca and 25% N) for a total application of 14 gpa. The composite nutrient value resulted in 46 lbs actual Ca and 39 lbs of N being applied per acre on the potato production area.

HERBICIDES AND PEST CONTROL

A pre-emergence application of Lorox at 1.5 lbs/A and Dual at 1.33 pints/A was made in late May. A post-emergence application of Sencor at 1/3 lb/A and Matrix at 1 oz/A was made in mid-July.

Admire and Vydate were applied in-furrow at planting at a rate of 8 fl oz/A and 2 quarts/A, respectively.

Two foliar applications of Vydate were made on June 24th and July 9th at the rate of 1 quart /A.

Fungicides used were; Bravo, Tanos and Manzate over 11 applications.

Potato vines were desiccated with Reglone in early September at a rate of 2 pints/A.

2010 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. 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 Farm, Lake City Experiment Station, Muck Soils Research Farm, 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). 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 solids, insect resistance, disease resistance and nutritional enhancement. 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 addition of the SolCAP translational genomics project, funded through the USDA, will enhance our abilities to identify important traits and then breed them into elite germplasm. The SolCAP project has developed a new set of genetic markers (8,300) called SNPs that are located in the genes and we can use for linking to traits of interest such as dry matter content, low reducing sugars, bright skin, disease resistance, etc. The USPB is supporting national early generation trials called the National Coordinated Breeder Trial (NCBT) which will feed lines into the SFA trial.

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 the grower's 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 Muck Soils Research Farm for late blight testing (now moving to Clarksville), 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 Farm, new land at the Lake City Experiment Station along with a well for irrigation and expanded land at the Montcalm Research Farm 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.

PROCEDURE

I. Varietal Development

The MSU breeding program has been operating for over 20 years and we feel that we have reached a point of "clarity and focus". We have the genetic variation to combine tuber shape, skin type, scab resistance and low sugars, yield and storability as well as late blight resistance. We have increased our standards for what we consider a commercial selection because of this clarity and focus. In addition, 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 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. The new NCBT in 2010 allowed us to test the over 40 MSU lines at 8 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. Five of these are in commercial seed production (MSJ126-9Y, MSH228-6, MSL292-A, MSR061-1 and MSQ070-1). At least 2 can store at temperatures below 50F and maintain low sugars until June.

Each year the MSU breeding program will cross elite germplasm to generate and evaluate 50,000 new seedlings for adaptation to Michigan. In the subsequent years these selections are then advanced to 12-hill, 30-hill, 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 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 500 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 or PVY expressing 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 Farm, 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.

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 16 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*), drought resistance (*CBF1*), PVY, late blight resistance from *S. microdontum*, and lower reducing sugars with acid invertase gene silencing.

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 2010 field season, progeny from over 500 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 2010 harvest, over 1,200 selections were made from the 50,000 seedlings produced. All potential chip-processing selections will be tested in January and April 2011 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 300 and 60 selections were made, respectively. 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.

Chip-Processing

Over 80% of the single hill selections have a chip-processing parent in their pedigree. Our promising chip-processing lines are MSJ147-1, MSH228-6 (moderate scab resistance), MSJ126-9Y (scab resistant), MSL007-B (scab resistance), MSR169-8Y (scab resistant), MSQ086-3, (late blight resistant), MSL292-A, MSR061-1 (scab and PVY resistant) and MSQ070-1 (scab and late blight resistant). Other new promising lines include MSP270-1 (scab resistant), MSP516-A (scab and late blight resistant), MSR036-5 (scab and late blight resistant), MSR127-2 (scab resistant) and MSQ279-1 (scab resistant).

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 are planning to release four lines for the specialty market (MSN215-2P, MSR226-1RR, MSQ425-4PY and Midnight). 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 2010, while others were tested under replicated conditions at the Montcalm Research Farm. Promising tablestock lines include MSL211-3, MSQ440-2, MSM182-1 and 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 late blight and moderate scab resistance with a bright skin. We are using these russets as parents in the breeding program to combine the late blight and scab resistance. Some newer lines with promise include the high yielding round white line MSQ279-1 (scab resistant), MSQ440-2 (scab resistant) and MSN230-6RY (scab and late blight resistant). MSM288-2Y is a bright yellow flesh selection similar in type to Yukon Gold. MSS544-1R is a new scab resistant red skinned table potato. Some new pigmented lines are MSS576-05SPL (red splash) and Michigan Red and Purple Splash. MSQ558-2RR and MSR226-1RR are red fleshed chippers and Midnight is a purple-fleshed chipper.

Early harvest breeding material screen

In 2010, we had a second 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 90 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 191 lines, we were able to identify some promising early breeding lines for the out-of-the-field chipping and tablestock use. **Table 1** (*next page*) 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 2011. Some of these lines are MSQ035-3, MSQ086-3 and MSR127-2. We also identified some desirable early tablestock lines among this material tested. These lines are MSL211-3, MSM182-1, MSM288-3Y, MSQ440-2 and MSS576-05SPL.

Table 1 Early Observation Trial: Most promising lines.

Line	1=Good; 4=Bad Merit	Total Weight (kg)	Specific Gravity	OTF Chip	8/16/10 MAT	Female	Male
Atlantic	**2**	**9.88**	**1.088**	**2.0**	**2.0**		
FL1879	**2**	**6.26**	**1.068**	**1.0**	**2.5**		
Kalkaska (J036-A)	**2.5**	**7.62**	**1.073**	**2.0**	**2.5**		
Snowden	**2**	**8.46**	**1.079**	**1.5**	**2.5**		
Michigan Purple	1.5	9.10	1.066	-	1.0	-	-
MSL211-3	1	11.14	1.070	-	2.0	MSG301-9	J. Lee
MSM182-1	2	6.78	1.059	-	2.5	Stirling	NY121
MSM288-2Y	2	9.94	1.067	1.5	2.5	MSG145-1	MSA097-1Y
MSN215-2P	1.5	6.97	1.064	-	2.0	MI Purple	Norland
MSNDU045-1	2	7.39	1.057	1.5	2.0	-	-
MSQ035-3	2	9.44	1.075	1.0	3.0	MSG227-2	Missaukee
MSQ086-3	2	9.09	1.076	1.0	3.0	Onaway	Missaukee
MSQ341-BY	2	7.11	1.071	1.0	2.5	MSJ126-9Y	NY120
MSQ425-4Y	2	9.66	1.069	-	2.5	MSG147-3P	MSJ319-1
MSQ440-2	1.5	8.78	1.060	-	2.5	MSK214-1R	Missaukee
MSQ461-2PP	2	9.26	1.074	1.5	3.0	NY120	POROOPG2-16
MSR089-9Y	2	7.79	1.080	1.0	3.0	MSJ319-1	OP
MSR127-2	2	8.04	1.077	1.5	3.0	MSJ167-1	MSG227-2
MSR214-2P	2	5.59	1.083	-	3.0	ND5084-3R	MSJ317-1
MSR219-2R	2	5.68	1.055	-	2.5	NDTX4271-5R	Stirling
MSR241-4RY	2	5.93	1.073	-	2.5	PoorpG9-3	MN96013-RY
MSS258-1	2	6.28	1.061	1.5	2.5	MSH098-2	MSH228-6
MSS576-05SPL	1	9.74	1.066	-	2.5	MSI005-20Y	MSL211-3
MSU161-1	2	7.09	1.068	2.5	3.0	MSM182-1	MSL211-3
MSU200-5PP	2	4.16	1.057	1.5	3.0	MSN111-4PP	NDTX4271-5R
MSU278-1Y	1.5	8.01	1.060	2.5	3.0	Torridon	MSL211-3
Reba	2	8.15	1.067	-	2.5	-	-

Disease and Insect Resistance Breeding

Scab: Disease screening for scab has been an on-going process since 1988. In 2010 we added an on-farm trial and a new site at the Montcalm Research Farm for scab evaluation. Some of results are summarized in **Table 2**. The susceptible checks of Snowden and Atlantic were highly infected with pitted scab. Interestingly, Onaway had pitted lesion in the on-farm field. Promising resistant selections were CO95051-7W, MSJ126-7Y, MSH228-6, MSL007-B, MSR061-1, MSR169-8Y, MSP270-1, MSQ279-1 and MSQ440-2. The high level of scab infection at the on-farm site with a history of scab infection and MRF helped with our assessment of resistance and susceptibility. Results from the 2010 MSU scab nursery were not used because the level infection was too low. We also had to drop our scab inoculation study to examine factors to increase scab in the field because of low infection on the tubers! The MRF scab site was used for assessing scab susceptibility in our advanced breeding lines and early generation material. Of the advanced breeding lines 60 of 160 lines evaluated had a scab rating of 1.0 or less (better than Pike). The single observation early generation assessment for scab resistance among our breeding material was very good. In 2010, 97 of 227 early generation selections showed strong scab resistance (rating of 1.0 or better). 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.

We have been conducting trials in the NFT system to identify the conditions and inoculation method that optimizes tuberization and infection of a scab susceptible cultivar. Previous trials were conducted at the MSU Crops Barn and resulted in poor tuberization and thrip infestations. For the spring, 2010 trial the NFT system was moved to our greenhouse in order to better control the intensity of light, the day-length and insect pressure and thereby improve tuberization. In general, each plant produced 1 mini-tuber with some plants producing two to three mini-tubers. We also tried using plastic cups for this trial rather than peat pots. This was done so that we could monitor stolon development and be better able to time the application of the inoculum. The plastic cups did allow us to see the stolons developing but may have contributed to the poor vigor of the plants and an unexpected number of rotten tubers.

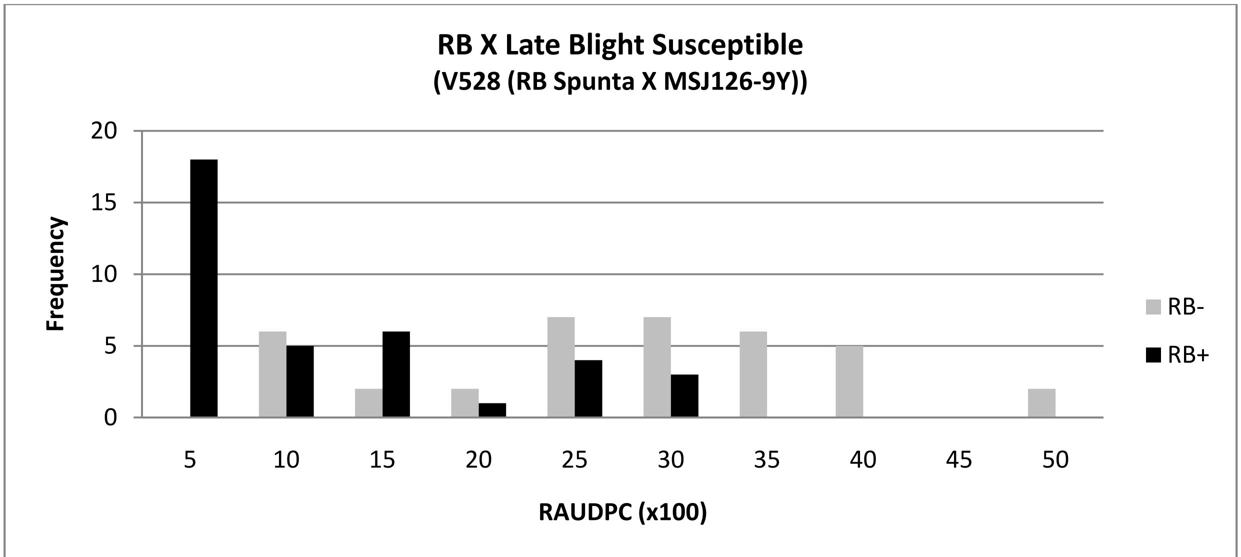
In Atlantic, as expected, the controls were basically uninfected and the inoculated plants yielded high numbers of infected tubers (92 to 100% infection rates). However, based on the scab index rating, there was no difference in the amount of disease between tubers subjected to inoculated vermiculite (2.4 scab index rating) and those that were drenched in addition to the inoculated vermiculite (2.5 scab index rating). In Liberator, 22% of the control tubers were infected (small patches of raised lesions), 92% of the tubers in inoculated vermiculite were infected and 72% of the tubers that were drenched were infected. Based on scab index ratings, there was no difference between tubers in inoculated vermiculite (1.6 scab index rating) and those that were drenched (2.4 scab index rating).

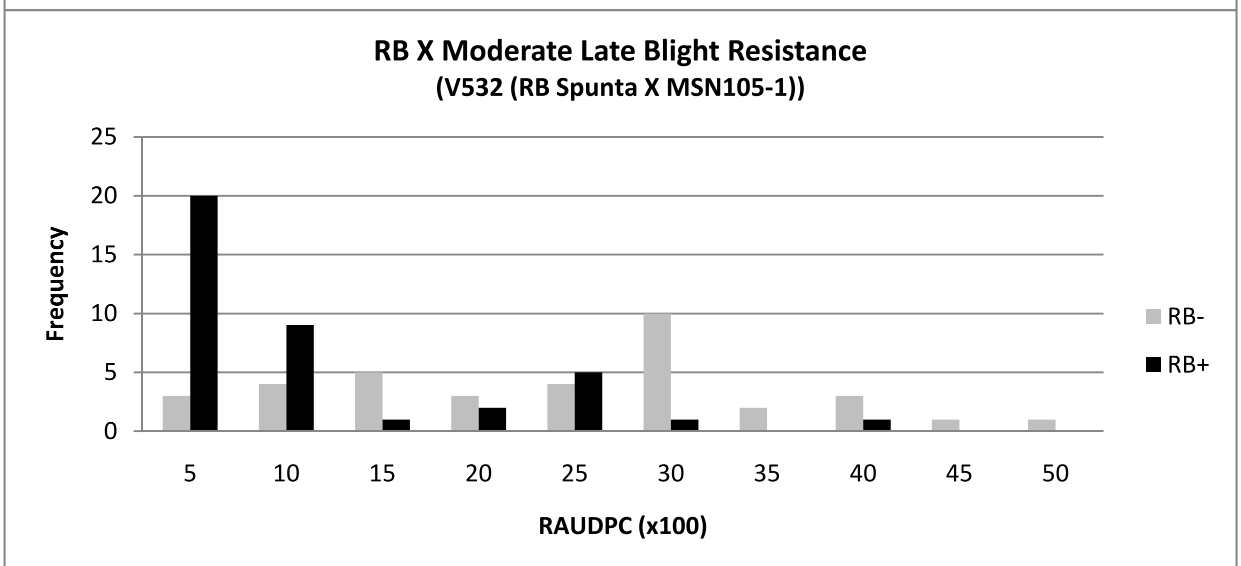
Based on the results of this study we will continue to conduct NFT trials in the greenhouse under the same growing conditions. However, we will revert to using peat pots rather than plastic cups. Not only were the plastic cups difficult to prepare, they retained more water and impeded the solution flow through the troughs allowing nutrient solution to stand in the troughs. This likely contributed to poor plant vigor and tuber rot. As there was no difference in the amount of disease between the 2 inoculation methods, we will use inoculated vermiculite in subsequent trials but will drench the plants once (3 weeks after the vermiculite is added to the pots) to ensure high concentrations of inoculum. We feel as though we have optimized the system and are ready to conduct replicated trials on multiple breeding lines. The NFT study is supported through Project GREEEN.

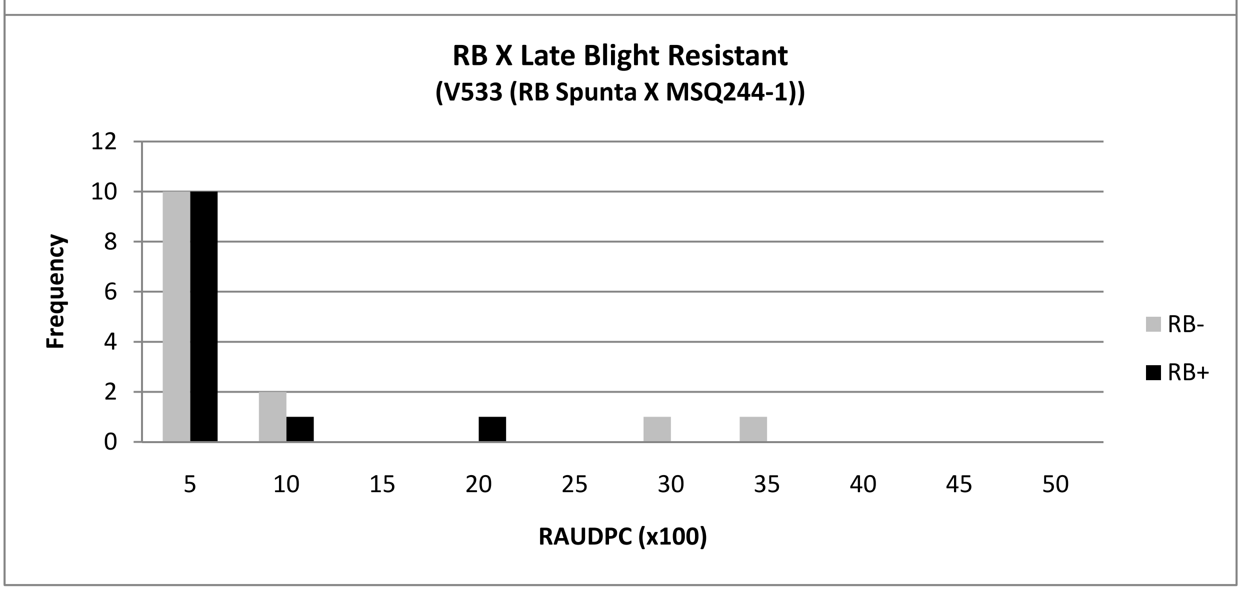
Table 2. *Streptomyces* Scab Trial Results from three trial locations.

		Location	
Line	**On Farm**	**Montcalm**	**Campus**
Chip-processing Lines			
Atlantic	**3.8**	**2.9**	**2.0**
Snowden	**3.0**	**2.9**	**1.5**
Beacon Chipper	**3.0**	**2.0**	**1.0**
Kalkaska	**1.8**	**1.5**	**0.5**
Pike	**1.5**	**1.1**	**0.9**
CO95051-7W	1.0	1.5	1.0
MSJ126-9Y	1.0	1.0	1.0
MSH228-6	2.0	1.0	1.0
MSL007-B	2.0	1.0	1.0
MSJ147-1	1.3	1.3	1.0
MSL292-A	3.5	2.5	1.5
MSR061-1	1.6	1.3	1.0
MSQ070-1	1.5	1.3	0.5
MSP270-1	1.0	1.0	0.5
MSQ035-3	1.8	1.0	1.0
MSR169-8Y	2.0	1.0	0.5
MSQ279-1	1.3	1.3	1.0
Mean	*1.9*	*1.5*	*1.0*
Tablestock Lines			
Onaway	2.3	2.1	0.8
MSL211-3	2.3	2.2	1.7
MSQ176-5	3.5	3.0	1.5
MSN215-2P	1.0	1.0	0.0
MSQ440-2	1.3	1.8	0.5
Mean	*2.1*	*2.0*	*0.9*

Late Blight: Our specific objective was 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. In 2010 we conducted late blight trials at the Muck Soils Research Farm. We inoculated with the US8 genotype, but the foliar reaction to the *Phytophthora infestans* was different from all previous years. 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 2010. This difference in late blight reaction could be attributed to the US22 genotype that was found in fields in Michigan. In the 2010 trials, 39 of 139 early generation lines were resistant to late blight comprised of 15 sources of late blight resistance. Of the 157 advanced breeding lines and varieties tested, 37 were resistant. 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. We used marker-assisted selection strategies to combine a resistance QTL through conventional breeding. One approach to breeding for foliar resistance to late blight is to use interploidy (4x-2x) crosses to introgress the late blight resistance from *Solanum microdontum*. Eight of 10 4x-2x selections were resistant combining resistance from *S. microdontum* and varieties Stirling and Jacqueline Lee. At the diploid level 18 of 30 2x selections were resistant that combine resistance genes from *S. berthaualtii* and *S. microdontum*. 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. *Agrobacterium*-mediated transformation has been used to introgress the RB gene, cloned from *Solanum bulbocastanum*, into susceptible cultivars. We have crossed these lines with the conventionally-bred resistant lines and applied the same marker-assisted selection strategies to characterize the lines that may be combining late blight resistance R-genes. Twelve of 20 4x selections express the RB gene for resistance to late blight in the 2010 trials. In addition, we compared three crosses for their late blight reaction when segregating for the RB gene. Spunta-RB (a late blight resistant transgenic line) was crossed to susceptible (MSJ126-9Y), moderately resistant (MSN105-1) and resistant (M244-1) line. Progeny were determined to be carrying the RB gene (RB+) or not (RB-). Foliar late blight reaction was measured on each individual in the cross over three replications. The crosses segregating for late blight resistance genes gave us valuable information. The data is summarized in the three figures. In all three crosses the majority of the RB progeny were resistant to late blight. The frequency of progeny with late blight resistance increased in relation to the late blight resistance of the parent crossed to Spunta-RB. The cross with only one resistant gene had a few progeny with late blight resistance. The lines with at least two resistant genes segregating had a much higher frequency of progeny with a high level of resistance to late blight. For example, only 6 of the 26 progeny in the Spunta-RB x MSQ244-1 cross were classified as susceptible. This study supports our breeding efforts to combine resistance genes to late blight to achieve more durable resistance. This is a GREEN-funded project.


RB X Late Blight Susceptible
(V528 (RB Spunta X MSJ126-9Y))
Frequency
RAUDPC (x100)
RB-
RB+
0
5
10
15
20
5
10
15
20
25
30
35
40
45
50


RB X Moderate Late Blight Resistance
(V532 (RB Spunta X MSN105-1))
Frequency
RAUDPC (x100)
RB-
RB+
0
5
10
15
20
25
5
10
15
20
25
30
35
40
45
50


RB X Late Blight Resistant
(V533 (RB Spunta X MSQ244-1))
Frequency
RAUDPC (x100)
RB-
RB+
0
2
4
6
8
10
12
5
10
15
20
25
30
35
40
45
50

Colorado potato beetle: With support from GREEEN, we conducted our Colorado potato beetle resistance screening. In 2010 we focused on screening our selections with detached leaf bioassays (no-choice) and screening new genetic material for resistance. The new species were screened through detached leaf bioassays and screened field cages. Some breeding lines were at least moderately resistant or showed reduced susceptibility to Colorado potato beetle in the detached leaf bioassays. In the field cages, the adults that were added to the cages clipped the leaves on some of the lines. We have seen this behavior previously when we have strong resistance but the beetles have no choice. We need to repeat the testing of some of these lines in 2011 and study larval behavior. Some of these lines are beginning to enter the preliminary trials in the breeding program and are being used as parents for further breeding. We have been using the moderately resistant breeding lines for crossing and we have been selecting seedling with improved tuber appearance. Combining host plant resistance to insects in a commercially acceptable line is a great challenge.

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 two 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 2009 and 2010. These early generation selections will be further evaluated in 2011 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 2009 - June 2010)

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 11 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 2009, tuber samples from 19 MSU lines from the Montcalm Research Farm and Lake City Experiment Station trials were placed in the bins along with four check varieties. The first samples were chip-processed in October and then 8 more times until June 2010. Samples were evaluated for chip-processing color and defects. **Table 3** summarizes the chip-processing color and scab rating of 19 lines and four check varieties (Atlantic, FL1879, Pike and Snowden) over the 7-month storage season. From November a number of lines had poor chip color that was attributed to the cold harvest conditions of some of the lines (Kalkaska, MSQ035-3, MSR102-3, MSR159-02, MSR058-1 and MSQ131-A). Other lines chip processed well from the storage until April. The lines that chip processed well until May were MSP459-5, MSP270-1 and MSR061-1.The lines that chip processed exceptionally well until June were MSH228-6, MSJ126-9Y, MSL292-A, and Pike. These lines are highlighted in the table. We are that some of the lines with good chip quality also have scab resistance and/or late blight resistance.

Table 3: 2009-2010 Demonstration Storage Chip Results of Elite MSU Breeding Lines

			11/10/09	12/9/09	1/5/10	2/1/10	3/1/10	4/7/10	5/10/10	6/2/10
		2010	SFA Chip Score Rating Scale 1-5							
Line	**Resistance**	Scab	56 F	55 F	55 F	55 F	55 F	55 F	54 F	54 F
Atlantic		**2.9**	**2.0**	**1.5**	**1.5**	**1.5**	**1.0**	**1.5**	**ND**	**ND**
Beacon Chipper	ScabMR	2.0	1.0	1.5	1.0	1.0	1.5	2.5	2.5	2.5
FL1879		**3.5**	**1.5**	**1.0**	**1.0**	**1.0**	**1.5**	**1.0**	**1.5**	**2**
Kalkaska	ScabR	1.5	2.5	2.0	2.0	2.0	1.5	2.0	2.5	2.5
MSH228-6	ScabR	1.0	1.0	1.0	1.5	1.5	1.5	1.5	1.0	1.5
MSJ126-9Y	ScabR	1.0	1.0	1.0	1.5	1.0	1.5	1.0	1.0	1.5
MSJ147-1	ScabMR	1.3	1.0	1.0	1.5	1.0	1.0	1.5	2.0	2
MSK061-4	ScabR	-	1.0	1.0	1.5	1.0	1.0	1.5	2.5	3
MSL292-A		2.5	1.0	1.0	ND	1.0	2.0	ND	1.0	1.5
MSN148-A	ScabMR	1.5	1.0	1.0	1.0	1.0	1.5	2	2.5	3.5
MSP459-5		3.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	ND
MSP270-1	ScabR	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.5	2
MSQ035-3	ScabR, LBR	1.0	3.0	2.0	2.0	1.5	2.5	2.0	1.5	2
MSQ070-1	ScabR, LBR	1.3	1.0	1.0	1.0	1.0	1.0	1.5	2.0	2.0
MSQ131-A	LBR	-	3.0	2.0	2.0	2.0	2.0	ND	ND	ND
MSQ461-2PP		2.0	1.0	1.0	1.5	1.5	1.5	1.5	1.5	2
MSR036-5	ScabR, LBR	1.0	3.5	2.5	2.5	2.5	2.5	2.5	3.0	3
MSR058-1	ScabMR, MRLB	1.5	3.0	2.0	2.0	2.0	2.0	2.0	1.5	2.5
MSR061-1	ScabR, LBR, PVYR	1.3	1.0	1.5	ND	1.0	1.0	1.5	1.5	ND
MSR102-3	LBR ScabR	1.0	2.5	1.0	1.5	1.5	1.0	1.5	ND	2
MSR159-02	MRScab	2.0	3.0	ND	2.0	ND	2.5	2.0	2.0	2.5
Pike	**ScabR**	**1.1**	**1.0**	**ND**	**1.0**	**1.0**	**1.5**	**1.0**	**2.0**	**1.5**
Snowden		**2.9**	**2.5**	**1.5**	**1.5**	**1.0**	**1.0**	**2.5**	**3.0**	**3**

Early generation sugar profiling was also conducted on a series of MSU advanced breeding lines. These glucose and sucrose sugar profiles are presented in Figures 1 and 2. The results confirm the good storage potential of MSJ126-9Y, MSH228-6 and MSL292-A. MSJ147-1 has stored longer in 2010 than 2009. The long storability advantage has been compromised by the average or below average yield in commercial fields. Of the newer advanced breeding lines tested MSQ070-1 and MSR061-1 showed promising sugar profiles. Both lines exhibit scab resistance.

During the 2009-10 storage season the MPIC/MSU conducted studies to examine acrylamide content in potato chips made from Snowden and three MSU advanced breeding lines stored in the MPIC commercial storage bins. Samples were collected every two weeks starting in December and continued for a total of 6 dates. The tuber samples were sent to MSU, TechMark and four commercial processors for chip processing. The commercial processors processed the potatoes as continuous and kettle chips. The chips were sent to MSU for acrylamide sampling. The ground chip samples were sent to the University of Wisconsin for acrylamide analysis. From this study we learned that variety, processor and process type (continuous vs. kettle) influences acrylamide levels in the chips. The oil temperature and dwell time were also important. Glucose levels were not as important within the range of values we observed (0.001-0.005%). Kettle chips, fried at lower temperatures, had lower acrylamide levels. One variety had an average of 230 ppb acrylamide in the kettle chips. A second study looked at more varieties over the storage season, but the chip samples evaluated for acrylamide were processed at TechMark. Variety differences were observed. 2009 was an unusually cool growing season. Many potatoes went into storage as immature tubers. This condition may have had an influence on the reducing sugar content in the tubers. 2010 has been a warm growing season and the tubers matured much faster.

Table 4. Overall Analysis of Variance of main effects means for acrylamide for variety, process-type, and processor effects.

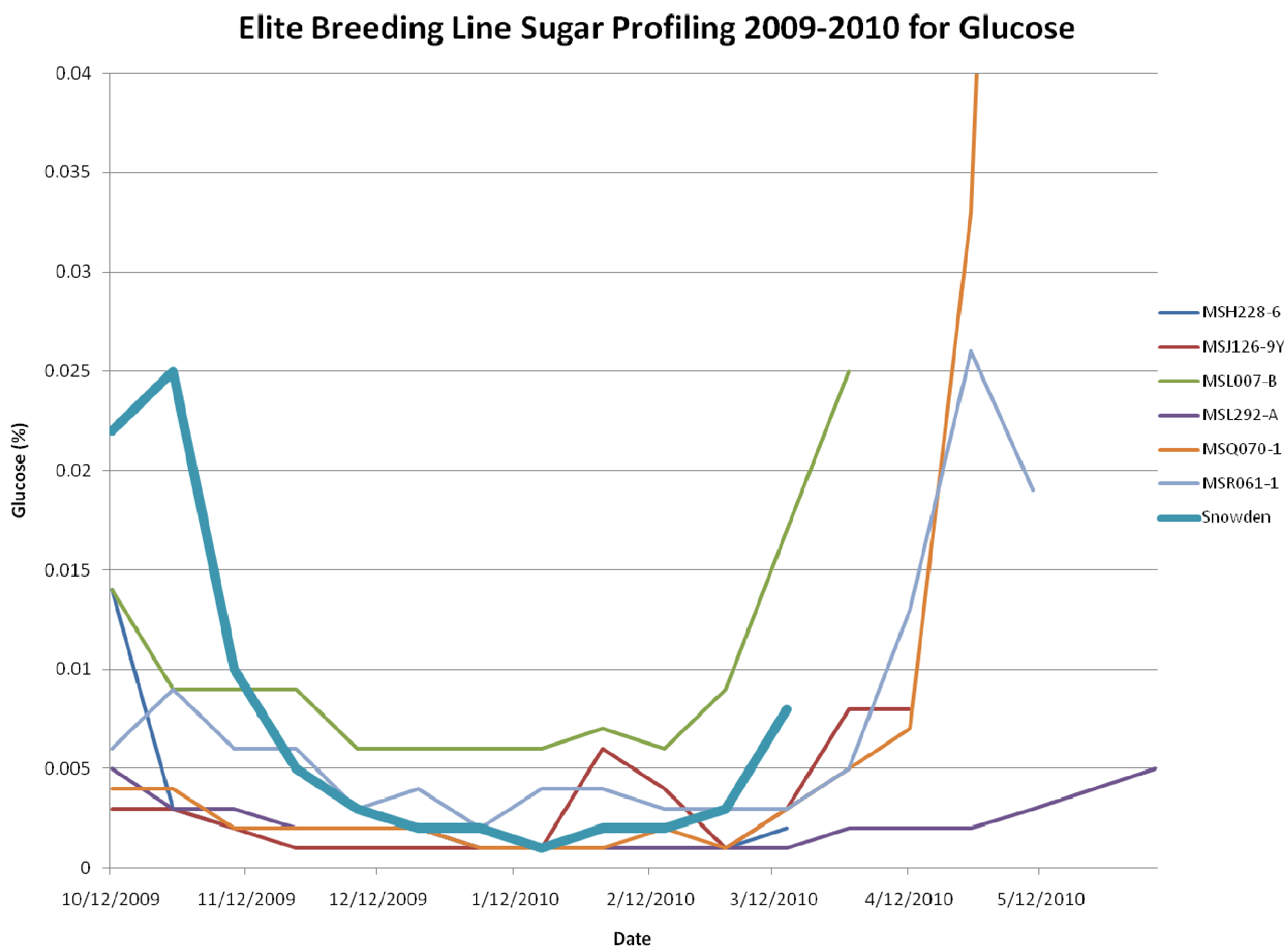
Overall ANOVA of Main Effects for Acrylamide

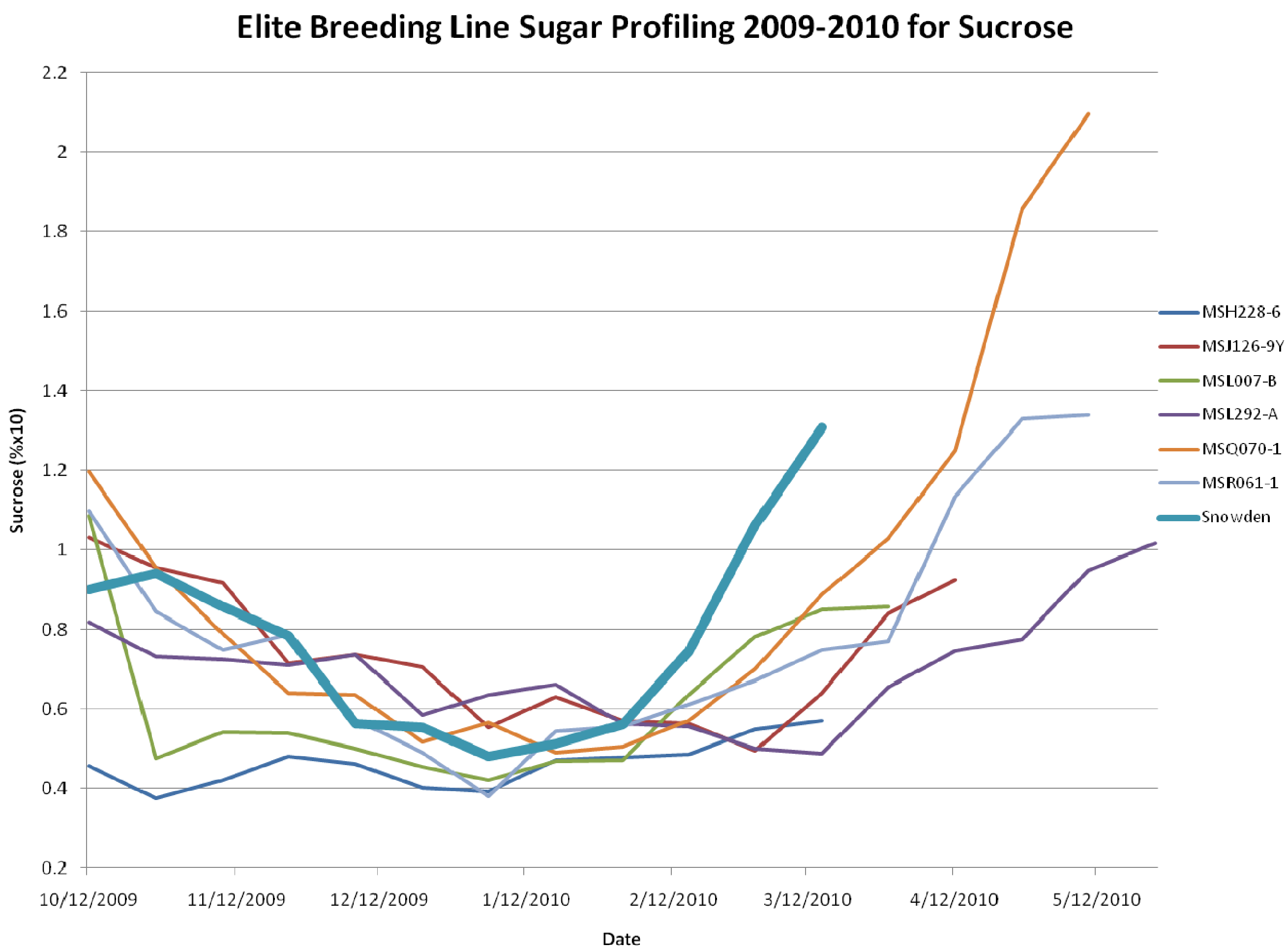
				Acrylamide (ppb)
Variety Effect				
Variety 2	A			708
Variety 1	A	B		644
Variety 4		B		552
Variety 3			C	401
Process-type Effect				
Continuous	A			733
Test Batch	A			635
Kettle		B		395
Processor Effect				
Processor 2	A			780
Processor 5	A			679
Processor 6	A	B		594
Processor 1		B		489
Processor 4		B		469
Processor 3		B		463

*Effects were analyzed separately. Effects with the same letter are not significantly different at $\alpha=0.05$.

We propose to conduct a follow up study to the 2009 season so that we can have a better understanding of the season effect on acrylamide formation in the chips. We will examine three potato lines: Snowden, MSJ147-1 and NY139. We will sample the tubers every four weeks during the storage season until the tubers reach physiological maturity. The tuber samples will be processed by TechMark and one commercial processor. The chips will be sent to MSU for processing and the University of Wisconsin will run the acrylamide analysis.

Snowden and MSJ147-1 are chosen because these two lines were the best lines for maintaining low acrylamide levels in the 2009-10 storage season. We need to make direct comparisons to that year. We will also include NY139 because of Michigan's commercial interest in this line.





National Coordinated Breeder Trial (NCBT)
2010 was the first 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 8 sites (North: NY, MI, WI, ND and South: NC, FL, TX, CA) in addition to a scab trial in MN. A total of 220 lines were tested as 15-hill single observation plots. The lines were evaluated for tuber type and appearance, yield, specific gravity, chip color and chip defects. 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 2011 and new early generation lines will be added. **Table 5** summarizes the data of the location merit rating. Three checks (Atlantic, Snowden and Megachip) and 68 lines are included in the table. Lines that received a high merit rating in at least two locations are included in the table. Those lines that had a high rating in at least two southern locations are highlighted in yellow. Those lines that had a high rating in at least two northern locations are highlighted in green. Those lines that had a high rating in at least two northern and southern locations each are highlighted in blue. MSU had 19 of the 68 lines in the table. Moreover, the MSU lines were more scab resistant than the lines from the programs. Some of the promising lines are MSL007-B, MSR169-8Y, MSR058-1, MSR127-2, MSR148-4 andMSS165-2Y. Beacon Chipper also showed merit in the northern sites.

Table 5. National Coordinated Breeder Trial (NCBT) Overall merit ranking summary.

				Merit									Merit					
				Location - South				Location - North				Scab	South	North	Overall	South	North	Overall
Line	Female	Male	Program	CA	FL	NC	TX	MI	NY	ND	WI	MN	Mean	Mean	Mean	Count	Count	Count
MSL007-B	MSA105-1	MSG227-2	MSU-MI	2	2			2	2	1	2	MR	2.0	1.8	1.8	2	4	6
CO02321-4W	A91790-13	S440	CSU-CO			1	3	1	2	1		SUSC	2.0	1.3	1.6	2	3	5
MSR058-1	Megachip	MSJ319-1	MSU-MI		2		3	2	1		2	MR	2.5	1.7	2.0	2	3	5
NYE106-4	NY128	MARCY	Cornell-NY	1			2	1	2	2		R	1.5	1.7	1.6	2	3	5
NYE50-8	V101-9	NY115	Cornell-NY	2		4		1		2	2	SUSC	3.0	1.7	2.2	2	3	5
Atlantic			**Check**	**1**		**4**	**1**	**1**	**1**			**SUSC**	**2.0**	**1.0**	**1.6**	**3**	**2**	**5**
MSR169-8Y	Pike	MSJ126-9Y	MSU-MI	2	2		3	1		2		R	2.3	1.5	2.0	3	2	5
MSS165-2Y	MSM188-1	MSL159-AY	MSU-MI		2	1		2		2		R	1.5	2.0	1.8	2	2	4
MSK409-1	MSC148-A	Liberator	MSU-MI	2	1	4					2	MR	2.3	2.0	2.3	3	1	4
MSR127-2	MSJ167-1	MSG227-2	MSU-MI		2			1	2		2	R	2.0	1.7	1.8	1	3	4
AC01151-5W	A91790-13	NDTX4930-5W	CSU-CO	1				2		2		SUSC	1.0	2.0	1.7	1	2	3
Beacon Chipper	UEC		MSU-MI			4		2			2	SUSC	4.0	2.0	2.7	1	2	3
MSM246-B	MSE274-A	NY115	MSU-MI	1				1		2		SUSC	1.0	1.5	1.3	1	2	3
ND8331Cb-3			NDSU-ND	1				2		2		SUSC	1.0	2.0	1.7	1	2	3
NYG20-58	ANDOVER	NY119	Cornell-NY		1				2	2		SUSC	1.0	2.0	1.7	1	2	3
NYG20-63	ANDOVER	NY120	Cornell-NY	1				2	1			SUSC	1.0	1.5	1.3	1	2	3
NYG86-1	NY138	C956-1	Cornell-NY	2					2	3		SUSC	2.0	2.5	2.3	1	2	3
NYG87-3	NY139	MARCY	Cornell-NY		2				2		2	MR	2.0	2.0	2.0	1	2	3
Snowden			**Check**		**2**			**1**	**1**			**SUSC**	**2.0**	**1.0**	**1.3**	**1**	**2**	**3**
A-32	Superior	Snowden	UoWI-WI			3.5	3		2			SUSC	3.3	2.0	2.8	2	1	3
B2721-78			USDA-MD			4	2			2		SUSC	3.0	2.0	2.7	2	1	3
BNC202-7			USDA-MD		2	1			2			ND	1.5	2.0	1.7	2	1	3
CO02024-9W	BC0894-2W	A91790-13	CSU-CO			2	2		2			SUSC	2.0	2.0	2.0	2	1	3
MSL292-A	Snowden	MSH098-2	MSU-MI		1		3	1				susc	2.0	1.0	1.7	2	1	3
MSR148-4	MSI152-A	Dakota Pearl	MSU-MI	1	2			1				SUSC	1.5	1.0	1.3	2	1	3
NYG20-30	ANDOVER	NY115	Cornell-NY		2		3			2		SUSC	2.5	2.0	2.3	2	1	3
B2721-101			USDA-MD					2	2			SUSC	-	2.0	2.0	0	2	2
B2721-13			USDA-MD							2	2	SUSC	-	2.0	2.0	0	2	2
MSR128-4Y	MSJ167-1	MSJ126-9Y	MSU-MI					2	2			SUSC	-	2.0	2.0	0	2	2
NYF57-3	WHITE PEARL	NY115	Cornell-NY					2		2		SUSC	-	2.0	2.0	0	2	2
NYG20-31	ANDOVER	NY115	Cornell-NY					2		2		SUSC	-	2.0	2.0	0	2	2
NYG20-41	ANDOVER	NY116	Cornell-NY					2	2			SUSC	-	2.0	2.0	0	2	2
NYG20-55	ANDOVER	NY117	Cornell-NY							1	2	MR	-	1.5	1.5	0	2	2
NYG20-56	ANDOVER	NY118	Cornell-NY						2		2	SUSC	-	2.0	2.0	0	2	2
NYG89-2	NY139	C956-1	Cornell-NY						2	2		SUSC	-	2.0	2.0	0	2	2
W5955-1			UoWI-WI						2		2.5	SUSC	-	2.3	2.3	0	2	2
W8539-2			UoWI-WI						2		2	MR	-	2.0	2.0	0	2	2
W8615-5			UoWI-WI						2	3		MR	-	2.5	2.5	0	2	2
B2721-63			USDA-MD			1	1					SUSC	1.0	-	1.0	2	0	2
B2721-64			USDA-MD		1	2						SUSC	1.5	-	1.5	2	0	2
B2721-73			USDA-MD			2	1					SUSC	1.5	-	1.5	2	0	2
MSK061-4	MSC148-A	Dakota Pearl	MSU-MI	2	2							MR	2.0	-	2.0	2	0	2
MSP459-5	Marcy	NY121	MSU-MI		1		2					SUSC	1.5	-	1.5	2	0	2
MSQ130-4	Boulder	MSJ456-4Y	MSU-MI			4	3					SUSC	3.5	-	3.5	2	0	2
NYD40-50	NY121	NY115	Cornell-NY	1		3						ND	2.0	-	2.0	2	0	2
NYG20-11	ANDOVER	NY114	Cornell-NY	2			1					SUSC	1.5	-	1.5	2	0	2
NYG20-13	ANDOVER	NY115	Cornell-NY			3	3					SUSC	3.0	-	3.0	2	0	2
W8603-1			UoWI-WI	1		2						SUSC	1.5	-	1.5	2	0	2
A03471-7C	Dakota Diamond	A98399-1C	USDA-ID	1				2				SUSC	1.0	2.0	1.5	1	1	2
AC03433-1W	A94322-8C	COA96141-4	CSU-CO		1			2				SUSC	1.0	2.0	1.5	1	1	2
AF4240-3	SC9512-4	AF290-5	UoM-ME	2						2		SUSC	2.0	2.0	2.0	1	1	2
AF4254-2	A8469-5	AF290-5	UoM-ME			2		2				SUSC	2.0	2.0	2.0	1	1	2
AF4307-1	A97070-51LB	A95162-1	UoM-ME			1				2		SUSC	1.0	2.0	1.5	1	1	2
AF4363-2	A91790-13	W2309-7	UoM-ME			4				2		SUSC	4.0	2.0	3.0	1	1	2
B1992-106			USDA-MD		1			1				ND	1.0	1.0	1.0	1	1	2
B2721-121			USDA-MD			1		2				SUSC	1.0	2.0	1.5	1	1	2
B2721-18			USDA-MD				2			2		SUSC	2.0	2.0	2.0	1	1	2
B2721-40			USDA-MD				1	2				SUSC	1.0	2.0	1.5	1	1	2
B2721-67			USDA-MD			2			2			MR	2.0	2.0	2.0	1	1	2
B2721-93			USDA-MD			4				2		SUSC	4.0	2.0	3.0	1	1	2
Boulder	MS702-80	NY88	MSU-MI			3		2				SUSC	3.0	2.0	2.5	1	1	2
CO00270-7W	CO95051-7W	A91790-13	CSU-CO	1						2		SUSC	1.0	2.0	1.5	1	1	2
MegaChip			**UoWI-WI**			**2**		**1**				**SUSC**	**2.0**	**1.0**	**1.5**	**1**	**1**	**2**
MSQ035-3	MSG227-2	Missaukee	MSU-MI				3	1				MR	3.0	1.0	2.0	1	1	2
MSQ089-1	A91790-13	Missaukee	MSU-MI	1				2				SUSC	1.0	2.0	1.5	1	1	2
MSR036-5	MSL766-1	Liberator	MSU-MI		2			2				R	2.0	2.0	2.0	1	1	2
MSS026-2Y	SJ-Y7	MSJ126-9Y	MSU-MI				1	2				SUSC	1.0	2.0	1.5	1	1	2
ND7799c-1			NDSU-ND	2				2				SUSC	2.0	2.0	2.0	1	1	2
NDMN07-B322BG1			UoM-MN			4					2	ND	4.0	2.0	3.0	1	1	2
W2324-1			UoWI-WI		1				2			SUSC	1.0	2.0	1.5	1	1	2
W2717-5			UoWI-WI				3	2				R	3.0	2.0	2.5	1	1	2
71				21	20	26	21	36	24	25	13		2.0	1.8	1.9	88	98	186

69 lines with 2 or more merit scores
2 checks: Snowden and Atlantic

select for both	7
select for north	22
select for south	18
one select in N and S	23

Variety Release

We released MSJ461-1 as Missaukee (late blight, golden nematode and verticillium wilt resistant round white) in 2010. 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. Boulder is being commercially grown in Quebec and they now have interest in Kalkaska based upon 2 years of trials. Lastly, commercial seed of MSH228-6 and MSJ126-9Y are being produced and we will continue to seek commercial testing of these lines. MSL292-A (long-term chipper), MSR061-1 (scab, PVY and late blight resistant chipper), MSL007-B (scab resistant chipper), MSQ086-3 (late blight resistant chipper) and MSQ070-1(scab and late blight resistant chipper) are being fast-tracked for the chip-processing market. We also have a focused ribavirin-based virus eradication system to generate virus-free tissue culture lines for the industry. About 30 lines are in ribaviran treatment at this time to remove PVS and PVY. This year, about 80 new MSU breeding lines are being put into tissue culture.

MSU Variety Releases:

MSJ147-1

Parentage: NorValley X S440
Developers: Michigan State University and the Michigan Agricultural Experiment Station
Plant Variety Protection: Will be considered.

Strengths: MSJ147-1 is a round white chip-processing potato that has a bright skin, white flesh and round shape. In addition, it has been determined to store at temperatures below 50°F and maintain low reducing sugar levels into May or June.

Weaknesses: Small vine, slow to emerge.

Incentives for production: MSJ147-1 produces many A-size tubers that are low in defects, however we are seeing some HH in the large tubers this storage season. Potatoes maintain low reducing sugar content for chip-processing out of the field and from storage.

MSJ126-9Y

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.

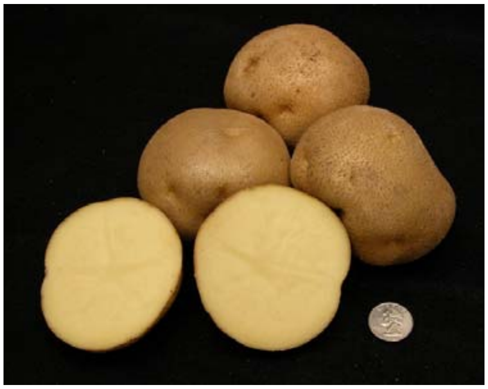
MSH228-6

Parentage: MSC127-3 x OP
Developers: Michigan State University and the Michigan Agricultural Experiment Station
Plant Variety Protection: Will be considered.

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.

MSL292-A



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

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.

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.

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

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.

MSQ176-5

Parentage: MSI152-A x Missaukee (MSJ461-1)
Developers: Michigan State University and the Michigan Agricultural Experiment Station
Plant Variety Protection: Will be considered.

Strengths: MSQ176-5 is a high-yielding freshmarket potato with bright skin and a uniform smooth, round appearance with an attractive tuber type. This variety has a strong vine and a mid-season maturity. MSQ176-5 has strong foliar resistance to the US8 genotype of late blight. MSQ176-5 also has resistance to *Streptomyces scabies* (common scab) similar to Pike.

Incentives for production: Excellent freshmarket tuber quality and type with foliar late blight resistance and common scab resistance.

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 will start to characterize these populations in 2011 and conduct the linkage analysis studies following the SNP genotyping. 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.

III. Integration of Genetic Engineering with Potato Breeding

Potato Translation Initiation Factor 4E (eIF4E) over-expression to obtain resistance to PVY in susceptible potato varieties

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Summary of the Problem

Numerous potato viruses are prevalent worldwide and can cause substantial economic losses. In the US four potato viruses PVY, PVX, PLRV and PVS are most frequently identified, but PVY and its various associated strains is the most common and economically most harmful (Valkonen 2007). These potato viruses are transmitted to the next seed generation through tubers. The use of disease-free tissue culture stocks in combination with state seed certification programs has historically been a source of clean seed to the commercial farmers, but in recent years, the level of PVY in potato certified seed lots has reached problem levels (Whitworth et al. 2005). The extensive spread of various strains of PVY have become very common in seed production due to the amount of PVY symptom-less expression varieties being grown combined with the high numbers of non-persistent PVY vectoring aphids present in potato growing regions. It is difficult to produce seed clean of PVY when the inoculum is so widely distributed throughout seed production regions.

The variety, Russet Norkotah and its line selections, make it the second most common variety in the US (NASS 2007). This variety along with Shepody and Silverton Russet are described as being symptom-less carriers of PVY. One solution to this problem is to replace these varieties with new and improved ones. Ideally these varieties would have extreme resistance to all PVY strains, but some advanced breeding lines such as A95109-1 that show great promise still have the weakness of PVY susceptibility. Resistance to PVY common and necrotic (NTN, N:O) strains is critical as the necrotic strains are present in the industry and can cause tuber defects. Michigan State University and other breeding programs are currently using the *Ry* gene to introduce extreme resistance to PVY into advanced breeding germplasm through conventional breeding combined with marker-assisted selection techniques (Gebhardt et al. 2006). It will take a significant number of years to identify, release and commercialize a new variety that will compete with the market impact of Russet Norkotah.

The conventional breeding strategy must be employed; however current technology exists to introduce PVY resistance directly into Russet Norkotah and other PVY susceptible varieties using pathogen-derived resistance (e.g. viral coat protein). NatureMark had released in the late 1990s transgenic lines of Russet Burbank that were resistant to PVY (Kaniewski and Thomas, 2003). It is well known that these and other transgenic potato lines were removed from the market in 2001 when the quick serve restaurant industry was attacked by the anti-biotech activists through media tactics to create concern among the public regarding the food and environmental safety of these potatoes (Simon 2003).

Transgenic technology has continued to advance since the 1990s and Simplot scientists have recently developed a new method to introduce native genes into potato without any additional genes or DNA sequences (Rommens *et al.*, 2004). With this technology they can create transgenic potato lines that contain only potato genes rather than genes obtained from other organisms. The public perception of this technology is much more accepting of this transformation technique that employs only the crop's genes rather than genes from other organisms such are viruses, bacteria, etc. (K. Swords pers. comm.).

Research Objectives and Research Plan

The new transgenic approach can be applied to the PVY problem in the potato industry. ***Our overall objective*** **is to conduct studies that will lead to transgenic Russet Norkotah, Silverton Russet, and A95109-1 lines that have PVY resistance conferred by a native resistance gene from potato.** Through gene mapping studies Valkonen's group was able to map the extreme resistance to PVY to Chr. 11 (Hamalainen et al. 1997). A genetic marker has been identified that co-segregates with the extreme resistance to PVY (Ry_{adg}) (Kasai et al. 2000). Valkonen's group has also made an effort to clone this PVY resistance gene (a LRR-NBS R-gene), but the over-expressed gene they cloned did not confer resistance and they theorized that another non-cloned R-gene in the hotspot on Chr. 11 may be the actual R-gene that confers resistance. In pepper a PVY resistance gene maps to Chr. 3 and provides natural resistance to PVY that is different than the R-gene resistance on Chr. 11. Ruffel et al. (2005) was able to demonstrate that the *pot-1* gene in tomato (*Solanum lycoperisicum*) is an orthologue to the *pvr2* gene in pepper. In transient expression assays, they were able to show that the eIF4E gene (referred to as *pot-1*) accounted for the resistance to PVY in tomato. **Using a comparative genomics approach, we have been able to clone the translation initiation factor 4E (eIF4E) gene from potato that may be the orthologue to the recessive PVY resistance conferred by the *pvr2* locus in pepper (*Capsicum annum*).** Our eIF4E gene, cloned from potato using the tomato *pot-1* primers has an identical sequence length and a 96% sequence homology match to the tomato orthologue that confers PVY resistance in tomato. We hypothesize that the eIF4E gene we cloned is the orthologue of the *pot-1* and *pvr2* PVY resistance genes in tomato and pepper, respectively.

Progress Report

One of the objectives of this research is to test the tomato *pot-1* (*eIF4E*) gene as a source of PVY resistance in potato. RT-PCR and cDNA amplification using gene specific primers allowed amplification of a tomato gene from *S. hirsutum* accession PI247087. The sequence of the cloned gene was identical to the Genbank sequence identified as *pot-1*(AY723736). This sequence was subsequently cloned into the Agrobacterium binary vector pSPUD4 which contains a Cauliflower mosaic virus 35S promoter (CaMV 35S) which should express the *pot-1* gene constitutively in plants. A previously cloned potato gene with over 96% sequence identity to the *S. hirsutum pot-1* gene but lacking the signature amino acid changes in key regions known to be associated with PVY resistance in pepper and tomato was sub-cloned into a pSPUD4 binary vector as well and will be used in transformations as a control.

Transformation experiments to introduce the *S. hirsutum* eIF4E gene or the potato gene into the PVY susceptible line E149-5Y were completed resulting in at least 20 independent clones for each gene. Culturing on medium containing kanamycin and PCR was used to confirm the presence of the transgene in each of the independent clones. In addition to the first round of transformation experiments, we now have 10 lines with the *S. hirsutum pot-1* gene derived from Russet Norkotah, 25 lines from Classic Russet and over 50 lines from Silverton Russet. Select lines from each of these varieties will be tested by JW this winter. Three PVY strains (O, N NTN) have been selected and increased in tobacco at Aberdeen to use for inoculation of tissue culture potato plants. Tissue culture plants (30 each) of 18 putative PVY resistant potato lines are being sent to JW for greenhouse PVY evaluation this fall.

PVY resistance to three PVY strains (O, N and NTN) of the MSE149-5Y lines was evaluated by JW in the winter of 2010. The check line was highly infected by all three strains. Of the transgenic lines, 3 lines (89-3, 89-22 and 89-26) demonstrated little to no PVY accumulated in the plants across the three PVY strains. These lines are being increased for minituber production so that field studies can be conducted in 2011.

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2010 POTATO VARIETY EVALUATIONS

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INTRODUCTION

Each year, the MSU potato breeding and genetics team conducts a series of variety trials to assess advanced potato selections from the Michigan State University and other potato breeding programs at the Montcalm Research Farm (Entrican). In 2010, we tested 182 varieties and breeding lines in the replicated variety trials, plus single observational plots of 186 lines for the Early Observational Trial and 219 lines in the National Chip Processing Trial. The variety evaluation also includes disease testing in the scab nursery (MSU Soils Farm, E. Lansing and Montcalm Research Farm, Lakeview) and foliar and tuber late blight evaluation (Muck Soils Research Farm, Bath). The objectives of the evaluations are to identify superior varieties for fresh or processing markets. The varieties were compared in groups according to market class, tuber type, skin color, and to the advancement in selection. Each season, total and marketable yields, specific gravity, tuber appearance, incidence of external and internal defects, chip color (from the field, 45°F (7.2°C) and 50°F (10°C) storage), as well as susceptibilities to common scab, late blight (foliar and tuber), and blackspot bruising are determined.

Improving agronomic performance of plots at the Montcalm Research Farm has been an on-going process. In 2010, we saw a significant increase in plot yields as a result of improved trial management. We would like to acknowledge the collaborative effort of Bruce Sackett, Mark Otto (AgriBusiness Consultants), Darryl Warncke, Chris Long, and the Potato Breeding Team.

PROCEDURE

Ten field experiments were conducted at the Montcalm Research Farm in Entrican, MI. They were planted as randomized complete block designs with two to four replications. The plots were 23 feet (7 m) long and spacing between plants was 10 inches (25.4 cm). Inter-row spacing was 34 inches (86.4 cm). Supplemental irrigation was applied as needed. The field experiments were conducted on a sandy loam soil that was in corn the previous year and in potatoes 4 years previously.

The most advanced selections in the breeding program were harvested at two dates to evaluate early and late harvest potential (Early Harvest Trial). These same clones also harvested at a later standard harvest date, included in the various other variety trials. The Date of Harvest Early and Late Trials were replaced by the Early Trial entries being included in other trials for the second (Late) harvest. The most advanced selections were tested in the Advanced trial, representing selections at a stage after the Adaptation Trial. The other field trials were the North Central, Russet, Adaptation (chip-processors and tablestock), and Preliminary (chip-processors and tablestock). *Note: We also conducted an early harvest observation trial (90 days), to screen newer lines from the breeding program for early performance potential as out of the field chip-processing and tablestock varieties. The early observational trial is discussed in the breeding report.*

2010 was the first year of the National Chip Processing Breeder Trial (NCPT). 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 NCPT has 8 sites (North: NY, MI, WI, ND and South: NC, FL, TX, CA) in addition to a scab trial in MN. A total of 220 lines were tested as 15-hill single observation plots. *The NCPT trial is discussed in the breeding report.*

In each of these trials, the yield was graded into four size classes, incidence of external and internal defects in >3.25 in. (8.25 cm) diameter (or 10 oz. (283.5 g) for Russet types) potatoes were recorded. Samples were taken for specific gravity, chipping, disease tests and bruising tests. Chip quality was assessed on 25-tuber composite sample from four replications, taking two slices from each tuber. Chips were fried at 365°F (185°C). The chip color was measured visually with the SFA 1-5 color chart. Tuber samples were also stored at 45°F (7.2°C) and 50°F (10°C) for chip-processing out of storage in January and March. Advanced selections are also placed in the MPIC B.F. Burt Cargill Commercial Demonstration Storage in Entrican, MI for monthly sampling. The lines in the agronomic trials were assessed for common scab resistance at the nursery at the MSU Soils Farm, and at *a new scab site at the Montcalm Research Farm*. There was very strong scab disease pressure at the new Montcalm Scab Disease Nursery. The 2010 late blight trial was conducted at the Muck Soils Research Farm. Maturity ratings (1 early - 5 late) were taken for all variety trial plots in late August to differentiate early and late maturing lines. The simulated blackspot bruise results for average spots per tuber have also been incorporated into the summary sheets.

RESULTS

A. Early Trial:

Chip-processors and Tablestock (Table 1: Early Harvest)

There were 12 entries that were evaluated at the early harvest trial. The results are summarized in **Table 1**. Atlantic, Snowden, Pike and Onaway were used as check varieties. The plot yields were above average in the early harvest (97 days), and specific gravity values were average to slightly below average. Hollow heart was the most prevalent internal defect in the early harvest this year, although only to a limited degree. Atlantic showed the highest incidence of hollow heart in the late harvest (18%). In the early harvest trial, the best yielding lines were Onaway, MSL211-3, Michigan Purple Sport III, and Michigan Purple. MSL211-3 is an attractive, smooth-skinned, round to oval tablestock line with foliar late blight resistance. Michigan Purple Sport III is a unique selection with splashes of purple from a sport of Michigan Purple. Michigan Purple continues to demonstrate early bulking potential for the farm market.

B. Advanced Trial (Table 2)

A summary of the 18 entries evaluated in the Advanced trial results is given in **Table 2**. Overall, the yields for the Advanced trial (140 days) were above average. The check varieties for this trial were Snowden, Atlantic, and FL1879. The highest yielding lines were Snowden (439 cwt/a), MSL292-A, Kalkaska, MSH228-6, MSQ279-1, and MSQ086-3 (372 cwt/a), followed by Atlantic, MSP515-2, and Beacon Chipper. Hollow heart and vascular discoloration were the predominant internal defects, with FL1879 and Atlantic having the highest levels of hollow heart (33 and 20%, respectively). There was a higher incidence of internal brown spot than typical, with 13% in MSP515-2 and 8% for Atlantic, MSQ070-1, and Kalkaska. Specific gravity was average with five lines having specific gravities equal to or higher than Snowden (1.079): MSQ070-1 (1.088), Atlantic (1.085), MSJ147-1 (1.083), Kalkaska (1.081), and MSL292-A (1.079). All entries in the trial had excellent chip-processing quality out of the field, with an SFA score of 1.0. Many of the MSU breeding lines have moderate to strong scab resistance. Beacon Chipper continues to be consistently high yielding line with good specific gravity, chip quality, and scab resistance. MSH228-6 also continues to be a top agronomically performing clone with scab resistance. Two newer promising chip-processing lines are MSL292-A (chip quality, high yield, good specific gravity, and shows potential as a long-term storage chipper) and MSQ279-1 (good yield and chip quality and scab résistance). Other lines that continue to show promise are MSL007-B, MSJ126-9Y, MSR061-1, MSP270-1, and MSJ147-1.

Variety and Advanced Breeding Line Characteristics

Beacon Chipper – a chip processing line that has high yield potential and moderate scab tolerance along with excellent chip-processing quality. Yield performance in the USPB/SFA trials was also high.

MSH228-6 – a chip-processing line with moderate scab resistance. It has a good type and has performed well in on-farm trials.

Kalkaska (MSJ036-A) – an MSU chip-processing selection with high yield potential. It also has a high specific gravity and scab resistance. The tuber type of MSJ036-A is round and attractive. We are conducting transformations to lower the reducing sugar in the tubers.

MSJ126-9Y – an earlier season chip-processing line with excellent chip quality and long-term storage potential. This line also has scab resistance and an attractive type.

MSL007-B – an MSU chip-processing selection with strong scab resistance, uniform round type, and a unique netted skin. This newer line produces excellent chips with a good specific gravity and average yield.

MSL211-3 – an attractive round-white tablestock line with strong foliar late blight resistance, moderate scab resistance, and an early maturity.

MSL268-D – is also a round-to-slightly oval white tablestock line with moderate scab resistance, strong foliar late resistance, and PVY resistance. This line has an average yield with mid-early maturity.

MSL292-A – a round-white chip-processing line with high yield, good specific gravity, and excellent chip quality that has demonstrated potential for good long-term chip quality.

MSP270-1 – a new round-white chip-processing line with good scab resistance, average specific gravity, and good type. This line produces clean chips with good specific gravity and an early maturity, and has storage potential.

MSQ279-1 – a round-white chip-processing line with good agronomic performance and excellent chip quality that has good scab tolerance.

MSR061-1 – is also a round-white chip-processing line with good scab resistance, moderate foliar late resistance, and PVY resistance. This line has an average yield with mid-early maturity.

In the past the MPIC has sponsored a booth at the Great Lakes Fruit, Vegetable, and Farm Market Expo in December to market Liberator, Michigan Purple, Jacqueline Lee, and new specialty potato varieties to the farm market/roadside stand market segment. The breeding program sponsored the booth in 2009 and 2010 to continue to promote varieties and promising advanced selections that may be of interest to this market segment. There continues to be a strong interest in specialty potato varieties and a growing demand for new, unique potato varieties. We also showcased some of the newer up-and-coming selections from the breeding program to get a sense of the interest from growers who stopped by the booth.

C. North Central Regional Trial Entries (Tables 3 and 4)

The North Central Trial is conducted in a wide range of environments (11 regional locations) to provide adaptability data for the release of new varieties from Michigan, Minnesota, North Dakota, Wisconsin, and Canada. Twenty-two entries were tested in Michigan in 2010. The clones were from three market classes: Red (5 entries), Russet (5 entries), or Round White (12 entries). The results are presented in **Tables 3**

and 4. The MSU lines MSL211-3, MSL268-D, MSM182-1, and MSQ176-5 were the Michigan representatives included in the 2010 North Central Trial. MSL211-3 is an attractive, bright-skinned round to oval white tablestock with late blight resistance and reduced susceptibility to scab. MSL268-D has dual-purpose characteristics; good chip-processing quality and an attractive freshmarket type, combined with late blight resistance, and some early bulking potential. MSM182-1 is a tablestock line with bright-skin, and round type. MSQ176-5 is a late blight resistant tablestock with very uniform, large, round-white tubers and smooth, bright skin.

D. Russet Trial (Table 4)

We continue to increase our russet breeding efforts to reflect the growing interest in russet types in Michigan. In 2010, 13 lines evaluated after 128 days. The results are summarized in **Table 4**. Russet Burbank, Russet Norkotah, Silverton Russet were the reference varieties used in the trial. The highest yielding lines were Silverton Russet (337 cwt/a), A98134-2RUS, W6234-4RUS, and AC00395-2RUS (289 cwt/a). Overall, the internal quality in the russet trial was above average; however, hollow heart and vascular discoloration continue to be the most prevalent internal defects. The highest hollow heart level was observed in AC00395-2Rus (60%) and A01124-3Rus (60%). Specific gravity measurements were average to below average with Russet Norkotah at 1.064. Off type and cull tubers were found in nearly all lines tested, with the highest being Russet Burbank (33%).

E. Adaptation Trials (Tables 5 and 6)

The Adaptation Trials are conducted as two separate trials based on market class: chip-processing and tablestock trials. The majority of the lines evaluated in the Adaptation Trial were tested in the Preliminary Trial the previous year. Three reference cultivars (Atlantic, Snowden, and Pike), and 18 advanced breeding lines are reported in the chip-processing trial. The trial was harvested after 139 days and the results are summarized in **Table 5**. All entries had good out-of-the-field chip scores. Specific gravity values were average for the Montcalm Research Farm (Atlantic was 1.086 and Snowden was 1.080). The highest specific gravity was Atlantic (1.086), followed by MSK409-1 (1084). The greatest hollow heart was noted in MSR159-02 (40%), followed by Atlantic and MSR036-5 (25%). The overall plot yields for this trial were above average in 2010. MSQ035-3 was the highest yielding line in 2010 (514 cwt/a), followed closely by MSS206-2 (504 cwt/a), Missaukee (491 cwt/a), and then Snowden (476 cwt/a). Multiple new breeding lines combine scab resistance and chip-processing: MSQ035-3, MSR036-5, MSR169-8Y and MSR131-2.

In the tablestock trial, 15 advanced breeding lines were evaluated with Onaway and check variety. The trial was harvested after 126 days and the results are summarized in **Table 6**. In general, the yield was above average in this trial and internal defects were low. The greatest amount of hollow heart was seen in Reba (18%). There were a significant number of oversize potatoes in MSS582-1SPL and Reba. The highest yielding line was MSS582-1SPL (round-white with red splashes) at 510 cwt/a, followed by Reba, MSQ461-2PP, MSQ341-BY, and Onaway (379 cwt/a). Five of the lines have moderate to strong scab resistance. Eight of the 15 lines also had early maturity, similar to Onaway. Promising lines with an attractive type for the tablestock market are MSS582-1SPL, MSQ461-2PP, MSQ341-BY, and MSM288-2Y. Four specialty lines are being considered for release for 2011: MSQ425-4Y (purple splash skin with yellow flesh), MSN215-2P (purple skin with white flesh), MSR226-1R (red skin and red flesh), and Midnight (purple skin with deep purple flesh).

F. Preliminary Trials (Tables 7 and 8)

The Preliminary trial is the first replicated trial for evaluating new advanced selections from the MSU potato breeding program. The division of the trials was based upon pedigree assessment for chip-processing and tablestock utilization. The chip-processing Preliminary Trial (**Table 7**) had 33 advanced selections and two check varieties (Atlantic and Snowden). The chip-processing trial was harvested after 134 days. Most lines chip-processed well from the field (SFA chip score 1.0 – 1.5). Specific gravity values were average to below average for the trial (Atlantic: 1.090). The MSU lines with the highest specific gravities were MSR127-2, MSU383-1, MSU245-1, and MSU246-1. The yields were above average with Snowden at 423 cwt/a and Atlantic at 417 cwt/a. The highest yielding lines were MSU379-1 (547 cwt/a), MR148-A, MSR127-2, MSU383-1, and MST220-8 (434 cwt/a). Sixteen of the lines (46%) were classified to be resistant or moderately resistant to scab (≤ 1.5 scab disease rating). The greatest internal defects were hollow heart (Atlantic, MSU245-1, and MSQ029-1 at 45%), and 55% internal brown spots in Atlantic. Many of the lines in the Preliminary Trial combine good agronomic performance with chip quality, specific gravity, and scab resistance.

Table 8 summarizes the 35 tablestock lines evaluated in the Preliminary Trial (Onaway was the check variety). This tablestock trial was harvested and evaluated after 126 days. Eight of the selections were scab resistant or moderately resistant (≤ 1.5 scab disease rating). MSU161-1 (490 cwt/a), MSR214-2P, MST386-1P, MST285-2, and Onway (417 cwt/a) were the highest yielding lines. In general, there was a low incidence of internal defects. In addition to traditional round white, red-skinned, and yellow flesh freshmarket categories, there are some unique specialty lines. Zongshu 3 and Jingshu 2 were two lines from the Chinese breeding program that were also evaluated.

G. Potato Scab Evaluation (Table 9)

Each year, a replicated field trial at the MSU Soils Farm (E. Lansing, MI) is conducted to assess resistance to common scab. In 2010, we added two new scab testing locations. A site at the Montcalm Research Farm with high common scab disease pressure was chosen as a second testing location for the early generation observational trial (240 lines), and two replications of the scab variety trial (158 lines). *Additionally, we added a replicated On-Farm scab trial (32 lines), which is summarized in the Research Report.* We use a rating scale of 0-5 based upon a combined score for scab coverage and lesion severity. Usually examining one year's data does not indicate which varieties are resistant but it should begin to identify ones that can be classified as susceptible to scab. Our goal is to evaluate important advanced selections and varieties in the study at least three years to obtain a valid estimate of the level of resistance in each line. The 2010 scab ratings are based upon the Montcalm Research Farm site. **Table 9** categorizes many of the varieties and advanced selections tested in 2010 along with three-year averages where applicable. The varieties and breeding lines are placed into six categories based upon scab infection level and lesion severity. A rating of 0 indicates zero scab infection. A score of 1.0 indicates a trace amount of infection. A moderate resistance (1.2 – 1.8) correlates with <10% infection. Scores of 4.0 or greater are found on lines with >50% infection and severe pitted lesions.

The check varieties Russet Burbank, Russet Norkotah, GoldRush, Red Norland, Red Pontiac, Onaway, Pike, Atlantic, and Snowden can be used as references (bolded in **Table 9**). The table is sorted in ascending order by 2010 rating. This year's results continue indicate that we have been able to breed numerous lines for the chip-processing and tablestock markets with resistance to scab. A total of 60 lines, of the 158 tested, had a scab rating of 1.5 (better than or equivalent to Pike) or lower in 2010. Most notable scab resistant MSU lines are MSH228-6, Kalkaska, MSJ126-9Y, MSL007-B, MSM037-3, MSN215-2P, MSP270-1, MSR036-5, MSR102-3 and MSR169-8Y; as well as some earlier generation lines MSS297-3, MSS544-1R, MSU383-1, and MSU384-1. The greater number of MSU lines in the resistant and moderately resistant categories indicates we are making progress in breeding more scab resistant lines for the chip-processing and tablestock markets. There are also an increasing number of scab resistant lines that also have late blight resistance and PVY resistance. We also continue to conduct early generation scab screening on selections in the breeding program beginning after one year. Of the 240 early generation selections that were evaluated, 98 were resistant (scab rating of ≤ 1.0). Scab results from the disease nursery are also found in the Trial Summaries (**Tables 2-8**).

H. Late Blight Trial (Table 10)

In 2010, the late blight trial was planted at the Muck Soils Research Farm. As in previous years, 196 entries were planted in replication for evaluation in replicated plots. These include lines tested in the agronomic variety trial (157 lines) and entries in the National Late Blight Variety Trial (39 lines). Block planting full rows of advanced selections provide a better assessment of the late blight resistance of these lines. We also planted 132 early generation breeding lines that have a late blight resistant pedigree. The field was planted on June 7. The trials were inoculated on August 3 with a US-8 genotype of *P. infestans*. Late blight infection was identified in the plots 10 days after inoculation. The plots were evaluated more than seven times over a 45 day period following inoculation. We need to note that the disease reaction in the plots was not typical to the previous years' ratings. All disease lesions tested were identified as US-22, which would explain the higher disease ratings (susceptibility) on lines with late blight resistance to US-8 (Tollocan-based resistance lines Jacqueline Lee, Missaukee, etc.). In

2010, twenty-nine lines had moderate to strong late blight resistance to US-22. These were from various late blight resistance sources (Torridon, Stirling, NY121, B0718-3, etc.). **Table 10** lists select lines in the foliar resistance and susceptibility categories.

I. Blackspot Bruise Susceptibility (Table 11)

Evaluations of advanced seedlings and new varieties for their susceptibility to blackspot bruising are also important in the variety evaluation program. Based upon the results collected over the past years, the non-bruised check sample has been removed from our bruise assessment. A composite bruise sample of each line in the trials consisted of 25 tubers (a composite of 4 replications) from each line, collected at the time of grading. The 25 tuber sample was held in 50°F (10°C) storage overnight and then was placed in a hexagon plywood drum and tumbled 10 times to provide a simulated bruise. The samples were peeled in an abrasive peeler in October and individual tubers were assessed for the number of blackspot bruises on each potato. These data are shown in **Table 11**. The bruise data are represented in two ways: percentage of bruise free potatoes and average number of bruises per tuber. A high percentage of bruise-free potatoes is the desired goal; however, the numbers of blackspot bruises per potato is also important. Cultivars which show blackspot incidence greater than Atlantic are approaching the bruise-susceptible rating. In addition, the data is grouped by trial, since the bruise levels can vary between trials. Conducting the simulated bruise on 50°F (10°C) tubers has helped to standardize the bruise testing. We are observing less variation between trials since we standardized the handling of the bruise sample.

In 2010, the bruise levels were comparable to previous years. The most bruise resistant MSU breeding lines this year from the Advanced trial were MSP270-1, MSQ440-2, MSH228-6, MSQ086-3, MSJ126-9Y, MSR061-1, and MSJ147-1. The most susceptible lines from the Advanced trial were MSP515-2, Snowden, MSP459-5, and Atlantic. The Adaptation Trial lines with the best bruise resistance were MSS108-1, MSQ432-2PP, MSR102-3, MSR159-02, MSM288-2Y, MSS544-1R, MSN105-1, MSR157-1Y, and MSS576-05SPL. Of the earlier generation breeding lines (Preliminary Trial), the most bruise resistant were MSR160-2Y, MST202-5, A00188-3C, MSU384-1, CO00188-4W, MSU379-1, MST437-1, MSQ130-4, MSU202-1P, MSR297-A, 1991-563-18, MSQ405-1PP, MST406-2RR, and MSU613-1. The most bruise resistant russet entries were A01124-3RUS, Silverton Russet, W6234-4RUS, CO99053-3RUS, and A98134-2RUS; the most susceptible were W8946-1RUS-NCR and W2683-2RUS. The most bruise resistant entries in the US Potato Board/Snack Food Association Trial were MSJ126-9Y, NY138, and W2978. While W2310-3, Atlantic, Snowden, and W5015-12 were the most bruise susceptible in this trial.

Table 1

EARLY HARVEST TRIAL
MONTCALM RESEARCH FARM
May 4 to August 9, 2010 (97 days)

	CWT/A		PERCENT OF TOTAL[1]						CHIP	PERCENT (%) TUBER QUALITY[3]					3-YR AVG US#1
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	SCORE[2]	HH	VD	IBS	BC	MAT[4]	CWT/A
Onaway	**369**	**433**	**85**	**12**	**81**	**4**	**3**	**1.062**	**-**	**0**	**8**	**0**	**0**	**2.2**	**342***
MSL211-3	338	387	87	11	81	6	1	1.066	-	0	0	0	0	3.0	295*
MI Purple Sport III	325	364	89	10	80	9	0	1.068	-	5	5	0	0	3.0	-
MI Purple	321	354	91	9	84	7	1	1.070	-	5	3	3	0	3.0	-
Snowden	**315**	**367**	**86**	**14**	**83**	**3**	**0**	**1.081**	**1.0**	**3**	**8**	**0**	**0**	**3.5**	**-**
Atlantic	**302**	**361**	**84**	**16**	**81**	**3**	**0**	**1.085**	**1.0**	**18**	**5**	**0**	**0**	**3.5**	**257**
MSM037-3	293	340	86	13	84	2	1	1.065	1.0	0	0	0	0	3.0	259*
MSM171-A	287	315	91	8	75	16	1	1.055	-	8	5	0	0	2.9	288
MSQ425-4Y	221	326	68	32	68	0	0	1.065	1.0	3	0	0	0	2.7	-
Pike	**203**	**266**	**76**	**23**	**75**	**1**	**1**	**1.075**	**1.0**	**5**	**0**	**0**	**0**	**3.8**	**207**
MSQ086-3	160	283	56	44	56	0	0	1.066	1.0	0	0	0	0	4.3	219*
MSN215-2P	154	236	65	32	64	1	3	1.069	-	0	0	0	0	2.9	-
MEAN	274	336						1.069							
$HSD_{0.05}$	101	102	11					0.006							

* Two-Year Average

[1]SIZE: B: < 2 in.; A: 2-3.25 in.; OV: > 3.25 in.; PO: Pickouts.
[2]CHIP SCORE: Snack Food Association Scale (Out of the field); Ratings: 1-5; 1: Excellent, 5: Poor.
[3]QUALITY: HH: Hollow Heart; BC: Brown Center; VD: Vascular Discoloration; IBS: Internal Brown Spot. Percent of 40 Oversize and/or A-size tubers cut.
[4]MATURITY RATING: August 3, 2010; Ratings 1-5; 1: Early (vines completely dead); 5: Late (vigorous vine, some flowering).

Table 2

MICHIGAN STATE UNIVERSITY
POTATO BREEDING and GENETICS

ADVANCED TRIAL
MONTCALM RESEARCH FARM
May 4 to September 21, 2010 (140 days)

	CWT/A		PERCENT OF TOTAL[1]						CHIP	PERCENT (%) TUBER QUALITY[3]							3-YR AVG
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	SCORE[2]	HH	VD	IBS	BC	SCAB[4]	MAT[5]	BRUISE[6]	US#1 CWT/A
Snowden	**439**	**490**	**90**	**10**	**80**	**10**	**1**	**1.079**	**1.0**	**8**	**50**	**0**	**0**	**2.9**	**2.1**	**1.5**	**322**
MSL292-A	403	468	86	14	83	3	0	1.079	1.0	3	0	0	0	2.5	1.2	1.3	276*
Kalkaska (MSJ036-A)	400	504	79	21	78	1	0	1.081	1.0	3	8	8	0	1.5	3.3	1.2	371
MSH228-6	383	427	90	9	84	5	2	1.073	1.0	8	25	0	0	1.0	2.4	0.4	287
MSQ279-1	373	411	91	9	77	14	1	1.072	1.0	3	0	0	0	1.3	3.6	0.2	282*
MSQ086-3	372	514	72	27	72	0	0	1.074	1.0	0	5	0	0	2.3	2.9	0.4	-
Atlantic	**356**	**410**	**87**	**13**	**81**	**6**	**0**	**1.085**	**1.0**	**20**	**8**	**8**	**0**	**2.9**	**1.9**	**2.2**	**-**
MSP515-2	349	418	84	16	71	12	0	1.077	1.0	5	10	13	0	2.3	3.0	1.4	333*
Beacon Chipper	349	370	94	5	71	24	1	1.075	1.0	5	35	0	0	2.0	2.8	1.3	347
FL1879	**339**	**373**	**91**	**8**	**77**	**14**	**1**	**1.072**	**1.0**	**33**	**13**	**5**	**0**	**3.5**	**2.0**	**0.7**	**347**
MSQ070-1	338	422	80	20	79	1	0	1.088	1.0	3	8	8	0	1.3	3.6	1.0	304
MSQ440-2	314	353	89	11	82	6	0	1.055	1.0	0	38	0	0	1.8	2.0	0.2	-
MSL007-B	310	382	81	19	79	2	0	1.074	1.0	3	10	0	0	1.0	2.7	0.8	214*
MSJ126-9Y	259	306	85	15	82	3	0	1.070	1.0	0	20	0	0	1.0	2.1	0.6	240
MSR061-1	259	339	76	23	75	1	0	1.077	1.0	8	5	0	0	1.3	2.0	0.6	244
MSP270-1	240	318	75	25	75	1	0	1.070	1.0	0	3	0	0	1.0	3.0	0.2	-
MSP459-5	217	344	63	37	62	1	0	1.070	1.0	0	3	0	0	3.0	2.5	1.6	208
MSJ147-1	158	265	59	33	59	0	8	1.083	1.0	0	0	0	0	1.3	2.9	0.6	197
MEAN	325	395						1.075						1.9	2.5	0.9	
$HSD_{0.05}$	149	153						0.007						2.3	1.4	* Two-Year Average	

LBR Line(s) demonstrated foliar resistance to Late Blight (*Phytopthora infestans*) in inoculated field trials at the MSU Muck Soils Research Farm.
[1]SIZE: B: < 2 in.; A: 2-3.25 in.; OV: > 3.25 in.; PO: Pickouts.
[2]CHIP SCORE: Snack Food Association Scale (Out of the field); Ratings: 1-5; 1: Excellent, 5: Poor.
[3]QUALITY: HH: Hollow Heart; BC: Brown Center; VD: Vascular Discoloration; IBS: Internal Brown Spot. Percent of 40 Oversize and/or A-size tubers cut.
[4]SCAB DISEASE RATING: MSU Scab Nursery; 0: No Infection; 1: Low Infection <5%; 3: Intermediate; 5: Highly Susceptible.
[5]MATURITY RATING: August 24, 2010; Ratings 1-5; 1: Early (vines completely dead); 5: Late (vigorous vine, some flowering).
[6]BRUISE: Simulated blackspot bruise test average number of spots per tuber.

Table 3

MICHIGAN STATE UNIVERSITY
POTATO BREEDING and GENETICS

NORTH CENTRAL REGIONAL TRIAL
MONTCALM RESEARCH FARM
May 4 to September 7, 2010 (126 days)

	CWT/A		PERCENT OF TOTAL[1]							PERCENT (%) TUBER QUALITY[3]							3-YR AVG US#1
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	CHIP SCORE[2]	HH	VD	IBS	BC	SCAB[4]	MAT[5]	BRUISE[6]	CWT/A
MSL211-3	406	458	89	10	81	8	2	1.068	2.5	0	3	0	0	2.2	1.3	1.0	-
ND8555-8R	391	509	77	23	75	2	0	1.067	1.5	3	0	3	0	2.0	1.0	1.1	-
Snowden	**382**	**433**	**88**	**11**	**82**	**7**	**1**	**1.081**	**1.0**	**18**	**10**	**0**	**0**	**2.9**	**1.6**	**1.4**	**330**
Atlantic	**375**	**420**	**89**	**9**	**75**	**14**	**2**	**1.086**	**1.5**	**53**	**13**	**13**	**0**	**2.9**	**1.8**	**1.4**	**332**
W5015-12	372	451	83	17	77	6	1	1.085	1.0	28	0	10	0	3.0	2.3	2.4	316*
MSQ176-5	367	411	89	10	66	23	1	1.066	1.0	23	3	5	0	3.0	2.0	0.6	292*
Red Pontiac	**365**	**421**	**87**	**10**	**72**	**15**	**3**	**1.061**	**3.5**	**10**	**0**	**0**	**0**	**4.5**	**2.1**	**0.7**	**-**
NorValley	**352**	**416**	**85**	**15**	**77**	**8**	**0**	**1.072**	**1.0**	**0**	**0**	**0**	**0**	**2.3**	**1.4**	**1.2**	**-**
MSL268-D	343	419	82	16	81	1	2	1.081	1.0	0	10	0	0	3.0	1.8	1.5	307
MSM182-1	321	382	84	15	78	6	1	1.068	2.5	5	3	13	0	3.0	2.0	1.2	-
ND8307C-3	289	370	78	21	77	1	1	1.087	1.0 !	5	3	0	0	1.5	1.6	0.8	-
ND8229-3RUS	274	331	83	16	75	8	1	1.076	1.0	3	0	0	0	1.0	2.3	2.0	-
W2609-1R	270	328	82	17	79	3	1	1.058	2.5	0	0	3	0	1.0	1.3	0.4	-
Red Norland	**251**	**287**	**87**	**13**	**84**	**4**	**0**	**1.055**	**2.0**	**3**	**3**	**0**	**0**	**2.0**	**1.5**	**0.2**	**260***
W2978-3	248	322	77	23	74	3	0	1.072	1.0	0	0	0	0	3.5	1.1	0.5	244*
W2717-5	232	282	82	16	82	0	1	1.088	1.5	5	10	3	3	3.0	1.1	1.2	-
W2310-3	227	295	77	21	76	1	2	1.086	1.0	5	0	0	0	2.0	2.1	1.9	-
ND8314-1R	201	365	55	44	53	2	1	1.063	3.0	5	5	0	0	3.0	1.0	1.0	-
MEAN	315	383						1.073						2.5	1.6	1.1	
$HSD_{0.05}$	155	158						0.006						2.3	0.8	* Two-Year Average	

LBR Line(s) demonstrated foliar resistance to Late Blight (*Phytopthora infestans*) in inoculated field trials at the MSU Muck Soils Research Farm.

All the lines in the Round White Trial in 2008 were North Central Regional Trial entries.

[1]SIZE: B: < 2 in.; A: 2-3.25 in.; OV: > 3.25 in.; PO: Pickouts.

[2]CHIP SCORE: Snack Food Association Scale (Out of the field); Ratings: 1-5; 1: Excellent, 5: Poor.

[3]QUALITY: HH: Hollow Heart; BC: Brown Center; VD: Vascular Discoloration; IBS: Internal Brown Spot. Percent of 40 Oversize and/or A-size tubers cut.

[4]SCAB DISEASE RATING: MSU Scab Nursery; 0: No Infection; 1: Low Infection <5%; 3: Intermediate; 5: Highly Susceptible.

[5]MATURITY RATING: August 24, 2010; Ratings 1-5; 1: Early (vines completely dead); 5: Late (vigorous vine, some flowering).

[6]BRUISE: Simulated blackspot bruise test average number of spots per tuber.

Table 4

RUSSET TRIAL
MONTCALM RESEARCH FARM
May 4 to September 9, 2010 (128 days)

LINE	CWT/A US#1	CWT/A TOTAL	PERCENT OF TOTAL[1] US#1	Bs	As	OV	PO	SP GR	PERCENT (%) TUBER QUALITY[2] HH	VD	IBS	BC	SCAB[3]	MAT[4]	BRUISE[5]	3-YR AVG US#1 CWT/A
Silverton Russet	**337**	**385**	**88**	**10**	**65**	**23**	**2**	**1.070**	**3**	**5**	**0**	**0**	**1.0**	**2.9**	**0.3**	**322**
A98134-2RUS	302	411	74	24	65	8	3	1.071	0	15	0	0	1.3	2.6	0.4	-
W6234-4RUS	300	390	77	17	62	15	6	1.079	8	5	0	0	3.5	1.8	0.4	-
AC00395-2RUS	289	408	71	26	65	6	3	1.091	60	15	0	0	1.0	2.6	0.6	-
MSN170-A**	278	331	84	13	79	5	3	1.078	5	0	0	0	1.8	1.7	0.5	289
W2683-2RUS	252	330	76	20	65	11	4	1.071	8	3	3	0	1.0	2.9	2.6	-
A01124-3RUS	231	291	79	13	67	12	8	1.075	60	5	3	0	1.5	3.1	0.0	-
W8946-1RUS	228	391	58	36	57	1	5	1.091	0	8	3	0	1.3	3.8	1.5	-
Goldrush	**215**	**323**	**67**	**27**	**58**	**8**	**6**	**1.065**	**0**	**15**	**0**	**0**	**1.0**	**1.5**	**0.6**	**235***
CO99053-3RUS	191	241	79	18	67	12	3	1.074	8	18	0	0	2.0	3.3	0.4	271
Russet Norkotah	**156**	**252**	**62**	**37**	**60**	**2**	**1**	**1.064**	**0**	**5**	**0**	**0**	**2.3**	**1.4**	**0.1**	**155**
Russet Burbank	**124**	**293**	**42**	**25**	**39**	**3**	**33**	**1.073**	**5**	**10**	**0**	**0**	**2.0**	**2.0**	**0.8**	**-**
A98289-1RUS	84	170	50	50	50	0	0	1.066	0	20	5	0	0.5	2.0	0.6	-
MEAN	230	324						1.074					1.5	2.4	0.7	
$HSD_{0.05}$	147	139						0.005					2.3	1.3	* Two-Year Average	

**Not Russet lines

[LBR] Line(s) demonstrated foliar resistance to Late Blight (*Phytopthora infestans*) in inoculated field trials at the MSU Muck Soils Research Farm.

[1]SIZE: B: < 4 oz.; A: 4-10 oz.; OV: > 10 oz.; PO: Pickouts.

[2]QUALITY: HH: Hollow Heart; BC: Brown Center; VD: Vascular Discoloration; IBS: Internal Brown Spot. Percent of 40 Oversize and/or A-size tubers cut.

[3]SCAB DISEASE RATING: MSU Scab Nursery; 0: No Infection; 1: Low Infection <5%; 3: Intermediate; 5: Highly Susceptible.

[4]MATURITY RATING: August 24, 2010; Ratings 1-5; 1: Early (vines completely dead); 5: Late (vigorous vine, some flowering).

[5]BRUISE: Simulated blackspot bruise test average number of spots per tuber.

Table 5

MICHIGAN STATE UNIVERSITY
POTATO BREEDING and GENETICS

ADAPTATION TRIAL, CHIP-PROCESSING LINES
MONTCALM RESEARCH FARM
May 4 to September 20, 2010 (139 days)

	CWT/A		PERCENT OF TOTAL[1]						CHIP	PERCENT (%) TUBER QUALITY[3]						
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	SCORE[2]	HH	VD	IBS	BC	SCAB[4]	MAT[5]	BRUISE[6]
MSQ035-3	514	561	92	8	84	8	0	1.075	1.0	0	5	0	0	1.0	2.3	2.2
MSS206-2	504	531	95	4	76	19	1	1.065	1.5	0	15	0	0	2.5	2.3	0.9
Missaukee	491	576	85	14	79	6	0	1.075	1.0	0	3	5	0	2.5	2.4	1.5
Snowden	**476**	**528**	**90**	**10**	**83**	**7**	**0**	**1.080**	**1.0**	**10**	**23**	**0**	**0**	**2.9**	**2.6**	**1.6**
MSQ432-2PP	407	468	87	9	77	10	4	1.070	2.0	3	0	0	0	2.0	2.5	0.4
Atlantic	**378**	**434**	**87**	**12**	**81**	**6**	**1**	**1.086**	**1.0**	**25**	**3**	**8**	**0**	**2.9**	**1.9**	**1.9**
MSR036-5	365	428	85	9	64	21	6	1.078	1.5	25	10	0	0	1.0	2.5	1.2
MSR058-1	360	486	74	20	70	4	6	1.076	1.0	8	20	0	0	1.5	2.5	1.5
MSR169-8Y	359	450	80	20	77	3	0	1.081	1.0!	3	5	0	0	1.0	2.6	1.0
MSK409-1	333	395	84	14	78	6	2	1.084	1.0	13	18	3	0	1.3	2.0	2.6
MSS026-2Y	286	343	83	17	76	7	0	1.080	1.0	5	8	0	0	3.0	2.8	1.5
MSS108-1	276	354	78	22	75	3	1	1.072	2.0	0	10	0	0	1.5	2.5	0.3
MSR159-02	269	330	82	14	67	14	4	1.080	1.0	40	5	5	0	2.0	2.9	0.6
CO95051-7W	262	338	77	22	76	1	0	1.079	1.0	0	13	0	0	1.5	2.9	2.0
MSR131-2	256	383	67	33	66	1	0	1.072	1.0	0	15	5	0	1.0	3.1	1.0
MSN148-A	249	350	71	28	69	2	1	1.083	1.0	3	3	0	0	1.5	2.8	1.9
Pike	**243**	**298**	**82**	**17**	**78**	**4**	**1**	**1.078**	**1.0**	**3**	**8**	**0**	**0**	**1.1**	**2.1**	**0.8**
MSQ558-2RR	230	380	60	39	60	1	1	1.066	1.0	0	0	0	0	2.3	1.3	1.8
MSR102-3	207	256	81	12	69	12	7	1.078	1.0	8	10	0	0	1.0	3.4	0.5
MSS258-1	187	225	83	17	78	5	0	1.059	1.0	0	0	0	0	2.0	1.3	0.8
MSR226-1RR	169	294	57	39	55	2	4	1.060	1.0!	0	0	0	0	3.0	1.6	0.6
MEAN	325	400						1.075						1.8	2.4	1.3
$HSD_{0.05}$	193	199						0.009						2.3	1.0	

LBR Line(s) demonstrated foliar resistance to Late Blight (*Phytopthora infestans*) in inoculated field trials at the MSU Muck Soils Research Farm.

[1]SIZE: B: < 2 in.; A: 2-3.25 in.; OV: > 3.25 in.; PO: Pickouts.

[2]CHIP SCORE: Snack Food Association Scale (Out of the field); Ratings: 1-5; 1: Excellent, 5: Poor.

[3]QUALITY: HH: Hollow Heart; BC: Brown Center; VD: Vascular Discoloration; IBS: Internal Brown Spot. Percent of 40 Oversize and/or A-size tubers cut.

[4]SCAB DISEASE RATING: MSU Scab Nursery; 0: No Infection; 1: Low Infection <5%; 3: Intermediate; 5: Highly Susceptible.

[5]MATURITY RATING: August 24, 2010; Ratings 1-5; 1: Early (vines completely dead); 5: Late (vigorous vine, some flowering).

[6]BRUISE: Simulated blackspot bruise test average number of spots per tuber.

Table 6

ADAPTATION TRIAL, TABLESTOCK LINES
MONTCALM RESEARCH FARM
May 4 to September 7, 2010 (126 days)

	CWT/A		PERCENT OF TOTAL[1]						PERCENT (%) TUBER QUALITY[2]						
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	HH	VD	IBS	BC	SCAB[3]	MAT[4]	BRUISE[5]
MSS582-1SPL	510	541	94	5	78	17	1	1.074	0	3	0	0	2.0	2.3	0.5
Reba	469	494	95	5	81	14	0	1.072	18	23	0	0	2.5	2.8	1.4
MSQ461-2PP	412	465	89	10	85	3	1	1.079	0	0	0	0	2.0	1.9	0.4
MSQ341-BY	399	458	87	13	84	3	0	1.078	0	18	0	0	1.5	2.5	0.5
Onaway	**379**	**432**	**88**	**11**	**82**	**6**	**1**	**1.060**	**0**	**30**	**0**	**0**	**2.1**	**1.7**	**1.1**
MSN230-1RY	364	447	82	17	81	1	1	1.087	3	13	0	0	2.0	2.6	1.9
MSM288-2Y	358	483	74	25	74	0	0	1.071	3	13	0	0	3.0	1.5	0.1
MSS576-05SPL	347	422	82	18	81	1	0	1.071	0	3	0	0	2.0	1.9	0.4
MSL228-1SPL	318	361	88	10	82	6	2	1.077	3	10	0	0	1.8	1.8	0.5
MSQ134-5	302	413	73	26	72	1	1	1.074	0	5	0	0	2.5	3.0	0.6
MSR157-1Y	266	307	87	13	83	4	1	1.075	0	10	0	0	1.3	2.4	0.3
MSQ425-4Y	259	359	72	28	72	0	0	1.067	0	15	0	0	2.5	1.9	1.5
MSS514-1PP	251	340	74	23	74	0	3	1.061	0	0	0	0	2.0	2.0	0.5
MSN215-2P	240	338	71	22	71	0	7	1.072	0	10	0	0	1.0	1.6	0.6
Jacqueline Lee	155	309	50	37	50	0	12	1.079	0	8	0	0	3.3	2.6	0.9
MSS544-1R	140	219	64	36	64	0	0	1.059	0	3	0	0	1.0	1.6	0.1
MEAN	323	399						1.072					2.0	2.1	0.7
$HSD_{0.05}$	134	149						0.006					2.3	1.0	

[LBR] Line(s) demonstrated foliar resistance to Late Blight (*Phytopthora infestans*) in inoculated field trials at the MSU Muck Soils Research Farm.

[NCR] North Central Regional Entry

[1]SIZE: B: < 2 in.; A: 2-3.25 in.; OV: > 3.25 in.; PO: Pickouts.

[2]QUALITY: HH: Hollow Heart; BC: Brown Center; VD: Vascular Discoloration; IBS: Internal Brown Spot. Percent of 40 Oversize and/or A-size tubers cut.

[3]SCAB DISEASE RATING: MSU Scab Nursery; 0: No Infection; 1: Low Infection <5%; 3: Intermediate; 5: Highly Susceptible.

[4]MATURITY RATING: August 24, 2010; Ratings 1-5; 1: Early (vines completely dead); 5: Late (vigorous vine, some flowering).

[5]BRUISE: Simulated blackspot bruise test average number of spots per tuber.

Table 7

MICHIGAN STATE UNIVERSITY
POTATO BREEDING and GENETICS

PRELIMINARY TRIAL, CHIP-PROCESSING LINES
MONTCALM RESEARCH FARM
May 4 to September 15, 2010 (134 days)

	CWT/A		PERCENT OF TOTAL[1]						CHIP	PERCENT (%) TUBER QUALITY[3]						
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	SCORE[2]	HH	VD	IBS	BC	SCAB[4]	MAT[5]	BRUISE[6]
MSU379-1	547	604	91	8	80	11	1	1.071	1.0	0	0	0	0	1.5	2.8	0.2
MSR148-4	534	638	84	16	84	0	0	1.073	1.0	0	20	10	0	2.5	2.0	1.0
MSR127-2	486	575	84	16	84	0	0	1.091	1.0	0	0	0	0	1.0	3.8	2.3
MSU383-1	446	488	91	7	78	13	1	1.088	1.0	10	5	0	0	1.0	1.5	1.4
MST220-8	434	522	83	15	78	6	1	1.071	1.5	20	0	0	0	1.5	3.3	0.8
Snowden	**423**	**478**	**88**	**10**	**76**	**12**	**1**	**1.079**	**1.0**	**25**	**10**	**0**	**0**	**3.0**	**2.8**	**1.2**
CO02033-1W	422	512	82	12	78	4	5	1.089	1.0	20	25	10	0	3.5	2.8	1.1
Atlantic	**417**	**483**	**86**	**11**	**75**	**11**	**2**	**1.090**	**1.0**	**45**	**5**	**55**	**0**	**3.0**	**2.3**	**1.5**
NY139	416	466	89	10	86	3	1	1.085	1.0	0	20	0	0	2.0	3.0	0.9
AF2291-10	403	455	89	11	83	5	1	1.086	1.0	10	25	5	0	2.0	2.5	1.4
MSU384-1	393	444	88	10	84	4	1	1.083	1.0	0	10	10	0	1.0	2.8	0.2
MSQ130-4	379	452	84	16	76	7	0	1.074	1.5	25	0	10	0	2.0	2.3	0.4
CO02024-9W	377	492	77	22	75	1	1	1.078	1.0	0	0	0	0	3.0	3.0	0.7
MSU389-1	370	425	87	11	84	3	2	1.074	-	0	0	0	0	-	1.8	-
MST191-2Y	367	471	78	21	75	3	1	1.084	1.0!	0	0	0	0	3.0	2.8	1.5
MSNDU030-1	364	437	83	16	77	7	1	1.080	1.0	10	5	0	0	1.5	2.3	1.0
CO02321-4W	363	425	85	14	76	10	1	1.082	1.0	10	0	10	0	3.0	2.0	1.3
CO00197-3W	361	482	75	21	75	0	4	1.080	1.0	0	15	0	0	3.5	1.8	0.7
MSU088-1	356	421	85	15	83	2	0	1.084	1.0	0	0	0	0	3.0	2.8	1.2
MST306-1	351	481	73	26	73	0	1	1.078	1.5	0	0	5	0	1.5	2.0	0.4
MSU245-1	325	416	78	20	78	0	2	1.088	1.0	45	0	0	0	-	2.3	0.6
MST424-3	308	345	89	9	84	5	2	1.069	1.0	0	15	0	0	1.5	2.0	1.1
MST437-1	304	364	84	13	72	11	3	1.084	1.0	10	5	0	0	2.5	2.5	0.4
MSU246-1	301	381	79	21	77	2	0	1.088	1.0	5	20	5	0	-	2.5	1.6
CO00188-4W	294	395	75	25	73	2	1	1.074	1.0	0	10	0	0	1.5	1.3	0.2
MSS297-3	290	391	74	26	74	0	0	1.074	1.0	0	0	0	0	1.0	2.3	1.2
MSQ029-1	288	338	85	13	74	11	2	1.076	1.5	45	0	0	0	1.5	4.5	0.5
MSU245-2	270	332	81	18	77	4	1	1.081	1.0	20	15	5	0	-	3.3	0.6

Table 7

MICHIGAN STATE UNIVERSITY
POTATO BREEDING and GENETICS

PRELIMINARY TRIAL, CHIP-PROCESSING LINES
MONTCALM RESEARCH FARM
May 4 to September 15, 2010 (134 days)

	CWT/A		PERCENT OF TOTAL[1]						CHIP	PERCENT (%) TUBER QUALITY[3]						
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	SCORE[2]	HH	VD	IBS	BC	SCAB[4]	MAT[5]	BRUISE[6]
Pike	**269**	**338**	**80**	**18**	**74**	**6**	**2**	**1.076**	**1.0**	**10**	**5**	**0**	**0**	**1.0**	**2.0**	**0.6**
MST441-1	253	341	74	25	69	5	1	1.072	1.5	0	0	0	0	1.0	1.3	0.8
MSU358-2	251	291	87	12	74	13	1	1.079	1.0	0	0	0	0	-	1.8	1.2
A01143-3C	247	326	76	15	76	0	10	1.078	1.5	5	0	25	0	1.5	3.5	0.6
A00188-3C	230	342	67	29	67	0	4	1.082	1.0	0	10	0	0	1.5	2.5	0.1
AC01151-5W	206	310	66	31	66	0	3	1.076	1.0	0	0	15	0	3.5	2.8	0.7
MST202-5	147	239	61	36	61	0	2	1.064	1.0	0	30	0	0	1.5	1.0	0.0
MSR160-2Y	126	320	39	61	39	0	0	1.083	1.5	0	0	0	0	2.0	2.0	0.0
MEAN	342	423						1.080						2.0	2.4	0.8
$HSD_{0.05}$	233	225						0.012						2.3	1.8	

LBR Line(s) demonstrated foliar resistance to Late Blight (*Phytopthora infestans*) in inoculated field trials at the MSU Muck Soils Research Farm.

[1]SIZE: B: < 2 in.; A: 2-3.25 in.; OV: > 3.25 in.; PO: Pickouts.

[2]CHIP SCORE: Snack Food Association Scale (Out of the field); Ratings: 1-5; 1: Excellent, 5: Poor.

[3]QUALITY: HH: Hollow Heart; BC: Brown Center; VD: Vascular Discoloration; IBS: Internal Brown Spot. Percent of 20 Oversize and/or A-size tubers cut.

[4]SCAB DISEASE RATING: MSU Scab Nursery; 0: No Infection; 1: Low Infection <5%; 3: Intermediate; 5: Highly Susceptible.

[5]MATURITY RATING: August 24, 2010; Ratings 1-5; 1: Early (vines completely dead); 5: Late (vigorous vine, some flowering).

[6]BRUISE: Simulated blackspot bruise test average number of spots per tuber.

Table 8

PRELIMINARY TRIAL, TABLESTOCK LINES
MONTCALM RESEARCH FARM
May 4 to September 7, 2010 (126 days)

	CWT/A		PERCENT OF TOTAL[1]						CHIP	PERCENT (%) TUBER QUALITY[3]						
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	SCORE[2]	HH	VD	IBS	BC	SCAB[4]	MAT[5]	BRUISE[6]
MSU161-1	490	529	93	7	80	12	1	1.074	2.5	0	1	0	0	2.0	2.5	0.8
MSR214-2P	457	543	84	16	84	0	0	1.069	2.5	0	0	0	0	2.5	3.0	0.8
MST386-1P	454	509	89	7	78	11	4	1.079	2.5	1	4	0	0	1.0	1.8	1.6
MST285-2	419	481	87	10	77	10	3	1.079	2.5	3	0	0	0	1.3	2.8	1.0
Onaway	**417**	**469**	**89**	**11**	**81**	**8**	**0**	**1.063**	**3.5**	**0**	**3**	**0**	**0**	**2.1**	**1.5**	**1.7**
CO99256-2R	398	510	78	22	77	1	0	1.069	2.5	0	4	0	0	2.8	3.0	0.8
MSU320-2Y	393	462	85	14	83	2	1	1.074	2.5	0	1	0	0	1.0	3.0	0.8
MSU613-1	350	385	91	9	83	8	0	1.070	1.0!	0	0	0	0	2.5	1.8	0.5
Colorado Rose	330	390	85	13	75	9	2	1.065	2.5	0	3	0	0	3.5	1.3	0.6
MSU202-1P	322	376	86	13	68	18	1	1.062	2.5	0	0	0	0	-	2.3	0.2
MSU279-1	307	412	75	24	72	2	1	1.079	3.5	0	1	0	0	1.8	2.8	0.8
Midnight	286	415	69	30	67	2	1	1.048	1.5	0	0	0	0	3.5	1.0	0.8
W5767-1R	284	334	85	14	73	12	1	1.070	2.5	1	0	0	0	2.0	1.8	2.0
MSU500-2SPL	280	466	60	40	60	0	0	1.071	1.5	0	0	0	0	2.0	1.5	0.8
MSU200-5PP	242	278	87	13	78	9	0	1.064	1.5	0	0	0	0	1.0	2.5	0.8
Zongshu 3	242	302	80	16	80	0	3	1.070	3.0	1	0	0	0	3.5	2.3	0.9
MSNDU022-1	238	282	85	14	80	5	1	1.079	1.0	2	0	0	0	3.0	1.0	1.0
MSNDU045-1	225	315	71	28	71	0	1	1.063	1.0	0	1	0	0	-	1.0	0.8
CO00291-5R	222	268	83	17	83	0	0	1.063	2.5	1	1	0	0	2.5	4.0	0.7
MSU616-3P	197	282	70	28	70	0	2	1.066	1.5	0	0	0	0	2.0	2.0	-
MSR217-1R	194	238	81	16	73	9	3	1.059	2.0	0	0	0	0	2.0	1.0	0.7
MSR297-A	173	211	82	18	79	3	0	1.065	1.0!	0	0	0	0	1.0	1.8	0.3
MSU616-1PP	168	276	61	38	61	0	1	1.065	1.5	0	0	0	0	2.0	1.0	0.8
Jingshu 2	154	291	53	46	52	1	1	1.089	2.0	1	4	0	0	3.0	3.5	2.4
MST406-2RR	146	213	69	16	63	5	16	1.048	1.5	0	0	0	0	1.5	1.8	0.5
MSR241-4RY	120	204	59	41	58	1	0	1.067	1.5	0	0	0	0	3.5	1.8	0.8
Sieglinde	75	217	34	61	34	0	4	1.071	-	0	0	0	0	0.5	2.8	-
MSQ405-1PP	72	159	45	55	45	0	0	1.064	1.5	0	0	0	0	2.0	3.3	0.5

Table 8

PRELIMINARY TRIAL, TABLESTOCK LINES
MONTCALM RESEARCH FARM
May 4 to September 7, 2010 (126 days)

	CWT/A		PERCENT OF TOTAL[1]						CHIP	PERCENT (%) TUBER QUALITY[3]						
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	SCORE[2]	HH	VD	IBS	BC	SCAB[4]	MAT[5]	BRUISE[6]
1991-563-18	58	144	40	60	40	0	0	1.082	1.5	0	0	0	0	1.0	3.3	0.4
MSU616-2PP	17	104	16	84	16	0	0	1.071	1.0	0	0	0	0	2.0	1.8	0.6
MEAN	258	336						1.069						2.1	2.1	0.9
$HSD_{0.05}$	268	276						0.010						2.3	2.1	

[LBR] Line(s) demonstrated foliar resistance to Late Blight (*Phytopthora infestans*) in inoculated field trials at the MSU Muck Soils Research Farm.

[1]SIZE: B: < 2 in.; A: 2-3.25 in.; OV: > 3.25 in.; PO: Pickouts.

[2]CHIP SCORE: Snack Food Association Scale (Out of the field); Ratings: 1-5; 1: Excellent, 5: Poor.

[3]QUALITY: HH: Hollow Heart; BC: Brown Center; VD: Vascular Discoloration; IBS: Internal Brown Spot. Percent of 20 Oversize and/or A-size tubers cut.

[4]SCAB DISEASE RATING: MSU Scab Nursery; 0: No Infection; 1: Low Infection <5%; 3: Intermediate; 5: Highly Susceptible.

[5]MATURITY RATING: August 24, 2010; Ratings 1-5; 1: Early (vines completely dead); 5: Late (vigorous vine, some flowering).

[6]BRUISE: Simulated blackspot bruise test average number of spots per tuber.

Table 9

MICHIGAN STATE UNIVERSITY
POTATO BREEDING and GENETICS

2008-2010 SCAB DISEASE TRIAL SUMMARY
SCAB NURSERY, MONTCALM CO., MI

LINE	*3-YR* AVG.*	2010 RATING	2010 WORST	2010 N	2009 RATING	2009 WORST	2009 N	2008 RATING	2008 WORST	2008 N
Sorted by ascending 2010 Rating;										
A98289-1RUS	-	0.5	1	2	-	-	-	-	-	-
Sieglinde	-	0.5	1	2	-	-	-	-	-	-
MSS297-3	***1.1***	0.9	1	4	1.0	1	4	1.5	2	1
1991-563-18	-	1.0	1	2	-	-	-	-	-	-
AC00395-2RUS	-	1.0	1	2	-	-	-	-	-	-
Goldrush Russet	***1.0****	**1.0**	**1**	**2**	**1.0**	**1**	**4**	**-**	**-**	**-**
MSH228-6	***1.1***	1.0	1	2	1.3	2	4	1.0	1	3
MSJ126-9Y	***1.1***	1.0	1	2	1.3	2	4	1.1	2	4
MSL007-B	***1.0****	1.0	1	2	1.0	1	3	-	-	-
MSM037-3	***1.3***	1.0	1	2	1.3	2	4	1.8	2	4
MSN215-2P	***0.9***	1.0	1	2	0.8	1	4	1.0	1	4
MSP270-1	***1.3****	1.0	1	2	1.5	2	4	-	-	-
MSQ035-3[LBR]	***1.5***	1.0	1	2	2.0	2	4	1.5	2	3
MSR036-5[LBR]	***1.3***	1.0	1	2	1.3	2	4	1.5	2	3
MSR102-3[LBR]	***1.0***	1.0	1	2	0.8	1	4	1.1	2	4
MSR127-2	***1.1***	1.0	1	2	1.0	1	4	1.3	2	4
MSR131-2	-	1.0	1	2	-	-	-	-	-	-
MSR169-8Y	***1.0***	1.0	1	2	1.0	1	4	1.0	1	2
MSR297-A	***1.5***	1.0	1	2	1.7	2	3	1.8	2	3
MSS544-1R	***0.9***	1.0	1	2	0.8	1	4	1.0	1	4
MST386-1P	-	1.0	1	2	-	-	-	-	-	-
MSU320-2Y	-	1.0	1	1	-	-	-	-	-	-
MSU383-1	-	1.0	1	2	-	-	-	-	-	-
MSU384-1	-	1.0	1	2	-	-	-	-	-	-
ND8229-3	-	1.0	1	2	-	-	-	-	-	-
Silverton Russet	***1.0***	1.0	1	2	1.3	2	4	0.8	1	4
W2609-1R	-	1.0	1	2	-	-	-	-	-	-
W2683-2RUS	-	1.0	1	2	-	-	-	-	-	-
MSU200-5PP	-	1.0	2	2	-	-	-	-	-	-
Pike	***1.3***	**1.1**	**2**	**8**	**1.5**	**2**	**8**	**1.4**	**2**	**15**
A98134-2RUS	-	1.3	2	2	-	-	-	-	-	-
MSJ147-1	***1.4***	1.3	2	2	1.7	2	3	1.4	2	4
MSK409-1	***1.6***	1.3	2	2	1.6	2	4	2.0	4	3
MSQ279-1	-	1.3	2	2	-	-	-	-	-	-
MST441-1	-	1.3	2	2	-	-	-	-	-	-
W8946-1RUS	-	1.3	2	2	-	-	-	-	-	-
MSQ070-1[LBR]	***1.2***	1.3	2	2	1.3	2	3	1.0	1	4
MSR061-1[LBMR,PVYR]	***1.2***	1.3	2	2	1.1	2	4	1.3	2	4
MSR157-1Y	***1.4***	1.3	2	2	1.5	2	4	1.5	2	4
MST285-2	***1.4****	1.3	2	2	1.5	2	4	-	-	-
MSU230-2Y	-	1.5	2	1	-	-	-	-	-	-
A00188-3C	***1.4****	1.5	2	2	1.3	2	3	-	-	-
A01124-3RUS	-	1.5	2	2	-	-	-	-	-	-

Table 9

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SCAB NURSERY, MONTCALM CO., MI

LINE	*3-YR* AVG.*	2010 RATING	2010 WORST	2010 N	2009 RATING	2009 WORST	2009 N	2008 RATING	2008 WORST	2008 N
Sorted by ascending 2010 Rating;										
CO00188-4W	***1.8****	1.5	2	2	2.0	2	4	-	-	-
CO95051-7W	-	1.5	2	2	-	-	-	-	-	-
Kalkaska (MSJ036-A)	***1.3***	**1.5**	**2**	**2**	**1.3**	**2**	**4**	**1.1**	**2**	**4**
MSM171-A[LBR]	***1.8***	1.5	2	2	2.3	3	4	1.7	3	8
MSN148-A	***1.6***	1.5	2	2	2.0	3	4	1.4	2	4
MSNDU030-1	-	1.5	2	2	-	-	-	-	-	-
MSQ341-BY	-	1.5	2	2	-	-	-	-	-	-
MSR058-1	***1.3***	1.5	2	2	1.3	2	4	1.3	2	4
MSR605-11	-	1.5	2	2	-	-	-	-	-	-
MSS108-1	-	1.5	2	2	-	-	-	-	-	-
MSS737-1Y[LBR]	***1.5***	1.5	2	2	1.3	2	4	1.7	2	3
MST202-5	***1.6****	1.5	2	2	1.8	3	4	-	-	-
MST220-8	***1.8****	1.5	2	2	2.1	3	4	-	-	-
MST306-1	***1.3****	1.5	2	2	1.0	2	4	-	-	-
MST406-2RR	-	1.5	2	2	-	-	-	-	-	-
MSU379-1	-	1.5	2	2	-	-	-	-	-	-
ND8307c-3	-	1.5	2	2	-	-	-	-	-	-
A01143-3C	***1.5****	1.8	2	2	1.3	2	4	-	-	-
MSL228-1SPL	***2.0***	1.8	2	2	2.5	4	3	1.6	2	4
MSN170-A	-	1.8	2	2	-	-	-	-	-	-
MSQ440-2	***1.3***	1.8	2	2	1.0	2	4	1.3	2	4
MST424-3	***1.5****	1.8	2	2	1.3	2	4	-	-	-
MSU279-1	-	1.8	2	2	-	-	-	-	-	-
AF2291-10	-	2.0	2	2	-	-	-	-	-	-
Beacon Chipper	***1.4***	2.0	2	2	1.3	2	4	1.0	1	1
CO99053-3RUS	***1.7***	2.0	2	2	1.5	3	4	1.5	3	4
MSN230-1RY	***1.1****	2.0	2	2	0.3	1	4	-	-	-
MSN251-1Y	-	2.0	2	2	-	-	-	-	-	-
MSQ029-1[LBR]	***2.0***	2.0	2	1	2.0	2	4	2.0	2	4
MSQ405-1PP	***1.4****	2.0	2	2	0.8	1	4	-	-	-
MSQ432-2PP	***1.8***	2.0	2	2	1.8	3	4	1.5	2	2
MSQ461-2PP	***1.4***	2.0	2	2	0.8	1	4	1.5	2	4
MSR041-3	-	2.0	2	2	-	-	-	-	-	-
MSR159-02[LBR]	***1.7***	2.0	2	2	1.5	2	4	1.5	2	3
MSR160-2Y	-	2.0	2	2	-	-	-	-	-	-
MSR217-1R	***1.9****	2.0	2	1	1.8	3	4	-	-	-
MSR605-5	-	2.0	2	2	-	-	-	-	-	-
MSS258-1	***2.0***	2.0	2	2	2.0	3	4	2.0	2	1
MSS514-1PP	***1.4***	2.0	2	2	1.5	3	4	0.8	1	4
MSS576-05SPL	***2.0***	2.0	2	2	2.0	3	4	-	-	-
MSS582-1SPL	***2.0***	2.0	2	2	1.6	3	4	2.4	3	4
MSU161-1	-	2.0	2	2	-	-	-	-	-	-
MSU372-1Y	-	2.0	2	2	-	-	-	-	-	-

Table 9

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SCAB NURSERY, MONTCALM CO., MI

LINE	*3-YR* AVG.*	2010 RATING	2010 WORST	2010 N	2009 RATING	2009 WORST	2009 N	2008 RATING	2008 WORST	2008 N
Sorted by ascending 2010 Rating;										
MSU500-2SPL	-	2.0	2	2	-	-	-	-	-	-
MSU616-1PP	-	2.0	2	2	-	-	-	-	-	-
MSU616-2PP	-	2.0	2	1	-	-	-	-	-	-
MSU616-3P	-	2.0	2	2	-	-	-	-	-	-
ND8555-8R	-	2.0	2	2	-	-	-	-	-	-
NY139	-	2.0	2	2	-	-	-	-	-	-
Red Norland	-	**2.0**	**2**	**2**	-	-	-	-	-	-
Russet Burbank	-	**2.0**	**2**	**2**	-	-	-	-	-	-
W2310-3	-	2.0	2	2	-	-	-	-	-	-
W5767-1R	-	2.0	2	2	-	-	-	-	-	-
MSQ130-4[LBR]	***1.8***	2.0	3	2	1.8	3	4	1.5	2	4
MST437-1	-	2.0	3	2	-	-	-	-	-	-
Onaway	***1.8***	**2.1**	**3**	**6**	**1.6**	**2**	**8**	**1.8**	**2**	**7**
MSL211-3	***2.3****	2.2	3	6	2.4	3	4	-	-	-
MSP515-2	***2.0****	2.3	3	2	1.8	2	4	-	-	-
Spunta	-	2.3	3	2	-	-	-	-	-	-
MI Purple Sport III	-	2.3	3	2	-	-	-	-	-	-
MSQ086-3[LBR]	***2.1***	2.3	3	4	2.5	4	4	1.5	2	4
MSQ558-2RR	***1.7***	2.3	3	2	1.3	2	4	1.6	2	4
NorValley	-	2.3	3	2	-	-	-	-	-	-
Russet Norkotah	***2.1****	**2.3**	**3**	**4**	**2.0**	**3**	**4**	-	-	-
CO00291-5R	-	2.5	3	2	-	-	-	-	-	-
Missaukee	-	2.5	3	2	-	-	-	-	-	-
MSL292-A	***2.5***	2.5	3	2	2.3	3	4	2.8	3	4
MSN105-1[LBMR]	***2.1***	2.5	3	2	2.0	2	4	1.9	3	4
MSQ134-5[LBR]	***2.1***	2.5	3	2	1.9	2	4	1.9	3	4
MSQ425-4Y SPL	***2.2***	2.5	3	4	2.3	4	4	1.9	2	4
MSR148-4	-	2.5	3	2	-	-	-	-	-	-
MSR214-2P	-	2.5	3	2	-	-	-	-	-	-
MSR219-2R	***2.4***	2.5	3	2	2.5	3	2	2.3	3	4
MSR605-02	-	2.5	3	2	-	-	-	-	-	-
MSR606-02	-	2.5	3	2	-	-	-	-	-	-
MSS206-2[LBR]	***2.1***	2.5	3	2	2.1	3	4	1.8	2	4
MSU278-1	-	2.5	3	2	-	-	-	-	-	-
MSU613-1	-	2.5	3	2	-	-	-	-	-	-
Reba	***2.2***	2.5	3	2	2.0	3	8	2.0	3	8
Spunta G2	-	2.5	3	2	-	-	-	-	-	-
CO99256-2R	***2.3****	2.8	4	2	1.8	3	4	-	-	-
Snowden	***2.6***	**2.9**	**4**	**10**	**2.3**	**3**	**12**	**2.6**	**3**	**16**
Atlantic	***2.7***	**2.9**	**3**	**10**	**2.7**	**3**	**8**	**2.4**	**3**	**12**
CO02024-9W	-	3.0	3	2	-	-	-	-	-	-
CO02321-4W	-	3.0	3	2	-	-	-	-	-	-
MSL268-D[LBR,PVYR]	***2.2***	3.0	3	2	2.5	4	4	1.1	2	4

Table 9

2008-2010 SCAB DISEASE TRIAL SUMMARY
SCAB NURSERY, MONTCALM CO., MI

LINE	*3-YR* AVG.*	2010 RATING	2010 WORST	2010 N	2009 RATING	2009 WORST	2009 N	2008 RATING	2008 WORST	2008 N
Sorted by ascending 2010 Rating;										
MSM182-1[LBR,PVYR]	***2.7***	3.0	3	2	2.9	4	4	2.1	3	4
MSM288-2Y	-	3.0	3	2	-	-	-	-	-	-
MSNDU022-1	-	3.0	3	2	-	-	-	-	-	-
MSP459-5	-	3.0	3	2	-	-	-	-	-	-
MSQ176-5[LBR]	***2.3***	3.0	3	2	1.8	3	4	2.0	2	3
MSR089-9Y	-	3.0	3	2	-	-	-	-	-	-
MSR226-1RR	***2.0***	3.0	3	2	1.0	2	4	2.0	2	3
MSS026-2Y	***2.6***	3.0	3	2	2.5	3	4	2.2	3	3
MST191-2Y	-	3.0	3	2	-	-	-	-	-	-
MSU088-1	-	3.0	3	2	-	-	-	-	-	-
ND8314-1R	-	3.0	3	2	-	-	-	-	-	-
W2717-5	-	3.0	3	2	-	-	-	-	-	-
Jingshu 2	-	3.0	4	2	-	-	-	-	-	-
MSS070-B	***2.5****	3.0	4	2	2.0	3	4	-	-	-
W5015-12	-	3.0	4	2	-	-	-	-	-	-
Jacqueline Lee[LBR]	***3.0***	3.3	4	2	2.5	3	4	3.3	4	4
CO00197-3W	***3.3****	3.5	4	2	3.1	4	4	-	-	-
Colorado Rose	-	3.5	4	2	-	-	-	-	-	-
FL1879	***2.7***	3.5	4	2	2.0	3	7	2.5	3	11
Midnight	***2.9****	3.5	4	2	2.3	4	3	-	-	-
MSR241-4RY	***2.5***	3.5	4	2	1.8	3	4	2.3	3	4
MSR606-10	-	3.5	4	2	-	-	-	-	-	-
W2978-3	-	3.5	4	2	-	-	-	-	-	-
W6234-4RUS	-	3.5	4	2	-	-	-	-	-	-
Zongshu 3	-	3.5	4	2	-	-	-	-	-	-
CO02033-W	-	3.8	4	2	-	-	-	-	-	-
AC01151-5W	-	3.8	5	2	-	-	-	-	-	-
MSM183-1	-	4.0	4	2	-	-	-	-	-	-
Red Pontiac	-	**4.5**	**5**	**2**	-	-	-	-	-	-
$H/LSD_{0.05}$ =		**2.3**			**1.1**			**0.9**		

SCAB DISEASE RATING: MSU Scab Nursery plot rating of 0-5; 0: No Infection; 1: Low Infection <5%, no pitted leisions; 3: Intermediate >20%, some pitted leisions (Susceptible, as commonly seen on Atlantic); 5: Highly Susceptible, >75% coverage and severe pitted leisions.

[LBR] Line(s) demonstrated foliar resistance to Late Blight (*Phytopthora infestans*) in inoculated field trials at the MSU Muck Soils Research Farm.

Table 10

2010 LATE BLIGHT VARIETY TRIAL
MUCK SOILS RESEARCH FARM

LINE	RAUDPC[1] MEAN	Female	Male	LINE	RAUDPC[1] MEAN
Sorted by ascending RAUDPC value:					
Foliar Resistance Category (select lines):				***Foliar Susceptibility Category (select lines)[2]:***	
Torridon	0.4			Beacon Chipper	43.5
MCR150	0.4			MSR217-1R	43.8
MCR205	0.4			MST306-1	44.3
ND039036-2R	0.4			Silverton Russet	44.3
LBR9	0.6			MSR297-A	44.4
VSB16 (LBR8)	0.7			MSQ134-5	44.7
Montanosa	0.8			A01124-3RUS	44.7
J138K6A22	0.9			A01143-3C	45.1
MSR214-2P	0.9	ND5084-3R	MSJ317-1	ND8229-3RUS	45.5
MSM183-1	0.9	Torridon	J. Lee	Midnight	45.5
Sherriff	0.9			MSQ086-3	45.6
Kenya Baraka	1.0			MSU245-2	46.0
Monserrat	1.0			Austrian Crescent	46.2
MSL268-D	1.0	NY103	J. Lee	MST191-2Y	46.4
Satina	1.0			A98134-2RUS	46.9
MSQ029-1	1.4	B0766-3	NY121	NY139	47.9
Stirling	1.4			MSR041-3	48.6
MSR160-2Y	1.5	NY121	MSJ126-9Y	MSS576-05SPL	48.6
A9520-43	1.7			MSR605-05	49.3
CO00291-5R	2.1			NDU030-1	49.5
Mnandi	2.5			Russian Banana	49.9
MSE149-5Y 82.4	3.9	Saginaw Gold	ND860-2	MSQ035-3	50.4
MSQ405-1PP	4.1	MSG147-3P	MSJ319-1	W2310-3	51.3
NY121	4.9			MSU307-3Y	52.2
MSI152-A	5.0	Mainestay	B0718	**Red Norland**	**52.3**
MSU279-1	6.1	Torridon	NY132	ND8314-1R	53.0
MSR061-1	8.7	MegaChip	NY121	**Russet Norkotah**	**53.0**
MSR036-5	8.8	MSL766-1	Liberator	CO02321-4W	53.5
MSE149-5Y 82.1	9.0	Saginaw Gold	ND860-2	MSR219-2R	54.5
Gala	9.9			MSS026-2Y	55.0
MSR148-4	10.2	MSI152-A	Dakota Pearl	**Onaway**	**56.3**
Sieglinde	10.6			**D Red Norland**	**57.4**
MSM182-1	10.9	Stirling	NY121	W2609-1R	58.1
MSR605-02	10.9	Spunta G2	Missaukee	W2978-3	62.9
MSQ176-5	11.8	MSI152-A	Missaukee	A98289-1RUS	64.7
Tukey $HSD_{0.05}$	20.2				

[1] Ratings indicate the average plot RAUDPC (Relative Area Under the Disease Progress Curve).

[2] 157 potato varieties and advanced breeding lines were tested in all. For brevity purposes, only selected varieties and breeding lines are listed.

Phytopthora infestans isolate US-8 was inoculated on 8/3/2010. NOTE: US-22 was identified at the Muck Soils Research Farm.

Planted as a randomized complete block design consisting of 3 replications of 4 hill plots on 6/7/2010.

Table 11

2010 BLACKSPOT BRUISE SUSCEPTIBILITY TEST
SIMULATED BRUISE SAMPLES*

ENTRY	NUMBER OF SPOTS PER TUBER 0	1	2	3	4	5+	PERCENT (%) BRUISE FREE	AVERAGE SPOTS/TUBER
ADVANCED TRIAL								
MSQ279-1	21	4					84	0.2
MSP270-1	20	5					80	0.2
MSQ440-2	20	5					80	0.2
MSH228-6	17	7	1				68	0.4
MSQ086-3	17	7	1				68	0.4
MSJ126-9Y	14	8	2	1			56	0.6
MSR061-1	11	13	1				44	0.6
MSJ147-1	12	10	3				48	0.6
FL1879	12	9	4				48	0.7
MSL007-B	10	11	3	1			40	0.8
MSQ070-1	11	5	6	3			44	1.0
Kalkaska (J036-A)	8	7	6	4			32	1.2
MSL292-A	8	5	9	3			32	1.3
Beacon Chipper	7	8	6	3	1		28	1.3
MSP515-2	7	8	6	2	2		28	1.4
Snowden	**9**	**5**	**5**	**4**		**2**	**36**	**1.5**
MSP459-5	6	6	7	4	2		24	1.6
Atlantic	**4**	**5**	**7**	**2**	**5**	**2**	**16**	**2.2**
RUSSET TRIAL								
A01124-3RUS	25						100	0.0
Russet Norkotah-NCR	**23**	**1**	**1**				**92**	**0.1**
MSS737-1Y	22	2	1				88	0.2
MSR605-11	20	5					80	0.2
MSR605-05	19	6					76	0.2
Silverton Russet	19	5	1				76	0.3
MSR606-10	17	8					68	0.3
W6234-4RUS	17	7	1				68	0.4
MSR606-02	8	5					62	0.4
CO99053-3RUS	16	8	1				64	0.4
A98134-2RUS	16	7	2				64	0.4
MSN170-A	15	8	2				60	0.5
Russet Norkotah-Sandyland	16	6	3				64	0.5
Spunta G2	15	8	2				60	0.5
Goldrush	15	6	4				60	0.6
A98289-1RUS	16	5	2	2			64	0.6
AC00395-2RUS	13	9	2	1			52	0.6

2010 BLACKSPOT BRUISE SUSCEPTIBILITY TEST
SIMULATED BRUISE SAMPLES*

ENTRY	NUMBER OF SPOTS PER TUBER 0	1	2	3	4	5+	PERCENT (%) BRUISE FREE	AVERAGE SPOTS/TUBER
Spunta	13	8	4				52	0.6
Russet Burbank-NCR	**12**	**9**	**2**	**2**			**48**	**0.8**
MSR605-02	8	6	6	2	2	1	32	1.5
W8946-1RUS-NCR	8	3	10	3		1	32	1.5
W2683-2RUS	1	2	11	5	3	3	4	2.6
NORTH CENTRAL REGIONAL TRIAL								
Red Norland	19	6					76	0.2
W2609-1R	16	9					64	0.4
W2978-3	14	9	2				56	0.5
MSQ176-5	11	13	1				44	0.6
Pontiac	14	7	3		1		56	0.7
ND8307C-3	11	9	4	1			44	0.8
MSL211-3	8	10	5	2			32	1.0
ND8314-1R	10	5	9	1			40	1.0
ND8555-8R	9	7	7	1	1		36	1.1
NorValley	8	9	5	2	1		32	1.2
MSM182-1	10	7	3	3	1	1	40	1.2
W2717-5	6	12	3	3	1		24	1.2
Atlantic	**8**	**5**	**7**	**4**	**1**		**32**	**1.4**
MSL268-D	5	9	6	3	2		20	1.5
W2310-3	6	3	9	3	3	1	24	1.9
ND8229-3RUS	4	4	10	4	1	2	16	2.0
W5015-12	0	7	7	6	4	1	0	2.4
ADAPTATION TRIAL, CHIP-PROCESSING LINES								
MSS108-1	18	6	1				72	0.3
MSQ432-2PP	16	8	1				64	0.4
MSR102-3	16	6	3				64	0.5
MSR159-02	12	12	1				48	0.6
MSR226-1RR	15	7	2	1			60	0.6
MSS258-1	12	9	2	2			48	0.8
Pike	11	10	3		1		44	0.8
MSS206-2	8	12	4	1			32	0.9
MSR131-2	9	9	5	2			36	1.0
MSR169-8Y	11	7	3	3	1		44	1.0
MSR036-5	9	8	4	3		1	36	1.2
MSS026-2Y	7	8	3	5	2		28	1.5
Missaukee	5	8	7	4	1		20	1.5
MSR058-1	7	7	6	3		2	28	1.5
Snowden	**5**	**10**	**4**	**4**	**1**	**1**	**20**	**1.6**

2010 BLACKSPOT BRUISE SUSCEPTIBILITY TEST
SIMULATED BRUISE SAMPLES*

ENTRY	NUMBER OF SPOTS PER TUBER 0	1	2	3	4	5+	PERCENT (%) BRUISE FREE	AVERAGE SPOTS/TUBER
MSQ558-2RR	7	3	7	6	1	1	28	1.8
Atlantic	**2**	**4**	**15**	**3**	**1**		**8**	**1.9**
MSN148-A	4	6	9	2	2	2	16	1.9
CO95051-7W	3	7	4	10	1		12	2.0
MSQ035-3	2	7	5	6	5		8	2.2
MSK409-1	1	8	4	5	2	5	4	2.6
ADAPTATION TRIAL, TABLESTOCK LINES								
MSM288-2Y	23	2					92	0.1
MSS544-1R	22	3					88	0.1
MSN105-1	6	1					86	0.1
MSR157-1Y	19	4	1				79	0.3
MSS576-05SPL	17	7	1				68	0.4
MSQ461-2PP	16	8	1				64	0.4
MSL228-1SPL	16	5	4				64	0.5
MSQ341-BY	17	4	3	1			68	0.5
MSS514-1PP	14	9	2				56	0.5
MSS582-1SPL	15	7	3				60	0.5
MSN215-2P	14	7	4				56	0.6
MSQ134-5	16	4	4	1			64	0.6
J. Lee	8	12	5				32	0.9
Onaway	**9**	**10**	**3**	**1**	**2**		**36**	**1.1**
Reba	5	7	11	2			20	1.4
MSQ425-4Y	5	8	7	5			20	1.5
MSN230-1RY	3	8	6	4	4		12	1.9
PRELIMINARY TRIAL, CHIP-PROCESSING LINES								
MSR160-2Y	25						100	0.0
MST202-5	13						100	0.0
A00188-3C	12	1					92	0.1
MSU384-1	21	4					84	0.2
CO00188-4W	20	5					80	0.2
MSU379-1	20	4	1				80	0.2
MST437-1	18	5	2				72	0.4
MSQ130-4	17	7		1			68	0.4
MST306-1	15	5	2				68	0.4
MSQ029-1	14	9	2				56	0.5
A01143-3C	16	5	3	1			64	0.6
Pike	**13**	**10**	**1**		**1**		**52**	**0.6**
MSU245-1	16	3	5	1			64	0.6
MSU245-2	13	9	2	1			52	0.6

2010 BLACKSPOT BRUISE SUSCEPTIBILITY TEST
SIMULATED BRUISE SAMPLES*

	NUMBER OF SPOTS PER TUBER						PERCENT (%) BRUISE FREE	AVERAGE SPOTS/TUBER
ENTRY	0	1	2	3	4	5+		
AC01151-5W	12	10	2	1			48	0.7
CO00197-3W	12	9	4				48	0.7
CO02024-9W	12	10	2	1			48	0.7
MST441-1	12	8	4	1			48	0.8
MST220-8	14	4	5	1	1		56	0.8
NY139	8	12	5				32	0.9
NDU030-1	10	7	5	3			40	1.0
MSR148-4	6	14	4		1		24	1.0
CO02033-1W	8	9	6	2			32	1.1
MST424-3	11	4	6	4			44	1.1
Snowden	**7**	**10**	**5**	**3**			**28**	**1.2**
MSS297-3	9	6	8	1		1	36	1.2
MSU358-2	9	7	5	3	1		36	1.2
MSU088-1	6	9	8	2			24	1.2
CO02321-4W	7	9	5	3	1		28	1.3
AF2291-10	6	7	9	1	2		24	1.4
MSU383-1	12	2	4	3	3	1	48	1.4
Atlantic	**5**	**8**	**8**	**3**	**1**		**20**	**1.5**
MST191-2Y	8	4	8	3	2		32	1.5
MSU246-1	5	7	8	2	3		20	1.6
MSR127-2	4	6	3	5	4	3	16	2.3
PRELIMINARY TRIAL, TABLESTOCK LINES								
MSU202-1P(1REP)	20	5					80	0.2
MSR297-A	19	5	1				76	0.3
1991-563-18	14	7	1				64	0.4
MSQ405-1PP	15	8	2				60	0.5
MST406-2RR	11	5	2				61	0.5
MSU613-1	8	3		1			67	0.5
MSU616-2PP	6	6	1				46	0.6
Colorado Rose	13	8	4				52	0.6
CO00291-5R	13	7	5				52	0.7
MSR217-1R	11	11	2	1			44	0.7
MSR214-2P	12	8	4	1			48	0.8
MSU279-1	12	7	6				48	0.8
MSU500-2SPL	5	6	2				38	0.8
CO99256-2R	11	9	4	1			44	0.8
MSR241-4RY	10	11	3	1			40	0.8
MSU161-1	12	7	5	1			48	0.8
MSU200-5PP	13	5	6	1			52	0.8

2010 BLACKSPOT BRUISE SUSCEPTIBILITY TEST
SIMULATED BRUISE SAMPLES*

	NUMBER OF SPOTS PER TUBER						PERCENT (%) BRUISE FREE	AVERAGE SPOTS/TUBER
ENTRY	0	1	2	3	4	5+		
MSU616-1PP	8	6	3	1			44	0.8
Midnight	7	16	1	1			28	0.8
MSNDU045-1	10	10	4	1			40	0.8
MSU320-2Y	12	9	2	1		1	48	0.8
Zongshu 3	14	4	3	4			56	0.9
MSNDU022-1	9	8	6	2			36	1.0
MST285-2	11	5	6	3			44	1.0
MST386-1P	4	8	8	4	1		16	1.6
Onaway	**5**	**6**	**8**	**4**	**1**	**1**	**20**	**1.7**
W5767-1R	3	8	5	5	3	1	12	2.0
Jingshu 2	3	4	8	4	3	3	12	2.4

2010 BLACKSPOT BRUISE SUSCEPTIBILITY TEST
SIMULATED BRUISE SAMPLES*

ENTRY	NUMBER OF SPOTS PER TUBER 0	1	2	3	4	5+	PERCENT (%) BRUISE FREE	AVERAGE SPOTS/TUBER
USPB/SFA TRIAL CHECK SAMPLES (Not bruised)								
NY138	23	1	1				92	0.1
W2978	22	3					88	0.1
MSJ126-9Y	20	5					80	0.2
W2717-5	15	10					60	0.4
CO97043-14W	14	10	1				56	0.5
NY139	14	9	1	1			56	0.6
CO97065-7W	13	9	3				52	0.6
Snowden	**14**	**8**	**2**	**1**			**56**	**0.6**
AF2291-10	10	13	2				40	0.7
MSL292-A	12	6	3	2	2		48	1.0
W2310-3	8	10	5	2			32	1.0
W5015-12	11	5	5	3	1		44	1.1
Atlantic	**2**	**12**	**4**	**5**	**1**	**1**	**8**	**1.8**
USPB/SFA TRIAL BRUISE SAMPLES								
MSJ126-9Y	15	9	1				60	0.4
NY138	17	6	1	1			68	0.4
W2978	12	8	3	2			48	0.8
CO97043-14W	10	9	4	2			40	0.9
NY139	9	10	5		1		36	1.0
MSL292-A	10	9	3	1	1	1	40	1.1
W2717-5	10	5	5	3	2		40	1.3
CO97065-7W	5	5	11	4			20	1.6
AF2291-10	2	10	5	5	2	1	8	1.9
W2310-3	4	9	4	3	2	3	16	2.0
Atlantic	**3**	**7**	**7**	**2**	**3**	**3**	**12**	**2.2**
Snowden	**3**	**2**	**7**	**8**	**1**	**4**	**12**	**2.6**
W5015-12	1	4	5	6	3	6	4	3.0

* Twenty or twenty-five A-size tuber samples were collected at harvest, held at 50 F at least 12 hours, and placed in a six-sided plywood drum and rotated ten times to produce simulated bruising. Samples were abrasive-peeled and scored 10/18/2010. The table is presented in ascending order of average number of spots per tuber.

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2010 On-Farm Potato Variety Trials

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Introduction

On-farm potato variety trials were conducted with 13 growers in 2010 at a total of 18 locations. Eleven of the locations evaluated processing entries and seven evaluated fresh market entries. The processing cooperators were Crooks Farms, Inc. (Montcalm), Walther Farms, Inc. (St. Joseph), Lennard Ag. Co. (Branch), County Line Potato Farms, Inc. (Allegan), Main Farms (Montcalm), Michigan State University (MSU), Montcalm Research Farm (Montcalm) and Thorlund Brothers (Montcalm). The United States Potato Board/Snack Food Association (USPB / SFA) chip trial was at Sandyland Farms, LLC (Mecosta). Fresh market trial cooperators were Crawford Farms, Inc. (Montcalm), Elmaple Farms (Kalkaska), R & E Farms (Presque Isle), Horkey Bros. (Monroe), T.J.J. VanDamme Farms (Delta), Sandyland Farms, LLC (Newaygo) and Walther Farms, Inc. (Branch).

Procedure

There were six types of processing trials conducted this year. The first type contained 13 entries which were compared with the check varieties Snowden, Pike and FL1879. This trial type was conducted at Main Farms, Lennard Ag. Co. and County Line Farms. Varieties in these trials were planted in 100’ strip plots. Seed spacing in each trial was grower dependent, but in general ranged from 9.5 to 11 inches. The second type of processing trial, referred to as a “Select” trial, contained six lines which were compared to the variety in the field. In these trials, each variety was planted in a 15’ row plot. Seed spacing and row width were 10” and 34”, respectively. These trials were conducted on Crooks Farms, Inc. (Montcalm). The third was a processing variety trial where each plot consisted of three 34” wide rows which were 15’ long. Only the center row was harvested for the yield evaluation. This trial was conducted at Walther Farms, Inc. (St. Joseph). At Walther’s, 21 varieties were compared to the check varieties Snowden, Pike and FL1879. The plots were planted at 10” in-row spacing. The fourth type was the Box Bin trial at the Montcalm Research Farm in Montcalm County, MI. This trial contained 20 varieties compared against the check variety Snowden. Each of the 21 varieties were planted in a single 34” wide row, 600’ long with 10” in-row seed spacing. A single 23’ yield check was taken to evaluate each clone. The fifth type of chip trial consisted of large multiple acreage blocks of three newly commercialized or soon to be commercialized varieties. Agronomic and production practices for these varieties were based on each individual grower’s production system. The varieties and growers were: Thorlund Brothers (Montcalm), MSJ126-9Y; Lennard Ag. Co. (Branch), NY139 (Lamoka); Walther Farms (St. Joseph), W2133-1 (Nicolet).

The USPB / SFA chip trial was the 6th chip processing trial type. For procedural details on this trial, reference the 2010 annual report published by the United States Potato Board.

Within the fresh market trials, there were 26 entries evaluated. There were 7 to 22 lines planted at each of the following locations: Branch, Delta, Kalkaska, Monroe, Montcalm and Presque Isle counties. The varieties in each trial ranged from mostly round white varieties to mostly russet varieties. These varieties were generally planted in 100' strip plots. A single 23' yield check was taken to evaluate each clone in these strip trials. Seed spacing varied from 8 to 12 inches depending upon grower production practices and variety. At Walther Farms, Inc. (Branch), three row plots were evaluated. The plots were 15' long by 34" wide and seed spacing was 12". Only the center row was harvested and evaluated. The second freshpack trial type was the Russet Select Trial. The select russet trials were planted at three locations (Elmaple Farm (Kalkaska), Montcalm Research Farm (Montcalm) and Walther Farms, (St. Joseph)). Each russet variety was planted in one three row plot, that was thirty feet long with 34" wide rows and 11-12" in-row spacing. A yield determination was made on 23 feet of the center row. Each select trial varied in the number of varieties tested. The third type of freshpack trial was the small block plantings done at Horkey Bros. (Monroe) and Sandyland Farms, LLC (Newaygo). In each of these trials 2-3 varieties were planted in 4-8 row blocks 600-1200' in length. CO99053-3Rus was compared to Russet Norkotah at Sandyland in Newaygo Co. and MSL211-3, MSL268-D and MSQ176-5 were planted in Horkey's in Monroe Co. A single 23' plot was harvested in each of these plots to make a yield and quality determination.

Results

A. Processing Variety Trial Results

A description of the processing varieties, their pedigree and scab ratings are listed in Table 1. The overall averages of the eight locations from Allegan, Branch, Mecosta, Montcalm and St. Joseph counties are shown in Table 2.

Processing Variety Highlights

A00188-3C; is an Aberdeen Idaho chip processing selection with above average yield and good long term chip quality from storage. In 2010, it had a 432 cwt./A US#1 yield with a 1.082 average specific gravity (Table 2). The overall size profile of the variety was small, but exhibited some common scab tolerance and a mid-season maturity.

A01143-3C; is an Aberdeen Idaho chip processing selection with very strong yield potential and good long term chip quality from storage. In 2010, it had a 445 cwt./A US#1 yield with a 1.079 average specific gravity (Table 2). The overall size profile of the variety was smaller with 8 percent "B" size tubers and 83 percent

“A’s”. This variety exhibits some common scab tolerance, but appears to have a very late vine maturity.

AF2291-10; this selection has been developed at the University of Maine. This variety appears to chip process well from out of the field and has early to mid-season storage. It’s yield potential is good, producing 444 cwt./A US#1 in 2010 (Table 2). The average specific gravity of this line was 1.083. Four hollow heart were observed in 40 cut tubers. The overall tuber type of this variety is not very uniform. This line has some common scab tolerance (Table 1).

CO00188-4W; this selection is from the University of Colorado. It has a below average yield (Table 1), but has some common scab tolerance and late season chip quality and storability.

MSH228-6; This Michigan State University selection continues to have an above average yield of US#1 size tubers (Table 2) and good common scab resistance (Table 1). This variety over four years of on-farm trialing has a 357 cwt./A US#1 yield. Some internal vascular discoloration has been noted over the years in finished chips from storage.

MSJ126-9Y; This MSU selection was only at one location in 2010. Yield potential for this variety appears to be average, but it maintains a very uniform round tuber type. The four year yield average for this line is 334 cwt./A US#1. This variety is common scab resistant (Table 1). MSJ126-9Y has a good chip quality until March or April in storage.

MSL007-B; is an MSU selection with a heavy netted skin and common scab resistance (Table 1). In 2010, it yielded above average at 392 cwt./A US#1 (Table 2). Chip quality appears to be good from mid-season storage.

MSL292-A; is an Michigan State University developed variety. In 2010, MSL292-A had an average yield at 408 cwt/A US#1 (Table 2). This variety had 90% marketable yield and a slightly below average specific gravity at 1.076. Raw internal tuber quality was good. Pitted scab was noted in some plots. MSL292-A exhibited excellent chip quality out of the field and from storage in 2010 and early 2011.

MSQ070-1; is a MSU clone with common scab and late blight resistance. In 2010 on-farm trials, this variety yielded only 278 cwt/A US#1 with a 1.080 specific gravity. There was 11% hollow heart reported across seven trial locations (Table 2). This variety had a vine maturity that was later than Snowden. Tuber type was very uniformly round and chip quality was good from mid to late season storage. This variety appeared to set well and could benefit from a slightly wider in-row seed spacing of 11 inches.

MSR061-1; is an MSU developed variety with common scab tolerance, resistance to PVY and foliar late blight resistance (Table 1). This variety is a below average yielding line with an average specific gravity (Table 2).

NY139 (Lamoka); this is a Cornell, New York developed clone. This variety continues to exhibit a strong yield and good size profile. In the 2010 processing potato variety trials, NY139 yielded 378 cwt/A US#1 over eight locations with a 92% marketable yield average (Table 2). The specific gravity of this clone was above the trial average at 1.079. One hollow heart was noted in 100 cut tubers. NY139 also performed very well in the 2010 USPB/SFA trial (Table 3). This clone yielded 428 cwt/A US#1 with a 91% marketable yield. The specific gravity was two points above the trial average at 1.076. Raw tuber internal quality was good. Vine maturity for this variety appeared to be medium-late to late.

W2133-1 (Nicolet); this clone was developed at the University of Wisconsin and has excellent mid-season chip quality. It appeared to exhibit variable yield potential, but performed most consistently in environments where the growing season is longer. The variety does appear to have a late vine maturity that could be classified as later than Snowden. In 2010, W2133-1, when averaged across two southern Michigan locations, yielded 496 cwt/A US#1 with no hollow heart being observed (Table 2). The size profile and the specific gravity were above the trial averages. This variety was susceptible to common scab.

W5015-12; is a University of Wisconsin variety with strong yield potential. In 2010 it yielded 459 cwt./A US#1 with a 1.081 specific gravity (Table 2). Fifteen percent hollow heart was observed in this variety when averaged over 8 locations. Pitted and surface scab susceptibility was also noted. Chip quality from mid-season storage appears to be good.

B. USPB / SFA Chip Trial Results

The Michigan location of the USPB / SFA chip trial was on Sandyland Farms, LLC in Mecosta County in 2010. Table 3 shows the yield, size distribution and specific gravity of the entries when compared with Atlantic and Snowden. Table 4 shows the at harvest raw tuber quality results. Table 5 shows the out of the field chip quality evaluations from samples processed and scored by Herr Foods, Inc., Nottingham, PA and Table 6 provides the blackspot bruise susceptibility of each entry. Tables 7A and 7B provide a pre-harvest panel for each of the 13 varieties in the trial. These two tables compare tuber specific gravity, percent glucose and sucrose ratings taken on two different dates; August 24th, 2010 and September 7th, 2010 for each variety.

USPB / SFA Chip Trial Highlights

AF2291-10, W5015-12 and Snowden topped the yield chart in 2010 followed by MSL292-A, NY138, Atlantic and NY139 (Table 3). AF2291-10 and MSL292-A had a large percentage of recorded oversize tubers (Table 3). The MSL292-A, NY138, W2978-3 and MSJ126-9Y and CO97043-14W had very low specific gravities. The varieties in the 2010 trial that displayed the greatest potential for commercialization were AF2291-10, W5015-12 and NY139. Yield potential and specific gravity were good for AF2291-10 (Table 3). This clone has a full season maturity and good early to mid–season chip quality. AF2291-10 appeared to have a slight susceptibility to black spot bruise (Table 6), but some tolerance to common scab. Table 5 shows some of the other varieties that did not have the best all-around agronomic performance, but had great chip quality, such as MSL292-A and W2717-5.

C. <u>Fresh Market and Variety Trial Results</u>

A description of the freshpack varieties, their pedigree and scab ratings are listed in Table 8. Table 9 shows the overall average of seven locations: Branch, Delta, Kalkaska, Monroe, Montcalm, Newaygo and Presque Isle counties.

<u>Fresh Market Variety Highlights</u>

Three round whites and three russet lines are worthy of mention from the 2010 variety trials. They are MSL211-3, MSL268-D and MSQ176-5 (the round whites), and the russets, A0008-1TERus, A01124-3Rus and CO99053-3Rus.

MSL211-3; this Michigan State University variety has moderate foliar late blight resistance and slight common scab tolerance (Table 8). In the 2010 freshpack variety trials, this clone had a 369 cwt./A US#1 yield with a 1.069 specific gravity (Table 9). There were no hollow heart in 40 cut tubers and a trace of vascular discoloration was observed. The skin type of this variety was smooth and bright and the tubers were uniform in shape.

MSL268-D; this variety has nice tuber type with foliar late blight resistance. In 2010, MSL268-D yielded 393 cwt/A US#1 with a medium vine maturity (Table 9). This variety has a four year US#1 yield average of 385 cwt./A. The total yield of this variety was reported as 465 cwt/A. The percentage of "B" sized tubers and the specific gravity was higher than desired. This variety was also common scab susceptible.

MSQ176-5; this MSU clone has foliar late blight resistance, but appears to have some common scab susceptibility (Table 8). The 2010 yield trial data showed this variety having a 442 cwt/A US#1 yield which represents 89% of the total yield reported. Thirty-three percent of this marketable yield was oversize (Table 9). This variety averaged a 1.063 specific gravity, a medium maturity and two hollow heart in forty tubers cut. The tubers were generally bright skinned and uniformly round in appearance.

A0008-1TERus; this is a USDA Aberdeen, ID developed variety. In 2008 this variety was selected in Michigan for superior tuber type and acceptable yield. In 2010, in one southern location, this variety did not perform exceptionally well. When tested in Branch Co. it only yielded 209 cwt/A US#1 with 12 percent oversize (Table 9). The specific gravity was 1.063 with 6 of 10 cut tubers exhibiting hollow heart. Vine maturity was early. This variety exhibited strong common scab resistance. This variety needs to be observed once again to clarify the conflicting results observed from the 2008 and 2010 growing seasons.

A01124-3Rus; this University of Idaho selection had a 322 cwt/A US#1 yield, an average specific gravity of 1.072 and acceptable internal quality (Table 9). The tuber appearance was long and blocky with a nice russeted skin. Vine maturity was medium. This was the most promising new russet selection evaluated in 2010.

CO99053-3Rus; this Colorado State selection has good yield potential and tuber type. In 2010, it yielded 368 cwt/A US#1 with 23 percent oversize. The average specific gravity for this variety was 1.075 (Table 9). The clone had 8 hollow heart in fifty cut tubers. The vine maturity appeared to be late. The tubers exhibited a uniform, medium russet skin. The variety appeared to be common scab tolerant, but exhibited a trace of alligator hide.

Table 1

2010 MSU Processing Potato Variety Trials

Entry	Pedigree	2010 Scab Rating*	Characteristics
Atlantic	Wauseon X B5141-6 (Lenape)	2.9	High yield, early maturing, high incidence of internal defects, check variety, high specific gravity
Pike (NYE55-35)	Allegany X Atlantic	1.1	Average yield, early to mid-season maturity, small tuber size profile, early storage check variety, some internal defects, medium specific gravity
Snowden (W855)	B5141-6 X Wischip	2.9	High yield, late maturity, mid-season storage check variety, reconditions well in storage, medium to high specific gravity
A00188-3C	A91790-13 X Dakota Pearl	1.5	High U.S. No. 1 yield, scaly buff skin, high specific gravity
A01143-3C	COA95070-8 X Chipeta	1.8	High yielding, scaly buff chipper; smaller tuber size
AF2291-10	SA8211-6 X EB8109-1	2.0	Early blight resistant clone with good chipping quality, medium-late vine maturity, round to oblong, white netted tubers, specific gravity similar to Atlantic
CO00188-4W	A90490-1W X BC0894-2W	1.5	Medium yield potential. small tuber size, minimal grade defects, medium-early maturity, high specific gravity, some ability to recondition out of 40º F
CO00197-3W	A91790-13W X NDTX4930-5W	3.5	Medium yield potential, small size profile, minimal grade defects, early maturity, medium-high specific gravity, some ability to recondition out of 40º F
CO95051-7W	AC88456-6W X BC0894-2W	1.5	Low – average yield, medium to late maturity, high percent of US#1 tubers, low internal defects, medium specific gravity, vine rot is a concern
CO97043-14W	AC91817-5 X AC87340-2	3.0**	Average yield, medium maturity, white skin, oblong tuber type, medium specific gravity
CO97065-7W	AC92513-3 X Chipeta	2.0**	Average yield, early maturity, white skin, round tuber type, medium specific gravity
FL1879	Snowden X FL1207	3.5	High yield, late maturity, large tuber type, late season storage, medium specific gravity, check variety
MSH228-6	MSC127-3 X OP	1.0	Average yield, mid-late season maturity, blocky flat tuber type, shallow eyes, medium specific gravity
MSJ126-9Y	Penta X OP	1.0	Medium yield, cold chipper from 45º F, uniform A-size tubers, attractive appearance, good internal quality, long term storage potential, medium specific gravity
MSL007-B	MSA105-1 X MSG227-2	1.0	Average yield, early to mid-season maturity, uniform tuber type, medium specific gravity, scab resistant

*Scab rating based on 0-5 scale; 0 = most resistant and 5 = most susceptible. **2009 data

Table 1 continued

Entry	Pedigree	2010 Scab Rating*	Characteristics
MSL292-A	Snowden X MSH098-2	2.5	Above average yield, scab susceptible, late blight susceptible, medium-high specific gravity, long storage potential
MSP270-1	MSNT-1 X MSG227-2	1.0	Below average yield, uniform round type, netted skin, good chip quality from early to mid-season storage, average specific gravity
MSP459-5	Marcy X NY121	3.0	Bright chips, low incidence of defects, medium specific gravity
MSP515-2	Marcy X Missaukee	2.3	Above average yield, large tuber size, medium late maturity, below average specific gravity
MSQ035-3	MSG227-2 X Missaukee	1.0	Average yield potential, low specific gravity, uniform round tuber type
MSQ070-1	MSK061-4 X Missaukee	1.3	Round tuber type, late maturity, scab and late blight resistant, high specific gravity, strong vine and roots
MSQ279-1	Boulder X Pike	1.3	High yield, large round tubers, good internal qualities
MSR061-1	W1201 X NY121	1.3	Average yield, round tuber type with netted skin, low sugars, PVY resistant, moderate late blight resistance
MSR102-3	W1773-7 X Missaukee	1.0	Below average yield, very late maturity, uniform tuber type, foliar late blight resistance to US-8
NY138 (Waneta)	Marcy X NY115	-	High yield, large uniform round tuber type, below average specific gravity, great chip quality
NY 139 (Lamoka)	NY120 X NY115	2.0	High yield, mid-late season maturity, medium specific gravity, oval to oblong tuber type
W2133-1 (Nicolet)	Snowden X S440	1.8**	Medium to high yield, mid to late maturity, good internal quality, nice tuber type, 47º F cold chipper, medium specific gravity
W2310-3 (Tundra)	Pike X S440	2.0	Average yield potential, high specific gravity, smaller size profile, good chip quality from storage
W2717-5	S440 X ND2828-15	3.0	Round tuber type, medium yield, medium maturity, medium specific gravity, moderate scab susceptibility
W2978-3	Monticello X Dakota Pearl	3.5	Above average yield potential, early bulking, medium early vine maturity, scab susceptible
W5015-12	Brodick X W1355-1	3.0	High tuber set and yield, medium-late vine maturity, uniform size tubers, tubers tend toward flat shape, very flat in some environments

*Scab rating based on 0-5 scale; 0 = most resistant and 5 = most susceptible. **2009 data

Table 2

2010 Processing Potato Variety Trial
Overall Average - Eight Locations
Allegan, Branch, Mecosta, Montcalm, St. Joseph Counties

NUMBER OF LOCATIONS	LINE	CWT/A US#1	CWT/A TOTAL	PERCENT OF TOTAL[1] US#1	Bs	As	OV	PO	SP GR	CHIP SCORE[3]	TUBER QUALITY[2] HH	VD	IBS	BC	TOTAL CUT	VINE VIGOR[4]	VINE MATURITY[5]	COMMENTS	CHIP COMMENTS	4-YR AVG US#1 CWT/A
2	W2133-1	496	551	90	8	87	3	2	1.089	2.0	0	5	0	1	20	3.8	3.5	tr pitted scab	severe SED	490***
8	W5015-12	459	531	86	12	81	5	2	1.081	1.3	15	17	7	0	100	2.9	3.3	pitted and surface scab	sl SED	473**
2	A01143-3C	445	547	83	8	83	0	9	1.079	1.3	0	0	3	0	20	3.0	3.8		tr SED	335**
4	FL1879	444	458	97	2	89	8	1	1.075	1.8	14	3	0	0	40	2.9	2.6	sl surface scab	tr VD	464
1	NY138	444	471	94	6	82	12	0	1.071	1.0	1	5	0	0	30	3.0	3.0			444*
2	AF2291-10	444	507	88	8	76	12	4	1.083	1.3	4	11	0	0	40	2.3	3.0	not uniform type, tr points	sl SED, some HH	444*
1	Atlantic	443	472	94	6	82	12	0	1.082	1.5	8	3	2	0	30	3.0	3.5	surface and pitted scab	SED, VD	443*
6	Snowden	433	472	89	10	83	6	1	1.077	1.3	11	21	0	0	80	3.1	3.1	pitted scab	tr of severe SED	420
2	A00188-3C	432	518	82	16	82	0	2	1.082	1.3	0	7	0	0	20	3.3	2.5	small uniform tuber type	sl SED	330**
5	MSP515-2	414	439	95	5	83	12	0	1.072	1.3	2	6	2	0	50	2.6	3.8	sl surface and pitted scab	severe VD	414*
8	MSL292-A	408	453	90	10	85	5	0	1.076	1.1	2	15	1	0	100	3.3	2.4	pitted and surface scab, uniform type	tr SED	424***
5	MSL007-B	392	425	91	9	88	3	0	1.074	1.1	2	6	1	0	50	2.0	2.8	small overall size, heavy dark net, sl pitted and surface scab	tr VD	351***
3	W2978-3	391	446	87	11	83	4	2	1.071	1.3	1	7	0	0	50	2.7	2.2	surface and pitted scab	SED	391*
5	MSH228-6	384	405	94	5	86	8	1	1.076	1.3	1	12	0	1	50	3.3	2.9	surface scab	SED	357
8	NY139	378	407	93	6	87	6	1	1.079	1.1	1	13	0	0	100	2.9	2.6	sl surface scab, pointed pickouts	tr SED	412***
1	CO97065-7W	344	377	91	8	81	10	1	1.070	1.0	9	1	0	1	30	3.5	1.5	surface and pitted scab		336**
8	W2310-3	341	407	84	11	82	2	5	1.080	1.3	2	7	1	2	100	3.2	2.9	misshappen tubers in pickouts, surface and pitted scab	tr SED	299**

Table 2 continued

NUMBER OF LOCATIONS	LINE	CWT/A US#1	CWT/A TOTAL	PERCENT OF TOTAL[1] US#1	Bs	As	OV	PO	SP GR	CHIP SCORE[3]	TUBER QUALITY[2] HH	VD	IBS	BC	TOTAL CUT	VINE VIGOR[4]	VINE MATURITY[5]	COMMENTS	CHIP COMMENTS	4-YR AVG US#1 CWT/A
4	MSQ035-3	329	370	85	9	81	4	6	1.063	1.6	0	3	0	0	40	2.5	2.4	gc in pickouts, sl surface and pitted scab	SED	329*
2	CO00188-4W	317	425	71	29	71	0	0	1.076	1.0	0	2	0	0	20	3.3	2.3	small uniform tuber type		335**
5	Pike	317	356	89	9	83	6	2	1.078	1.0	4	8	1	0	50	3.1	2.3	heat necrosis in two tubers	tr heat necrosis	357
6	MSQ279-1	316	351	90	5	81	9	5	1.070	1.5	2	1	8	0	60	2.8	3.5	tr surface scab, gc and misshapen pickouts	SED	385**
2	CO00197-3W	298	381	71	26	71	0	3	1.072	1.0	1	3	0	0	20	3.0	3.5	small tuber yield	tr SED, VD	373**
1	MSJ126-9Y	285	336	84	16	81	3	0	1.065	1.0	0	3	0	0	30	2.5	2.5	uniform type		334
6	W2717-5	279	342	82	13	80	2	6	1.082	1.0	8	20	1	2	80	3.4	2.8	pitted scab, gc in pickouts, severe VD	SED	273**
7	MSQ070-1	278	334	82	13	81	1	5	1.080	1.2	8	10	8	2	70	2.4	3.7	sl surface scab, nice round tuber type, tr sticky stolons	sl SED	354**
5	MSR102-3	273	302	90	6	81	9	4	1.073	2.0	0	7	1	0	50	2.5	4.2	sicky stolen, surface scab	SED	273*
5	MSR061-1	271	314	85	14	85	0	1	1.076	1.5	3	1	2	1	50	2.6	2.6	misshapen pickouts, nice netted type, tr pitted scab	sl SED	275**
1	CO97043-14W	265	305	87	13	80	7	0	1.065	1.0	0	7	0	0	30	3.0	3.0	surface and pitted scab		301**
5	MSP459-5	264	334	77	23	77	0	0	1.079	1.3	3	10	0	0	50	3.1	2.3	small size profile, tr surface scab	SED, VD	288**
1	MSP270-1	252	304	83	17	80	3	0	1.074	1.0	0	1	1	0	10	1.0	3.5	netted skin, uniform type		252*
2	CO95051-7W	174	276	61	30	61	0	9	1.074	1.0	1	2	1	0	20	2.3	3.5	growth cracks, small tuber size	SED	271
	MEAN	**355**	**407**	**86**					**1.076**									tr = trace, sl = slight, N/A = not applicable		

SED = stem end defect, gc = growth crack

[1]SIZE	[2]TUBER QUALITY (number of tubers per total cut)	[3]CHIP COLOR SCORE - Snack Food Association Scale	[4]VINE VIGOR RATING	[5]VINE MATURITY RATING
Bs: < 1 7/8"	HH: Hollow Heart	(Out of the field)	Date Taken: N/A	Date Taken: N/A
As: 1 7/8" - 3.25"	VD: Vascular Discoloration	Ratings: 1 - 5	Ratings: 1 - 5	Ratings: 1 - 5
OV: > 3.25"	IBS: Internal Brown Spot	1: Excellent	1: Slow Emergence	1: Early (vines completely dead)
PO: Pickouts	BC: Brown Center	5: Poor	5: Early Emergence (vigorous vine, some flowering)	5: Late (vigorous vine, some flowering)

*One-Year Average

* *Two-Year Average

* * *Three-Year Average

Table 3. Yield ,Size Distribution*, Specific Gravity

Entry	Yield (cwt/A) US#1	Yield (cwt/A) TOTAL	Percent Size Distribution US#1	Small	Mid-Size	Large	Culls	Specific Gravity
AF2291-10	506	565	90	4	74	16	6	1.081
W5015-12	498	565	89	11	78	11	0	1.080
Snowden	**463**	**510**	**90**	**10**	**82**	**8**	**0**	**1.077**
MSL292-A	457	490	93	7	79	14	0	1.071
NY138	444	471	94	6	82	12	0	1.071
Atlantic	**443**	**472**	**94**	**6**	**82**	**12**	**0**	**1.082**
NY139	428	469	91	8	80	11	1	1.076
W2310-3	418	479	87	6	78	9	7	1.082
W2978-3	392	434	91	9	82	9	0	1.064
CO97065-7W	344	377	91	8	81	10	1	1.070
MSJ126-9Y	285	336	84	16	81	3	0	1.065
CO97043-14W	265	305	87	13	80	7	0	1.065
W2717-5	258	300	86	13	84	2	1	1.080
MEAN	**400**	**444**	**90**	**9**	**80**	**10**	**1.2**	**1.074**

*small <1 7/8"; mid-size 1 7/8"-3 1/4"; large >3 1/4"

Table 4. At-Harvest Tuber Quality. Sandyland Farms, Howard City, Michigan.

Entry	Internal Defects[1] HH	VD	IBS	BC	Total Cut
AF2291-10	2	5	0	0	30
W5015-12	3	5	6	0	30
Snowden	**1**	**7**	**0**	**0**	**30**
MSL292-A	0	5	0	0	30
NY138	1	5	0	0	30
Atlantic	**8**	**3**	**2**	**0**	**30**
NY139	0	2	0	0	30
W2310-3	0	3	0	1	30
W2978-3	0	2	0	0	30
CO97065-7W	9	1	0	1	30
MSJ126-9Y	0	3	0	0	30
CO97043-14W	0	7	0	0	30
W2717-5	3	7	0	0	30

[1]Internal Defects. HH = hollow heart, VD = vascular discoloration, IBS = internal brown spot, BC = brown center.

Table 5. 2010 Post-Harvest Chip Quality[1].

Entry	Agtron Color	SFA[2] Color	Specific Gravity	Percent Chip Defects[3] Internal	External	Total
AF2291-10	62.4	3	1.075	56.1	4.0	60.1
W5015-12	62.0	3	1.077	18.4	13.9	32.3
Snowden	**63.5**	**2**	**1.076**	**21.9**	**4.9**	**26.8**
MSL292-A	67.3	2	1.071	9.1	6.7	15.8
NY138	65.4	3	1.070	37.0	3.4	40.4
Atlantic	**62.9**	**4**	**1.080**	**47.9**	**5.4**	53.3
NY139	62.0	2	1.076	26.6	11.4	38.0
W2310-3	64.5	3	1.082	31.4	5.2	36.6
W2978-3	64.2	2	1.064	21.5	30.6	52.1
CO97065-7W	61.0	3	1.066	18.2	10.8	29.0
MSJ126-9Y	65.7	2	1.066	24.8	6.6	31.4
CO97043-14W	63.5	3	1.065	20.9	10.5	31.4
W2717-5	60.3	3	1.078	22.4	7.7	30.1

[1] Samples collected at harvest October 8th and processed by Herr Foods, Inc., Nottingham, PA on October 11, 2010 (3 days).

Chip defects are included in Agtron and SFA samples.

[2] SFA Color: 1= lightest, 5 = darkest

[3] Percent Chip Defects are a percentage by weight of the total sample; comprised of undesirable color, greening, internal defects and external defects.

Table 6. Black Spot Bruise Test

Entry	A. Check Samples[1] # of Bruises Per Tuber 0	1	2	3	4	5	Total Tubers	Percent Bruise Free	Average Bruises Per Tuber	B. Simulated Bruise Samples[2] # of Bruises Per Tuber 0	1	2	3	4	5	Total Tubers	Percent Bruise Free	Average Bruises Per Tuber
AF2291-10	10	13	2				25	40	0.7	2	10	5	5	2	1	25	8	1.9
W5015-12	11	5	5	3	1		25	44	1.1	1	4	5	6	3	6	25	4	3.0
Snowden	14	8	2	1			25	56	0.6	3	2	7	8	1	4	25	12	2.6
MSL292-A	12	6	3	2	2		25	48	1.0	10	9	3	1	1	1	25	40	1.1
NY138	23	1	1				25	92	0.1	17	6	1	1			25	68	0.4
Atlantic	2	12	4	5	1	1	25	8	1.8	3	7	7	2	3	3	25	12	2.2
NY139	14	9	1	1			25	56	0.6	9	10	5		1		25	36	1.0
W2310-3	8	10	5	2			25	32	1.0	4	9	4	3	2	3	25	16	2.0
W2978-3	22	3					25	88	0.1	12	8	3	2			25	48	0.8
CO97065-7W	13	9	3				25	52	0.6	5	5	11	4			25	20	1.6
MSJ126-9Y	20	5					25	80	0.2	15	9	1				25	60	0.4
CO97043-14W	14	10	1				25	56	0.5	10	9	4	2			25	40	0.9
W2717-5	15	10					25	60	0.4	10	5	5	3	2		25	40	1.3

[1]Tuber samples collected at harvest and held at room temperature for later abrasive peeling and scoring.

[2]Tuber samples collected at harvest, held at 50ºF for at least 12 hours, then placed in a 6 sided plywood drum and rotated 10 times to produce simulated bruising. They were then held at room temperature for later abrasive peeling and scoring.

Table 7A. Pre-Harvest Panels, 8/24/10

Entry	Specific Gravity	Glucose[1] %	Sucrose[2] Rating	Canopy Rating[3]	Canopy Uniform.[4]	Number of Hills	Number of Stems	Average[5] Tuber Weight
AF2291-10	1.072	0.013	0.568	90	90	5	9	6.84
W5015-12	1.073	0.002	0.385	80	90	5	17	4.00
Snowden	**1.073**	**0.002**	**0.297**	**85**	**95**	**4**	**28**	**4.68**
MSL292-A	1.069	0.002	0.363	75	95	4	10	4.80
NY138	1.065	0.002	0.228	75	95	4	7	5.89
Atlantic	**1.072**	**0.002**	**0.280**	**90**	**95**	**4**	**11**	**5.65**
NY139	1.074	0.002	0.363	85	90	4	13	5.73
W2310-3	1.079	0.005	0.419	80	90	5	17	5.02
W2978-3	1.063	0.002	0.469	20	90	3	7	5.48
CO97065-7W	1.070	0.002	0.226	10	80	5	18	4.36
MSJ126-9Y	1.066	0.002	0.720	60	90	7	13	4.24
CO97043-14W	1.062	0.001	0.280	85	90	5	12	3.64
W2717-5	1.083	0.002	0.636	70	90	5	12	4.71

[1]Percent Glucose is the percent of glucose by weight in a given amount of fresh tuber tissue.

[2]Sucrose Rating is the percent of sucrose by weight in a given amount of fresh tuber tissue X10.

[3]The Canopy Rating is a percent rating of green foliage (0 is all brown dead foliage, 100 is green vigorous foliage).

[4]The Canopy Uniformity is a percentage of how uniform the foliage health is at the date of observation.

[5]The Average Tuber Weight is the total tuber weight collected divided by the number of tubers reported in ounces.

Table 7B. Pre-Harvest Panels, 9/7/10

Entry	Specific Gravity	Glucose[1] %	Sucrose[2] Rating	Canopy Rating[3]	Canopy Uniform.[4]	Number of Hills	Number of Stems	Average[5] Tuber Weight
AF2291-10	1.079	0.003	0.503	45	90	5	9	6.51
W5015-12	1.080	0.002	0.312	35	90	4	15	4.24
Snowden	**1.076**	**0.002**	**0.484**	**40**	**95**	**3**	**24**	**3.99**
MSL292-A	1.075	0.002	0.452	35	95	4	9	5.92
NY138	1.071	0.002	0.299	35	95	4	7	5.07
Atlantic	**1.076**	**0.002**	**0.417**	**50**	**95**	**4**	**18**	**4.34**
NY139	1.076	0.002	0.428	40	95	5	15	4.74
W2310-3	1.085	0.003	0.275	35	90	5	15	4.48
W2978-3	1.064	0.003	0.434	15	85	4	12	5.23
CO97065-7W	1.070	0.002	0.286	5	95	6	15	5.21
MSJ126-9Y	1.064	0.002	0.705	20	90	4	10	3.37
CO97043-14W	1.069	0.001	0.316	30	85	5	13	4.94
W2717-5	1.065	0.003	0.796	30	90	5	19	3.92

[1]Percent Glucose is the percent of glucose by weight in a given amount of fresh tuber tissue.

[2]Sucrose Rating is the percent of sucrose by weight in a given amount of fresh tuber tissue X10.

[3]The Canopy Rating is a percent rating of green foliage (0 is all brown, dead foliage, 100 is green, vigorous foliage).

[4]The Canopy Uniformity is a percentage of how uniform the foliage health is at the date of observation.

[5]The Average Tuber Weight is the total tuber weight collected, divided by the number of tubers reported in ounces.

Table 8

2010 MSU Tablestock Potato Variety Trials

Entry	Pedigree	2010 Scab Rating*	Characteristics
Classic Russet (A95109-1Rus)	Blazer Russet X Summit Russet	1.3**	Medium yield, early maturity, attractive appearance, high percentage of US#1's, fresh market use, low - medium specific gravity, resistant to fusarium dry rot and common scab, some tuber storage rot and blackleg susceptibility reported
Colorado Rose	NDTX9-1068-11R X NT6063-1R	3.5	High yield, oval to oblong tubers, smooth red skin, shallow eyes, medium maturity
GoldRush (ND1538-1Rus)	ND450-3Rus X Lemhi Russet	1.0	Long to oval tubers, heavy russet, check variety
Onaway	USDA X96-56 X Katahdin	2.1	High yield, early maturity, round tuber type, low specific gravity, smooth skin, white flesh, medium deep eyes, few internal defects, check variety
Reba (NY 87)	Monona X Allegany	2.5	High yield, bright tubers, low incidence of internal defects, mid to late season maturity, medium – low specific gravity
Russet Norkotah (ND534-4Rus)	ND9526-4Rus X ND9687-5Rus	2.3	Medium yield, mid-season maturity, long to oval tubers, heavy russet skin, check variety, low specific gravity
Silverton Russet (AC83064-6)	A76147-2 X A 7875-5	1.0	High yield, oblong to long blocky tuber type, medium russet skin, masks PVY, medium specific gravity, possible Sencor & Linuron susceptibility
A98134-2Rus	A86707 X A9201-6	-	Medium yield, early to mid-season maturity, medium specific gravity, heavy russeting
A98289-1Rus	A9396-1 X Premier Russet	0.5	Yields similar to Russet Norkotah but higher US No.1 count, heavily russeted, bright eyes
A01124-3Rus	Bannock Russet X A94020-3	1.5	Medium yield, early to mid-season maturity, medium specific gravity, heavy russeting, nice uniform blocky tuber appearance

*Scab rating based on 0-5 scale; 0 = most resistant and 5 = most susceptible. ** 2009 data

Table 8 continued

Entry	Pedigree	2010 Scab Rating*	Characteristics
A0008-1TERus	Blazer Russet X Classic Russet	-	Medium yield, nice blocky tuber type, white flesh, medium russet skin, early maturity, low specific gravity
CO99256-2R	Rio Colorado X Colorado Rose	2.8	Medium to late maturity, oval tuber type, strong red skin color
CO99053-3Rus	AC91014-2 X Silverton Russet	2.0	High yield, medium to late maturity, large vine, medium specific gravity, uniform blocky tubers, medium russeting, nice appearance, blackspot resistant
CO00291-5R	CO94019-1R X Rio Colorado	2.5	Medium yield, uniform round tubers, late maturity, dark red skin color
MSL211-3	MSG301-9 x Jacqueline Lee (MSG274-3)	2.2	Round to oval tubers, smooth bright appearance, moderate late blight resistance, good yield
MSL268-D	NY103 X Jacqueline Lee	3.0	Medium – high yield, late blight resistance, round to oval tuber type
MSM182-1	Stirling X NY121	3.0	PVY & late blight resistance, low specific gravity, smaller size profile
MSQ176-5	MSI152-A X Missaukee (MSJ461-1)	3.0	High yield potential, uniform round tuber type, bright appearance, late blight resistance, good bulking
MSQ440-2	MSK214-1R X Missaukee (MSJ461-1)	1.8	Uniform round tubers, very bright white skin, common scab resistant
MSR217-1R	NDTX4271-5R X Missaukee (MSJ461-1)	2.0	Attractive dark red skin, round tuber type
MSS544-1R	CO93037-6R X MNR-8RR	1.0	Attractive dark red skin, round tuber type, common scab resistance
W2609-1R	Dark Red Norland X W774R	1.0	Some common scab tolerance, moderate red skin color, uniform round type

*Scab rating based on 0-5 scale; 0 = most resistant and 5 = most susceptible.

Table 8 continued

Entry	Pedigree	2010 Scab Rating*	Characteristics
W2683-2Rus	ND4093-4 X CO80011-5	1.0	Good yield, high percent of oversize, good internal quality, blackspot resistant, common scab resistance, medium low specific gravity, tuber shape may not be consistent
W5767-1R	MN96101-1 X MN86105	2.0	Dark red skin, white flesh, large tuber size, high yield potential, medium deep eyes, large vine, medium late maturity
W6234-4Rus	Umatilla Russet X A9014-2	3.5	Large vine type, blocky tubers, very light russet skin, high specific gravity
W8946-1Rus	PA98V1-2 X AOA95154-1	1.3	Medium yield potential, medium specific gravity, possibly susceptible to heat stress

*Scab rating based on 0-5 scale; 0 = most resistant and 5 = most susceptible.

Table 9

2010 Freshpack Potato Variety Trial

Overall Averages - Seven Locations

Branch, Delta, Kalkaska, Monroe, Montcalm, Newaygo & Presque Isle

NUMBER OF LOCATIONS	LINE	CWT/A US#1	CWT/A TOTAL	PERCENT OF TOTAL[1] US#1	Bs	As	OV	PO	SP GR	TUBER QUALITY[2] HH	VD	IBS	BC	TOTAL CUT	VINE VIGOR[3]	VINE MATURITY[4]	COMMENTS	4-YR AVG US#1 CWT/A
1	Classic Russet	592	636	93	1	24	69	6	1.077	1	0	0	0	10	3.5	4.5	large percent of oversize	423
3	W5767-1R	453	498	91	6	77	14	3	1.071	0	5	0	0	30	4.5	2.2	surface scab, sl netted skin, tr gc, misshapen pickouts	435* *
3	Colorado Rose	450	525	85	9	65	20	6	1.068	0	4	0	0	30	4.0	2.2	misshapen pickouts, surface and pitted scab, oblong tuber type, tr soft rot	450*
4	MSQ176-5	442	486	89	8	56	33	3	1.063	2	4	2	0	40	2.9	3.0	surface and pitted scab, gc in pickouts, nice tuber type, sl netted skin, bright appearance	435* *
7	**Silverton Russet**	**441**	**519**	**85**	**10**	**58**	**27**	**5**	**1.069**	**3**	**8**	**1**	**7**	**70**	**2.7**	**3.1**	**misshapen pickouts, sl alligator hide**	**397**
4	CO99265-2R	440	505	87	11	82	5	2	1.073	1	9	0	0	40	3.3	3.2	surface and pitted scab, oval to oblong tuber type, good red color	443* *
4	**Reba**	**440**	**476**	**92**	**6**	**78**	**14**	**2**	**1.072**	**0**	**2**	**0**	**0**	**40**	**3.8**	**2.3**	**tr surface and pitted scab, deep apical eye, gc in pickouts, oblong tuber type**	**427**
3	**Onaway**	**417**	**487**	**78**	**17**	**61**	**17**	**5**	**1.066**	**0**	**8**	**0**	**0**	**30**	**4.7**	**1.5**	**bright appearance, sl deep eye, gc and misshapen in pickouts, tr surface and pitted scab**	**374**
4	MSL268-D	393	465	84	10	77	7	6	1.080	3	13	0	0	40	3.8	3.1	tr surface and pitted scab, knobs in pickouts, buff / netted appearance	385
4	MSL211-3	369	432	84	12	77	7	4	1.069	0	4	0	0	40	4.3	2.1	smooth bright appearance, gc and misshapen tubers in pickouts, tr surface scab	369*
5	CO99053-3RUS	368	500	74	13	51	23	13	1.075	8	6	1	0	50	2.6	4.1	not uniform type, alligator hide, large tuber size	433* * *
4	MSM182-1	352	421	83	14	79	4	3	1.070	3	2	4	2	40	3.9	2.5	tr pitted scab, netted skin, severe heat necrosis	402* * *
2	A98134-2RUS	350	543	66	26	61	5	8	1.075	0	5	1	0	20	3.0	2.3	misshapen in pickouts, tr gc, alligator hide, type not uniform	350*
3	CO00291-5R	348	394	88	6	83	5	6	1.066	6	3	0	0	30	2.7	4.5	surface and pitted scab, misshapen pickouts, sticky stolons	348*

Table 9 continued

NUMBER OF LOCATIONS	LINE	CWT/A US#1	CWT/A TOTAL	PERCENT OF TOTAL[1] US#1	Bs	As	OV	PO	SP GR	TUBER QUALITY[2] HH	VD	IBS	BC	TOTAL CUT	VINE VIGOR[3]	VINE MATURITY[4]	COMMENTS	4-YR AVG US#1 CWT/A
3	W2609-1R	345	384	89	10	86	3	1	1.061	0	4	0	1	30	3.8	1.0	surface and pitted scab, gc in pickouts, light red skin color	345*
1	A98289-1RUS	332	431	77	17	73	4	6	1.070	0	3	0	0	10	1.0	1.5	gc and misshapen in pickouts, severe blackleg rot in plot	393* *
5	W6234-4RUS	323	447	70	23	54	16	7	1.078	2	8	0	0	50	3.1	2.1	tr surface scab, light russeting, misshapen pickouts, heat sprouts, heat necrosis in two tubers	323*
2	A01124-3RUS	322	502	64	30	56	8	6	1.072	3	0	2	1	20	1.3	2.5	misshapen pickouts, heavy russeting	322*
3	MSR217-1R	286	315	90	9	81	9	1	1.059	0	3	1	0	30	2.2	1.3	surface and pitted scab, dark red skin color, uniform round type, tr gc in pickouts	286*
4	MSQ440-2	279	333	82	17	76	6	1	1.058	0	20	1	0	40	3.0	2.4	1 glassy end, sl surface scab, some heat sprouts, bright appearance	279*
5	W8946-1RUS	276	496	56	28	54	2	16	1.087	2	4	6	0	50	3.1	3.6	sl surface scab, severe heat sprouts in pickouts	276*
6	**Russet Norkotah**	**266**	**396**	**65**	**27**	**54**	**11**	**8**	**1.066**	**0**	**13**	**1**	**0**	**60**	**2.8**	**1.6**	**alligator hide, uniform type, misshapen and knobs in pickouts**	**325**
3	**GoldRush**	**260**	**434**	**62**	**20**	**57**	**5**	**18**	**1.068**	**0**	**2**	**0**	**0**	**30**	**1.3**	**1.7**	**misshapen pickouts, heavy russeting**	**358* * ***
1	MSS544-1R	229	308	74	20	65	9	6	1.064	0	2	0	0	10	2.5	2.0	tr surface scab, misshapen pickouts, one tuber with severe VD	229*
4	W2683-2RUS	217	386	54	26	45	9	20	1.073	3	4	4	0	40	2.4	3.1	gc and misshapen tubers in pickouts	328* *
1	A0008-1TE	209	348	60	18	48	12	22	1.063	6	0	0	0	10	1.0	2.0	many gc and misshapen in pickouts, alligator hide	323* *
	MEAN	**354**	**449**						**1.070**								tr = trace, sl = slight, N/A = not applicable	
																	SED = stem end defect, gc = growth crack	

[1]SIZE
Bs: < 1 7/8" or < 4 oz.
As: 1 7/8" - 3.25" or 4 - 10 oz.
OV: > 3.25" or > 10 oz.
PO: Pickouts

[2]TUBER QUALITY (number of tubers per total cut)
HH: Hollow Heart
VD: Vascular Discoloration
IBS: Internal Brown Spot
BC: Brown Center

[3]VINE VIGOR RATING
Date Taken: N/A
Ratings: 1 - 5
1: Slow Emergence
5: Early Emergence (vigorous vine, some flowering)

[4]MATURITY RATING
Date Taken: N/A
Ratings: 1 - 5
1: Early (vines completely dead)
5: Late (vigorous vine, some flowering)

*One-Year Average
* *Two-Year Average
* * *Three-Year Average

2010 Weed Control Projects in Potato

Dr. Wesley Everman, Andrew J. Chomas and Chris Long

Delayed Release Nitrogen Effect on Potato Yield and Vine Kill,

Nitrogen fertilizer is one of the most costly inputs in potato production and the most important input for maximizing potato tuber yield. Field research was conducted in 2010 to examine: 1) The effect of controlled release and conventional urea-ammonium nitrate on potato yield. 2) Controlled release based fertility programs on vine vigor and vine kill. The site was established on a loamy sand soil with 2.2% OM a pH of 5.1 and at the Montcalm Research Farm, Entrican Michigan. The experiment was conducted in a factorial design with four replications. Individual plots were 3.5 meter wide and 7.6 meter long, consisting of four potato rows spaced at 0.86 meter. 'Snowden' variety tubers were planted on May 17, 2010. Treatments consisted of either controlled release (CR) or conventional 28% urea-ammonium nitrate (UAN) solution applied at a rate of 67 kg/ ha at planting, first cultivation and hilling followed by 112 kg/ha (urea) surface applied in late July for a total of 12 treatments. Vine kill treatments consisted of diquat + NIS (.28 kg ai/ha + .25% v/v/ha) followed by diquat + NIS (.28 kg ai/ha + .25% v/v/ha), glufosinate (.43 kg ai/ha), and a control treatment (no vine kill). Irrigation and other potato crop management practices followed that of commercial seed producers. Vine kill was evaluated visually 14, 21 and 28 days after treatment. Also, normalized difference vegetation index (NDVI) measurements were collected. Potato tubers were harvested and yields determined. There were no significant differences observed between herbicides in regards to potato vine kill. There was a very strong significant correlation between visual rating and NDVI measurements. No differences in potato vine vigor, using NDVI, among fertilizer program or herbicide were observed. In marketable tuber yield there were no significant differences.

Efficacy and Selectivity of Solida when Applied PRE and POST to Potato

A study investigating the tolerance of potato to applications of rimsulfuron formulations was conducted in 2010 at the Montcalm Research Farm. The study compared .75, 1.5 and 3 oz use rates of two formulations of rimsulfuron applied at CRACKING and EARLY POST. The results indicate there were no differences in weed control observed between the two formulations for any application timing.

Late Season Weed Control in FL-1922

Potato varieties are known to have varying growth habits which can affect late season management. Weed control in potato is most effective when implemented as a preventative system as few herbicides are available for postemergence weed control. The greatest weed problems often become apparent late in the season in varieties with low vine vigor, and after postemergence herbicides have been applied. Grass weeds such as large crabgrass, giant foxtail, and barnyardgrass and broadleaf weeds including nightshade, common purslane, and common lambsquarters often germinate in July and compete with potato for nutrient resources during the critical bulking period in August and early September. Tubers were planted May 17th at the Montcalm Research Farm at a 10-inch spacing in rows 34-inches apart. Each treatment was replicated four times. Treatments consisted of early postemergence and postemergence applications. Preemergence herbicides were applied to all plots and consist of Dual Magnum at 1.33 pt/A plus Lorox at 1.5 qt/A; early postemergence options andincluded Prowl at 1.8 pt/A, Boundary at 1.5 pt/A, V10142 at 8.5 oz/A, and No Early Postemergence; postemergence options will consist of Matrix at 1 oz/A, Sencor at 0.33 lb/A, V10142 at 8.5 oz/A, Matrix plus Sencor, and No Postemergence for a total of 21 treatments. The results indicate there were no differences in weed control observed among the various weed control strategies.

Halosulfuron Weed Control in Potato

A study investigating weed control in potato with applications of halosulfuron, metribuzin and metolachlor combinations in 2010 at the Montcalm Research Farm. The study compared PRE and POST strategies using various combinations of these herbicides. Research indicates that halosulfuron has the potential as a herbicide for use in potato.

Rimsulfuron Tank Mixes

A study investigating weed control in potato using various tank-mixes of rimsulfuron, dimethenamid, sulfentrazone, metribuzin and metolachlor applied PRE, POST and PRE followed by POST was conducted in 2010 at the Montcalm Research Farm. This study compared various weed control strategies using tank-mixes and timing strategies to attain season long weed control.

Effects of ALS Herbicides on Potatoes

A study investigating weed control in potato using various tank-mixes of CGA-362622, thifensulfuron, sulfentrazone, metribuzin and metolachlor applied PRE, POST and PRE followed by POST was conducted in 2010 at the Montcalm Research Farm. This study compared various weed control strategies using tank-mixes and timing strategies to attain season long weed control.

Maverick PRE in Potato

Five treatments were implemented comparing sulfosulfuron tank mixed with metolachor and metolachor and metribuzin at Montcalm Research farm in 2010. The treatments investigated were all applied PRE. The primary objective of this study was to evaluate sulfosulfuron as a potential herbicide for use in potato.

Vine Desiccation with Vida

A study was conducted in 2010 to evaluate the efficacy of Vida applied as a vine kill product. The study was conducted at the Montcalm Research Farm using Silverton as the potato variety. The variety Silverton was chosen as to challenge the vine kill treatments. This particular variety is known for its vigor and heavy growth. All herbicide treatments were compared with a non-treated control treatment. Each treatment was replicated four times. Irrigation and other potato crop management practices utilized closely mirror practices followed by producers. At 28 days after application acceptable levels of vine kill were not obtained with any treatment. The highest level of control was 69%. However some visual differences among treatments provide valuable information among products.

Effects of Compost and Weed Competition on Potato Growth and Yield

Increased agricultural sustainability in disturbed systems through bio-amendment addition can lead to increases in soil organic matter, increases in productivity, and improvements in soil health. However, organic amendments also increase the growth and competitive ability of weeds when compared to synthetic fertilizer, which may affect weed control and crop yield. A field study was established in 2010 in Entrican, MI to investigate the effect of compost rate on weed competition in potato. Three compost rates (0 ton acre^{-1}, 10 ton acre^{-1}, and 20 ton acre^{-1}) were incorporated in late April. Rates were based on application of carbon (0 ton acre^{-1}, 1.8 ton C acre^{-1}, and 3.6 ton C acre^{-1}) because the compost was used as a soil amendment rather than a nutrient source. 'Snowden' variety potatoes (*Solanum tuberosum*) were planted mid-May at 10.5 inch seed spacing with 34 inch row spacing. Hairy nightshade (*Solanum physalifolium*), giant foxtail (*Setaria faberi*), or common lambsquarters (*Chenopodium album*) seedlings, 1, 3, or 1 inch, respectively, were transplanted into the row at 1.6 plants foot^{-1} at potato cracking. Plant height and biomass were collected and recorded throughout the season. Data was subjected to analysis of variance with significance determined with $\alpha \leq 0.05$. No significant differences in biomass or height were observed within a species due to compost rate differences. Tuber yield and quality were evaluated at harvest, and significant differences were observed in yield from both weed species and compost rate. There was a significant loss in marketable tuber weight and number due to the presence of giant foxtail (271 cwt acre^{-1}; 5.28 x 10^5 tubers acre^{-1}) or hairy nightshade (270 cwt acre^{-1}; 5.16 x 10^5 tubers acre^{-1}) when compared to the weed free (357 cwt acre^{-1}; 6.35 x 10^5 tubers acre^{-1}), and potatoes grown in competition with common lambsquarters yielded less than all other treatments (176 cwt acre^{-1}; 3.48 x 10^5 tubers acre^{-1}). Total potato yield was also impacted significantly. The weed free treatment had a total potato weight of 394 cwt acre^{-1}, giant foxtail and hairy nightshade competition resulted in significant yield reductions compared to the weed free of 20.2 and 20.5%, respectively, and common lambsquarters competition significantly reduced yield by 47.7%. The treatments under giant foxtail competition produced similar total number of tubers to the weed free, 7.51 x 10^5 acre^{-1} and 8.17 x 10^5 acre^{-1}, respectively, but hairy nightshade treatments produced significantly fewer tubers (7.23 x 10^5 acre^{-1}) than the weed free, and common lambsquarters treatments produced fewer tubers than all other treatments (4.99 x 10^5 acre^{-1}). Compost rate also impacted the number of marketable tubers, where the high compost rate treatments produced significantly more tubers (5.53 x 10^5 acre^{-1}) than the low (4.77 x 10^5 acre^{-1}) and non-amended treatments (4.91 x 10^5 acre^{-1}). Total yield was greatest under the high compost rate treatments (336 cwt acre^{-1}), and was significantly greater than the low (293 cwt acre^{-1}) and non-amended (292 cwt acre^{-1}) treatments. Weed competition decreased marketable and total tuber yield and number, but the degree of reduction was species dependent. There was also an increase in marketable tuber number and total yield at the highest compost rate. Compost addition may increase marketable tuber production without increasing the competitive ability of the weeds, but this study still demonstrates the importance of weed control in the cropping system. This study will be repeated in 2011.

Soil treatments for control of Verticillium wilt and Common Scab of potatoes, 2010.

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Soil treatments were applied at the Michigan State University Potato Research Farm, Clarksville, MI (Sandy loam soil complex Alfic Haplorthod; 1.8% OM; pH 6.2); 43.3526, -85.1761 deg; elevation 951 ft on 23 Apr by a tractor-mounted soil injection system calibrated to deliver 70. 98, 116 and 140 lb/A of the products PicPlus 85.5AP and Vapam 32.7EC 73.5 gal/A into prepared seedbeds 12 ft wide x 70 ft long. The seedbeds were replicated four times in a randomized complete block design. Potato seed ("FL1879") was prepared for planting by cutting two days prior to planting. Seed were planted on 18 May ca. 9-in between plants at 34-in row spacing to give a target population of 20,000 plants/A. Fertilizer was drilled into plots before planting, formulated according to results of soil tests. Additional nitrogen (final N 28 lb/A) was applied to the growing crop with irrigation 45 DAP (days after planting). Bravo WS 6SC 1.5 pt/A was applied on a seven-day interval, total of eight applications, for foliar disease control. Weeds were controlled by hilling and with Dual 8E at 2 pt/A 10 DAP, Basagran at 2 pt/A 20 and 40 DAP and Poast at 1.5 pt/A 58 DAP. Insects were controlled with Admire 2F at 1.25 pt/A at planting, Sevin 80S at 1.25 lb/A 31 and 55 DAP, Thiodan 3 EC at 2.33 pt/A 65 and 87 DAP and Pounce 3.2EC at 8 oz/A 48 DAP. Vines were killed with Reglone 2EC (1 pt/A on 15 Sep). Plots (4 x 70-ft row) were harvested on 4 Oct and individual treatments were weighed and graded. Four plants per plot were harvested on 24 Aug [98 days after planting (DAP); 123 days after soil application (DASA)] and the percentage of stems and tubers with signs or symptoms of Verticillium stem wilt and tuber discoloration (vascular beading) were calculated. Tubers were washed and assessed for common scab (*S. scabies*) incidence (%) and severity. Samples of 100 tubers per plot and stored at 50°F and evaluated 14 days after harvest (153 DAP; 178 DASA). Severity of common scab was measured as an index calculated by counting the number of tubers (n = 100) falling in class 0 = 0%; 1 = 1 - 5%; 2 = 6 -10%; 3 = 11 - 15; 4 >16% surface area of tuber covered with tuber lesions (surface and pitted). The number in each class was multiplied by the class number and summed. The sum was multiplied by a constant to express as a percentage. Indices of 0 - 25 represent 0 - 5%; 26 - 50 represent 6 - 10%; 51 - 75 represent 11 - 15% and 75 - 100 >15% surface area covered with lesions. Meteorological variables were measured with a Campbell weather station located at the farm from 1 Apr to harvest (4 Oct). Maximum, minimum and average daily air temperature (°F) were 81.7 25.9 and 50.6 (Apr); 90.2, 27.5 and 59.4 (May); 86.4, 43.6 and 66.7 (Jun); 90.4, 43.9 and 72.7 (Jul); 91.0, 44.9 and 71.6 (Aug); 84.3, 38.8 and 59.2 (Sep); 68.1, 29.4 and 46.8 (to 4 Oct). Maximum, minimum and average daily soil temperature at 2" depth (°F) were 68.2, 37.2 and 52.1 (Apr); 83.0, 42.8 and 61.5 (May); 82.3, 58.5 and 71.4 (Jun); 86.2, 61.4 and 74.7 (Jul); 88.9, 59.4 and 73.8 (Aug); 76.8, 51.9 and 63.1 (Sep); 67.5, 44.5 and 54.9 (to 4 Oct). Maximum, minimum and average daily soil temperature at 4" depth (°F) were 58.7, 34.2 and 46.4 (Apr); 72.3, 39.2 and 54.9 (May); 72.7, 54.0 and 64.3 (Jun); 75.7, 56.5 and 67.0 (Jul); 77.4, 53.9 and 65.4 (Aug); 68.8, 46.5 and 55.5 (Sep); 57.3, 39.9 and 48.1 (to 4 Oct). Maximum, minimum and average soil moisture at 4" (% of field capacity) was 19.4, 14.8 and 15.9 (Apr); 22.3, 11.7 and 15.6 (May); 21.2, 16.2 and 17.7 (Jun); 25.0, 16.9 and 18.5 (Jul); 26.9, 16.8 and 18.8 (Aug); 23.8, 16.3 and 17.7 (Sep) and 16.3, 15.9 and 16.1 (to 4 Oct). Precipitation was 1.59 in. (Apr), 3.68 in. (May), 3.21 in. (Jun), 2.14 in. (Jul), 2.63 in (Aug), 1.88 in. (Sep) and 0.23 in. (to 4 Oct). Plots were irrigated to supplement precipitation to about 0.1 in./A/4 day period with overhead sprinkle irrigation.

No treatment affected final plant stand or the rate of emergence (data not shown). No treatments affected Verticillium wilt in either the stems or the tubers measured as stem wilt or tuber discoloration both of which developed over the season to a significant degree throughout the trial. Common scab developed in the trial and untreated plots had about 76% incidence and 45% severity scale score by 14 days after harvest, which on a quality scale would have made them difficult to market. PicPlus at the three higher rates significantly reduced common scab incidence and severity in comparison to the untreated control and to Vapam. All soil applied products increased US1 and total yield in comparison to the untreated control. Soil treatments were not phytotoxic.

Table 1. Efficacy of PicPlus against Verticillium wilt and commons scab of potato, 2010.

Treatment and rate/A	Stems with Verticillium (%)[z]	Tuber number per plant	Tubers with Verticillium (%)[z]	Common Scab Incidence (%)[y]	Common Scab Severity Scale (%)[x]
Vapam 32.7EC 37.5 gal (A[w])	89.5	10.4	63.2	73.8 a[v]	45.0 a
PicPlus 85.5AP 70 lb	100.0	11.0	60.9	60.0 a	30.6 ab
PicPlus 85.5AP 98 lb	97.9	12.0	48.2	40.0 b	19.7 b
PicPlus 85.5AP 116 lb	84.4	8.5	60.0	40.0 b	19.4 b
PicPlus 85.5AP 140 lb	93.4	11.9	51.1	36.3 b	19.1 b
Untreated Check………………..........	100.0	11.6	73.3	76.3 a	45.0 a
$HSD_{0.05}$	22.44	4.95	18.40	16.71	16.52

Treatment and rate/A	Yield (cwt/A) US1	Yield (cwt/A) B-size	Yield (cwt/A) Total
Vapam 32.7EC 37.5 gal	214.9 a	297.7 a	512.6 a
PicPlus 85.5AP 70 lb	188.6 a	318.0 a	506.6 a
PicPlus 85.5AP 98 lb	254.0 a	295.4 a	549.4 a
PicPlus 85.5AP 116 lb	202.1 a	311.4 a	513.5 a
PicPlus 85.5AP 140 lb	251.9 a	325.7 a	577.7 a
Untreated Check………………..........	104.6 b	264.4 a	369.0 b
$HSD_{0.05}$	74.13	44.03	83.4

[z] Four plants per plot were harvested on 24 Aug [98 days after planting (DAP); 123 days after soil application (DASA)] and the percentage of stems and tubers with signs or symptoms of Verticillium stem wilt and tuber discoloration (vascular beading) were calculated.
[y] Scab-free tubers; percentage falling in severity class 0 = 0%.
[x] Severity of common scab was measured as an index calculated by counting the number of tubers (n = 200) falling in class 0 = 0%; 1 = 1 - 5%; 2 = 6 -10%; 3 = 11 - 15; 4 >16% surface area of tuber covered with tuber lesions (surface and pitted).
[w] A = Soil treatments applied on 23 Apr by a tractor-mounted soil injection system
[v] Values followed by the same letter are not significantly different at $p = 0.05$ (Honest Significant Difference; Tukey Multiple Comparison).

Seed treatments and seed plus in furrow treatments for control of seed- and soil-borne *Rhizoctonia solani*, 2010.

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Potatoes with *Rhizoctonia solani* (black scurf), 2- 5% tuber surface area infected, were selected for the trials. Potato seed (Dark Red Norland) was prepared for planting by cutting and treating with fungicidal seed treatments two days prior to planting. Seed were planted at the Michigan State University Horticultural Experimental Station, Clarksville, MI (Capac loam soil); 42.8733, -85.2604 deg; elevation 895 ft. on 21 May into two-row by 20-ft plots (ca. 10-in between plants to give a target population of 50 plants at 34-in row spacing) replicated four times in a randomized complete block design. The two-row beds were separated by a 5-ft unplanted row. Dust formulations were measured and added to cut seed pieces in a Gustafson revolving drum seed treater and mixed for 2 min to ensure even spread of the fungicide. Fungicides applied as pre-planting potato seed liquid treatments were applied in water suspension at a rate of 0.2 pt/cwt onto the exposed seed tuber surfaces, with the entire seed surface being coated in the Gustafson seed treater. In- furrow at-planting applications were delivered at 8 pt water/A in a 7 in. band using a single XR11003VS nozzle at 30 p.s.i. Foliar applications were applied with a R&D spray boom delivering 25 gal/A (80 p.s.i.) and using three XR11003VS nozzles per row. Fertilizer was drilled into plots before planting, formulated according to results of soil tests. Additional nitrogen (final N 28 lb/A) was applied to the growing crop with irrigation 45 DAP (days after planting). Previcur Flex was applied at 0.7 pt/A on a seven-day interval, total of four applications, starting one day after inoculation of adjacent plots with *Phytophthora infestans* to prevent spread of potato late blight. Weeds were controlled by hilling and with Dual 8E at 2 pt/A 10 DAP and Poast at 1.5 pt/A 58 DAP. Insects were controlled with Admire 2F at 1.25 pt/A at planting, Sevin 80S at 1.25 lb/A 31 and 55 DAP, Thiodan 3 EC at 2.33 pt/A 65 and 87 DAP and Pounce 3.2EC at 8 oz/A 48 DAP. Vines were killed with Reglone 2EC (1 pt/A on 15 Sep). Plots (20-ft row) were harvested on 6 Oct and individual treatments were weighed and graded. Four plants per plot were harvested 51 days after the final treatment application (7 Jul) and the percentage of stems and stolons with greater than 5% of the total surface area affected were counted. An index of below ground health was evaluated 47 DAP on a scale of 0 - 5 where 0 = no symptoms of stem canker, 1 = 1 – 5%, 2 = 6 – 10%, 3 = 11 – 20%, 4 = 21 – 50%, 5 = 50 – 100% of the surface of roots, stolons and stem affected by *R. solani*. Samples of 50 tubers per plot were harvested 14 days after desiccation and assessed for black scurf (*R. solani*) incidence (%) and severity 40 days after harvest. Severity of black scurf was measured as an index calculated by counting the number of tubers (n = 50) falling into each class 0 = 0%; 1 = 1 - 5%; 2 = 6 -10%; 3 = 11 - 15; 4 >15% surface area of tuber covered with sclerotia. The number in each class is multiplied by the class number and summed. The sum is multiplied by a constant to express as a percentage. Indices of 0 - 25 represent 0 - 5%; 26 - 50 represent 6 - 10%; 51 - 75 represent 11 - 15% and 75 - 100 >15% surface area covered with sclerotia. Meteorological variables were measured with a Campbell weather station located at the farm from 1 May to harvest (15 Jul). Maximum, minimum and average daily air temperature (^oF) were 89.4, 28.8 and 59.7 (May); 86.3, 45.4 and 66.9 (Jun); 90.2, 46.4 and 73.1 and 1-d with maximum temperature >90^{o}F (Jul); 90.6, 46.8 and 71.9 and 2-d with maximum temperature >90^{o}F (Aug); 85.7, 40.2 and 60.1 (Sep); 85.7, 31.0 and 53.4 (to 15 Oct). Maximum, minimum and average relative humidity (%) was 92.8, 42.5 and 65.3 (May); 90.5, 55.4 and 73.4 (Jun); 90.8, 60.9 and 80.6 (Jul); 98.4, 33.6 and 72.3 (Aug); 98.7, 30.8 and 73.3 (Sep); 98.7, 19.3 and 68,5 (to 15 Oct). Maximum, minimum and average daily soil temperature (^oF) were 77.8, 53.1 and 66.5 (May); 89.2, 54.6 and 74.0 (Jun); 94.5, 59.8 and 76.7 (Jul); 89.2, 65.2 and 78.5 (Aug); 86.9, 65.7 and 76.8 (Sep); 78.2, 56.6 and 64.9 (to 15 Oct). Maximum, minimum and average soil moisture (% of field capacity) was 38.4, 28.8 and 31.7 (May); 39.9, 32.3 and 34.7 (Jun); 38.6, 34.1 and 35.4 (Jul); 39.5, 32.9 and 35.2 (Aug); 42.0, 31.3 and 34.5 (Sep) and 42.0, 33.4 and 34.2 (to 15 Oct). Precipitation was 3.82 in.

(May), 4.48 in. (Jun), 4.33 in. (Jul), 1.4 in (Aug), 5.14 in. (Sep) and 0.7 in. (to 15 Oct). Plots were irrigated to supplement precipitation to about 0.1 in./A/4 day period with overhead sprinkle irrigation.

The trials were divided into two sets; the first group of treatments was shown in Set 1 (Table 1). No treatment affected final plant stand. Moncoat MZ increased the rate of emergence (RAUEPC) in comparison to the untreated control. Moncoat MZ and Serenade ASO at the lowest application rate increased marketable yield in comparison to the untreated control but no other treatments were significantly different from the untreated control. No treatments had an affect on total yield. Treatments with greater than 4.7 stems had significantly more stems per plant than the untreated control. All treatments except the mid rate of Serenade ASO applied in-furrow had significantly less stem canker than the untreated check. The total number of stolons per plant was not affected by any treatment. All treatments had significantly less stolon canker incidence in comparison to the untreated check. All treatments had significantly less overall lower stem plant canker in comparison to the untreated check. All treatments had significantly lower incidence and severity of tuber black scurf in comparison to the untreated check. Seed treatments and in-furrow applications of fungicides and biofungicides were not phytotoxic (Table 1).

Set 2; (Table 2). No treatment affected final plant stand or the rate of emergence (RAUEPC). Marketable yield and total ranged from 123 to 200 cwt/A (untreated check = 149.7 cwt/A) and 320 to 557 cwt/A (untreated check = 432.1 cwt/A), respectively, but no treatments were significantly different from the untreated check or from the standard commercial seed treatment Maxim FS. Maxim 4FS had significantly more stems than the untreated check and Maxim 4FS 0.16 fl oz/cwt (A) +Actinogrow 0.0371WP 0.9 oz significantly less but no other treatments affected stem number. All treatments except the lowest rate of maxim plus Actinogrow had significantly less stem canker than the untreated check. The total number of stolons per plant was not affected by any treatment. All treatments had significantly less stolon canker incidence in comparison to the untreated check. All treatments had significantly less overall lower stem plant canker in comparison to the untreated check. All treatments had significantly lower incidence and severity of tuber black scurf in comparison to the untreated check. Seed treatments and seed treatment plus fungicide applications of fungicides were not phytotoxic. (Table 2).

Table 1. Efficacy of fungicides and biofungicides on Rhizoctonia stem canker and black scurf (Set 1).

Treatment and rate/1000 row feet and rate/cwt potato seed	Final plant stand (%)		RAUEPC[z]		Yield (cwt/A) US1		Yield (cwt/A) Total	
Moncoat MZ 7.5DP 0.75 lb/cwt (A[y])…..	99.0	a[x]	48.5	a	176.9	b	401.2	a
Serenade ASO 1.34SC 2.2 fl oz (B)……	96.5	a	39.4	bcd	206.8	a	425.8	a
Serenade ASO 1.34SC 7.7 fl oz (B)……	96.0	a	38.5	bcd	160.6	bc	370.0	a
Serenade ASO 1.34SC 13.2 fl oz (B)…..	90.0	a	35.7	cd	157.7	bc	329.5	a
Quadris 2.08FL 0.6 fl oz (B)…………...	85.5	a	33.9	d	152.8	c	365.4	a
Nubark Gold 6DS 1 lb/cwt (A)………...	96.0	a	34.1	d	154.2	c	369.5	a
Nubark Mancozeb 6DS 1 lb/cwt (A)…..	93.5	a	38.2	bcd	148.3	c	319.0	a
Nubark Mancozeb AS 8DS 1 lb/cwt (A).	95.5	a	41.4	bc	147.7	c	364.7	a
Maxim 4FS 0.08 fl oz/cwt + Nubark Gold 6DS 1 lb/cwt (A)………...	96.0	a	43.1	ab	159.4	bc	401.7	a
Maxim 4FS 0.08 fl oz/cwt + WE Germinate 10DS 0.2 oz/cwt (A)….	92.5	a	42.6	ab	162.1	bc	343.9	a
Untreated Check………………..............	95.0	a	40.4	bcd	144.4	c	332.9	a
$HSD_{0.05}$	10.31		6.85		19.92		78.69	

Treatment and rate/1000 row feet and rate/cwt potato seed[z]	Stems (35 DAP) Number		Stems (35 DAP) Percent infected[w]		Stolons (35 DAP) No./plant	Stolons (35 DAP) Girdling[v] > 5%		Root and lower stem canker index 35 DAP[u]		Tuber black scurf Incidence (%)		Tuber black scurf Severity scale (0 - 100)	
Moncoat MZ 7.5DP 0.75 lb/cwt (A[y])…..	5.6	a	26.8	c	17.6	9.8	b	2.2	bc	3.8	d	1.3	d
Serenade ASO 1.34SC 2.2 fl oz (B)……	4.1	c	47.6	b	17.6	8.9	bc	2.3	b	13.8	bcd	4.7	bcd
Serenade ASO 1.34SC 7.7 fl oz (B)……	4.2	bc	53.4	ab	15.1	7.6	bc	1.9	bcd	10.0	cd	2.8	cd
Serenade ASO 1.34SC 13.2 fl oz (B)…..	4.6	ab	21.7	c	14.8	4.5	bcd	1.6	cde	13.8	bcd	5.9	bcd
Quadris 2.08FL 0.6 fl oz (B)…………...	5.5	a	18.3	c	17.8	4.9	bcd	1.2	ef	18.8	bc	9.1	bc
Nubark Gold 6DS 1 lb/cwt (A)………...	5.3	a	23.0	c	15.0	3.6	cd	1.1	ef	23.8	ab	10.3	b
Nubark Mancozeb 6DS 1 lb/cwt (A)…..	4.7	ab	21.7	c	17.3	2.0	d	0.9	f	11.3	cd	3.4	cd
Nubark Mancozeb AS 8DS 1 lb/cwt (A).	5.3	a	21.1	c	16.8	4.9	bcd	1.0	ef	10.0	cd	5.6	bcd
Maxim 4FS 0.08 fl oz/cwt + Nubark Gold 6DS 1 lb/cwt (A)………...	5.1	ab	20.7	c	18.0	7.7	bc	1.4	def	21.3	abc	9.1	bc
Maxim 4FS 0.08 fl oz/cwt + WE Germinate 10DS 0.2 oz/cwt (A)….	5.2	a	19.6	c	14.8	4.8	bcd	0.9	ef	10.0	cd	3.1	cd
Untreated Check………………..............	3.9	c	63.6	a	14.1	26.5	a	4.0	a	32.5	a	17.2	a
$HSD_{0.05}$	0.94		14.16		3.97	5.43		0.67		11.37		6.68	

[z] RAUEPC = Relative area under the emergence progress curve measured from planting to 31 days after planting

[y] Application dates: A= 19 May (liquid formulations for seed piece application at 0.2 pt/cwt; B= 21 May (in-furrow).

[x] Values followed by the same letter are not significantly different at $p = 0.05$ (Honest Significant Difference; Tukey Multiple Comparison).

[w] Stems with greater than 5% of area with stem canker due to *Rhizoctonia solani*

[v] Stolons with greater than 5% of area with stolon canker due to *Rhizoctonia solani*.

[u] An index of below ground health was evaluated 35 DAP on a scale of 0 - 5 (see text)

Table 2. Efficacy of fungicides and biofungicides on Rhizoctonia stem canker and black scurf (Set 2).

Treatment and rate/1000 row feet and rate/cwt potato seed	Final plant stand (%)	RAUEPC[z]	Yield (cwt/A) US1	Yield (cwt/A) Total
Maxim 4FS 0.16 fl oz/cwt (A[y]) + Actinogrow 0.0371WP 0.3 oz (A[y])...	93.5 a[x]	45.5 a	122.9 a	320.3 a
Maxim 4FS 0.16 fl oz/cwt (A) + Actinogrow 0.0371WP 0.6 oz (B)….	97.0 a	48.3 a	162.9 a	362.7 a
Maxim 4FS 0.16 fl oz/cwt (A) + Actinogrow 0.0371WP 0.9 oz (B)…	95.0 a	48.2 a	183.1 a	434.6 a
Maxim 4FS 0.16 fl oz/cwt (A) + Tenet 4WP 0.5 oz (B)………………	94.5 a	41.1 a	167.2 a	345.3 a
Maxim 4FS 0.16 fl oz/cwt (A) + Quadris 2.08SC 0.6 fl oz (B)……….	99.5 a	51.4 a	199.9 a	491.8 a
LEM 17 200EC 0.67 fl oz (B)….........	99.0 a	43.8 a	171.2 a	395.3 a
LEM 17 200EC 1.6 fl oz (B)…...........	99.5 a	45.5 a	187.4 a	468.5 a
YT669 200EC 0.7 fl oz (B)………….	98.5 a	47.9 a	158.8 a	399.1 a
YT669 200EC 0.7 fl oz (B)………….	98.5 a	49.0 a	167.7 a	338.3 a
Q8Y78 240SC 1.6 fl oz (B)………….	99.5 a	50.5 a	158.3 a	393.7 a
LEM 17 4.75FS 0.42 fl oz (B)……….	93.5 a	48.5 a	189.8 a	557.1 a
LEM 17 4.75FS 0.21 fl oz (B)……….	97.0 a	48.7 a	152.7 a	380.8 a
LEM 17 4.75FS 0.11 fl oz (B)……….	98.5 a	47.8 a	175.3 a	443.9 a
Quadris 2.08SC 0.6 fl oz (B)………...	97.5 a	47.0 a	180.4 a	424.1 a
Maxim MZ 6.2DS 0.5 lb/cwt (A)……	95.5 a	44.4 a	192.3 a	407.6 a
Maxim 4FS 0.16 fl oz/cwt (A)………	99.0 a	49.2 a	180.5 a	412.6 a
Untreated Check………………..........	97.0 a	44.3 a	149.7 a	432.1 a
$HSD_{0.05}$	6.65	9.26	43.35	148.29

Treatment and rate/1000 row feet and rate/cwt potato seed[z]	Stems (35 DAP) Number	Stems (35 DAP) Percent infected[w]	Stolons (35 DAP) No./plant	Stolons (35 DAP) Girdling[v] > 5%	Root and lower stem canker index 35 DAP[u]	Tuber black scurf Incidence (%)	Tuber black scurf Severity scale (0 - 100)
Maxim 4FS 0.16 fl oz/cwt (A[y]) + Actinogrow 0.0371WP 0.3 oz (A[y])...	5.0 bcd	19.4 ab	13.4	7.7 b	1.7 b	10.0 b-e	2.5 bcd
Maxim 4FS 0.16 fl oz/cwt (A) + Actinogrow 0.0371WP 0.6 oz (B)….	6.1 ab	13.4 bcd	13.6	6.0 bcd	1.3 bc	20.0 b	7.5 b
Maxim 4FS 0.16 fl oz/cwt (A) + Actinogrow 0.0371WP 0.9 oz (B)…	3.9 d	4.9 cd	15.0	2.2 d	0.4 cd	7.5 b-e	2.5 bcd
Maxim 4FS 0.16 fl oz/cwt (A) + Tenet 4WP 0.5 oz (B)………………	4.3 cd	10.1 bcd	14.6	4.4 bcd	0.8 bcd	2.5 de	0.6 d
Maxim 4FS 0.16 fl oz/cwt (A) + Quadris 2.08SC 0.6 fl oz (B)……….	5.6 bc	14.4 bcd	15.9	4.6 bcd	1.2 bcd	7.5 b-e	3.1 bcd
LEM 17 200EC 0.67 fl oz (B)….........	5.6 bc	10.5 bcd	14.7	5.1 bcd	1.1 bcd	6.3 cde	2.5 bcd
LEM 17 200EC 1.6 fl oz (B)…...........	5.2 bcd	15.9 bc	13.6	7.7 b	1.6 b	0.0 e	0.0 d
YT669 200EC 0.7 fl oz (B)………….	5.3 bc	9.1 bcd	16.0	5.6 bcd	0.8 bcd	11.3 b-e	3.8 bcd
YT669 200EC 0.7 fl oz (B)………….	5.9 b	13.3 bcd	16.0	7.1 b	1.3 bc	16.3 bc	6.3 bc
Q8Y78 240SC 1.6 fl oz (B)………….	4.5 cd	6.6 cd	14.4	4.9 bcd	0.7 bcd	0.0 e	0.0 d
LEM 17 4.75FS 0.42 fl oz (B)……….	5.5 bc	17.1 bc	17.8	5.6 bcd	1.4 bc	7.5 b-e	2.5 bcd
LEM 17 4.75FS 0.21 fl oz (B)……….	5.4 bc	8.6 bcd	15.9	5.4 bcd	0.8 bcd	5.0 cde	1.3 cd
LEM 17 4.75FS 0.11 fl oz (B)……….	5.3 bcd	13.7 bcd	18.3	4.1 bcd	1.1 bcd	11.3 b-e	4.1 bcd
Quadris 2.08SC 0.6 fl oz (B)………...	5.9 b	2.5 d	17.0	3.1 cd	0.3 d	5.0 cde	1.3 cd
Maxim MZ 6.2DS 0.5 lb/cwt (A)……	6.1 ab	10.3 bcd	15.2	5.2 bcd	1.1 bcd	13.8 bcd	4.1 bcd
Maxim 4FS 0.16 fl oz/cwt (A)………	7.4 a	16.2 bc	15.4	6.5 bc	1.5 b	10.0 b-e	3.1 bcd
Untreated Check………………..........	5.5 bc	31.3 a	16.3	18.9 a	3.2 a	33.8 a	13.1 a
$HSD_{0.05}$	1.36	12.75	3.53	3.83	1.03	13.22	5.35

[z] RAUEPC = Relative area under the emergence progress curve measured from planting to 31 days after planting
[y] Application dates: A= 19 May (liquid formulations for seed piece application at 0.2 pt/cwt; B= 21 May (in-furrow).
[x] Values followed by the same letter are not significantly different at $p = 0.05$ (Honest Significant Difference; Tukey Multiple Comparison).
[w] Stems with greater than 5% of area with stem canker due to *Rhizoctonia solani*
[v] Stolons with greater than 5% of area with stolon canker due to *Rhizoctonia solani*.
[u] An index of below ground health was evaluated 35 DAP on a scale of 0 - 5 (see text)

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Impact of different US genotypes of *Phytophthora infestans* on potato seed tuber rot and plant emergence in different cultivars and breeding lines

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Introduction

Globally, *Phytophthora infestans* (Mont.) de Bary remains a threat to the potato crop, causing significant losses annually (Guenther *et al.* 2001). Under favorable conditions, foliar and tuber late blight are the most common symptoms resulting in tuber rotting in the field and storage, and affecting the economic value of the potatoes. Infected volunteer tubers can lead to a late blight epidemic in the following season. The transmission of potato late blight from tuber to sprouts has been confirmed (Berkeley 1846; Appel *et al.* 1998), but the progression mechanism from infected tubers to the plant is not fully understood.

Potato cultivars with higher foliar resistance tend to slow down the epidemics leading to longer periods of vegetative growth of *P. infestans*. As a result, zoospores and mycelia can be washed into the soil (Bain *et al.*, 1997). This fact may provide a high risk of tuber infection. In addition, the populations of *P. infestans* have changed to more aggressive genotypes, like US–8, which is highly aggressive on foliage, and also in tubers and sprouts (Kirk *et al.*, 2009). The changing *P. infestans* population has not been fully understood at in terms of virulence, fitness, aggressiveness and transmission. Also, the dynamics of potato blight development in tubers is highly influenced by temperature (Kirk *et al.*, 2009) resulting in non–emergence of plants due to seed and sprout rot. The objectives of this study were to evaluate the potential of different genotypes of *P. infestans* to impact plant establishment in potato cultivars and advanced breeding lines (ABLs) with different resistance to potato late blight.

Methods

Tubers for this study were obtained from the potato breeding programmes at Michigan State University, the University of Wisconsin, the University of Minnesota and North Dakota State University. Potato tubers from cultivars/ABLs harvested during the previous growing seasons were stored at 3 °C in the dark at 90% relative humidity until they were used. Tubers for the experiments were within the size grade range 50–150 mm diameter (any plane). Visual examination of a random sample of tubers from each entry for disease symptoms indicated that tubers were free from late blight. The sample was further tested with the ELISA immunodiagnostic Alert multiwell kit (Alert multiwell kit– *Phytophthora sp*., Neogen, Lansing, MI, USA). *P. infestans* was not detected in any of the tubers. Prior to inoculation, all tubers were washed with water to remove soil. The tubers were then surface-sterilized by soaking them in 2% sodium hypochlorite (Clorox) solution for 30 min. Tubers were dried in a controlled environment with continuous airflow at 15 °C in dry air (30% relative humidity) for 4 h prior to inoculation.

Cultures of *P. infestans*–isolates Pi95-3 (US-1), Pi96-2 [US-1.7 (restriction fragment length polymorphism genotype; Young et al. 2009)], Pi02-007 (US-8), Pi96-1 (US- 11) and

Pi98-1 (US-14) were selected as the most aggressive isolates from the collection of Kirk (Michigan State University) and grown on rye agar Petri plates for14 days in the dark at 18 °C. A homogenized mixture of mycelium and sporangia of *P. infestans* was prepared from 200 plate cultures (9 cm diameter × 15 mm depth Petri plates) from each isolate. Tubers were inoculated with a suspension of 10^5 and 10^6 spores/ml, exposing the cut surface was placed face down on the homogenized mixture of mycelium and sporangia of *P. infestans* for 30 s.

Potato cultivars/ABLs used for the experiments were evaluated for tuber blight severity after inoculation and re-storage. Tubers were inoculated as described and were then stored in the dark in net bags within ventilated plastic boxes. Each treatment was replicated four times. Boxes were arranged in a complete randomized design and stored in environmental growth chambers (Chagrin Falls, Ohio 44022-0390) in darkness at 10 °C and 90% relative humidity. Disease development rates within tubers in relation to storage temperature were known from previous experiments (Kirk et al. 2001c) and a single sampling date was selected 30 days after inoculation (DAI). fter incubation (30 DAI), seed pieces were cut 25, 50 and 75% from and parallel to the inoculated surface of inoculated seed pieces to assess tuber blight development in the tuber tissue.

For plant stand, eight seed pieces per replicate per treatment from 12 and 16 potato cultivars/ABLs, were planted 5 DAI at the Muck Soils Research Farm (Laingsburg, MI, USA) separated by two guard plants (cv. Red Norland) at the ends of each plot. Both trials were arranged as a randomized complete block design. In the plant establishment experiment the number of emerged plants was recorded over a 60-day period after planting and final plant stand (%) and the relative area under the emergence progress curve (RAUEPC) were calculated (Wharton et al. 2007).

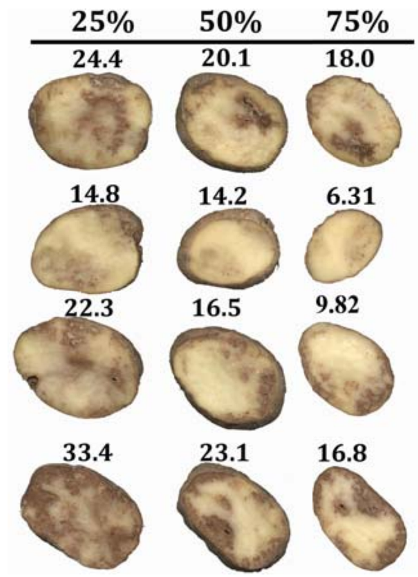
Data for all experiments were analyzed by analysis of variance (least squares method) using the JMP program version 7.0 (SAS Institute Inc., SAS Campus Drive, Cary, North Carolina 27513, USA).

Table 1. Varieties/ABLs challenged during the study including the breeders' estimate for foliar and tuber rating against US-8 (symbols referred to in Fig 2).

Variety / ABLs	Foliar Susceptibility	Tuber Susceptibility		Variety / ABLs	Foliar Susceptibility	Tuber Susceptibility	
Atlantic	S	S	▲	MSJ456-2Y	I	S	◆
MSI152-A	I	S	△	MSJ461-1	R	I	◇
MSJ317-1	R	S	▲ (grey)	Jacqueline - Lee	R	S	◆ (grey)
Pike	I	S	■	Megachip	S	S	▼
Torridon	R	R	□	FL1833	S	S	▽
FL1879	S	S	■ (grey)	FL1867	S	S	▼ (grey)
MSJ319-7	I	S	●	MN15620	S	S	⬢
MSJ316-A	I	S	○	MN98642	S	S	⬡
MSJ453-4Y	I	S	● (grey)	ND2443	S	S	⬢ (grey)
Snowden	S	S	★	ND5822C-7	S	S	☆

Funding: MPIC and MSU GREEEN

Figure 1. Cross sections of a tuber from the line ND2443 inoculated with *P. infestans* US–8 genotype. Numbers indicate RARI (%) for apical, middle, basal sections.



Results and Discussion

- RARI (%) values, for 2003 storage (10ºC) were significantly greater compared to the 2004 experiment (Fig 2).
- Regardless of the variety or ABL inoculated, US–8 genotype caused the most damage, which means a lower RARI (%) value (Fig 1).
- The US–14 genotype was the second most aggressive genotype in tubers in both the years.
- All the cultivars and ABLs demonstrated significant differences in the amount of necrotic tissue (RARI %) after the inoculation with different genotypes of *P. infestans*.
- Figure 2 shows the response of the varieties/ABLs is correlated to the tuber disease.
- The final plant stand of tubers (ratio of plants growing to seeds planted) inoculated with *P. infestans* genotype US-8 and US-14 were significantly lower than the non– inoculated control seed pieces.
- The genotypes US-1 and US-11 also reduced the final plant stand.
- In 2003, cv. Atlantic had the greatest final plant stand among *P. infestans* genotypes; for 2004, cv. Torridon had the highest final plant stand.
- Mean RAUEPC of seed pieces infected with genotypes US-8 and US-14 were significantly lower in 2003 and 2004.
- Final plant stand and RAUEPC were positive correlated for both years' trials (Fig 3). However, RAUEPC and final plant stand values were different for varieties/ ABLs inoculated.
- Foliar symptoms of late blight were absent on plants emerging from the different inoculated seed pieces.

- In fact, the question of the frequency and rate of transmission from infected tubers to foliage is still unresolved.
- The absence of late blight symptoms in the emerged plants from the inoculated seed piece could be affected by different factors.

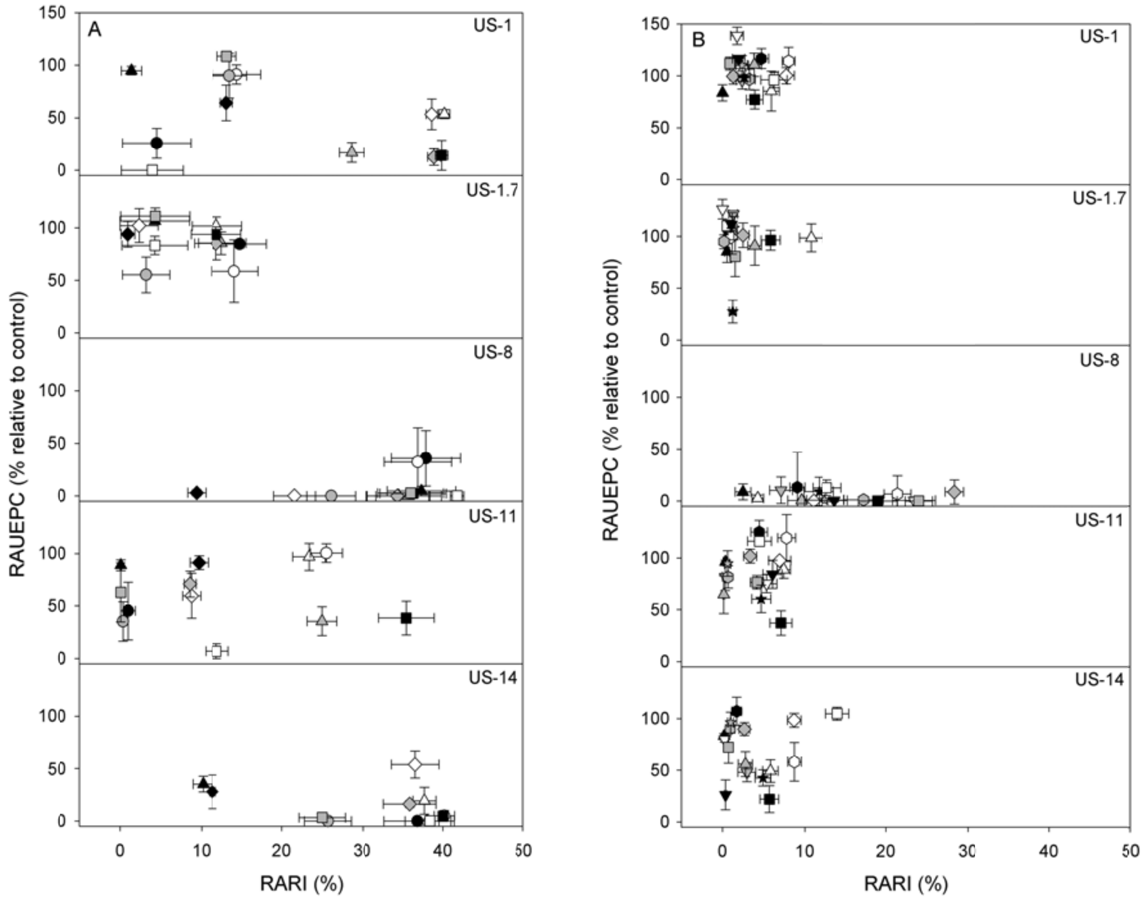


Figure 2. RAUEPC expressed as function of tuber susceptibility (mean RARI %) across varieties/ABLs with different genotypes of *P. infestans* in 2003 and 2004.

Funding: MPIC and MSU GREEEN

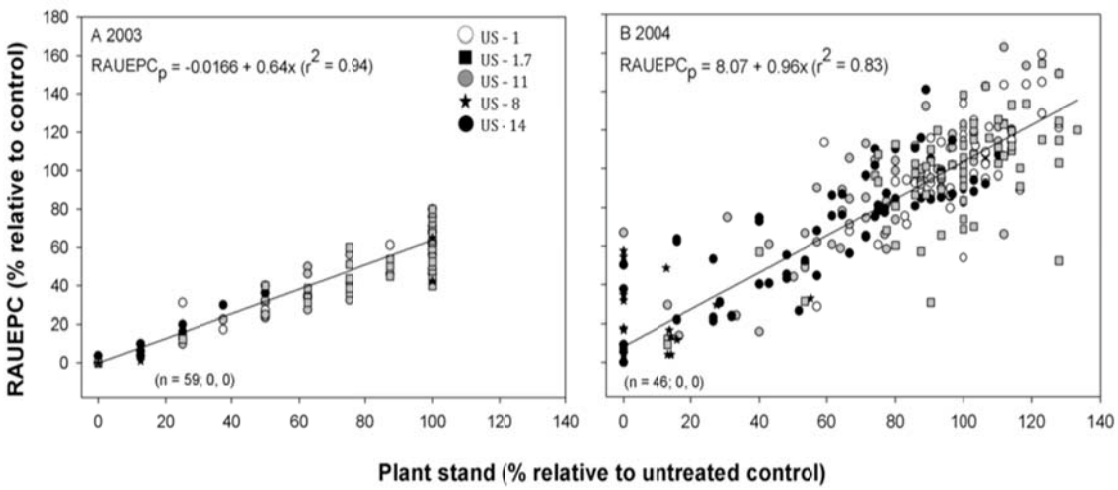


Figure 3. RAUEPC expressed as a functional of final plant stand (%) across varieties/ABLs with different genotypes *of P. infestans* in 2003 and 2004.

Conclusion

A correlation was observed between tuber susceptibility and plant growth, where tuber pathogenicity lowers the field establishment (Kirk *et al*., 2009). As the aggressiveness of *P. infestans* isolates is increasing, more breeding lines on tuber resistance could be helpful. Latent infection of tuber and sprouts could be leading cause for a new epidemic.

References

Appel R, *et al.* (2001) A method for the artificial inoculation of potato tubers with *Phytophthora infestans* and polymerase chain reaction assay of latently infected sprouts and stems. Phytopathology 149: 287-292.

Bain RA, *et al.* (1997) The role of *Phytophthora infestans* inoculum from stem lesions in the infection of tubers. In: Bouma E, Schepers H, eds. Proceedings of the Workshop on the European Network for Development of an Integrated Control Strategy of Potato Late Blight. PAV-Special Report No. 1, January 1997. 98–105.

Berkeley MJ (1846) Observations, botanical and physiological, on the potato murrain. Phytopathological Classics No. 8. American Phytopathological Society. 1948 reproduction. 108 pp East Lansing, MI, USA.

Guenther JF, Michael, KC and Nolte, P (2001) The economic impact of potato late blight on US growers. Potato Res 44: 121-125

Kirk, W.W., F. Abu-el, P.W. Samen, D. Douches, P. Tumbalam, C. Thill, and A. Thompson. 2009. Impact of different US genotypes of *Phytophthora infestans* on potato seed tuber rot and plant emergence in a range of cultivars and advanced breeding lines. Potato Research 51: 121–140.

Funding: MPIC and MSU GREEEN

Niemira BA, Kirk WW and Stein JM (1999) Screening for late blight susceptibility in potato tubers by digital analysis of cut tuber surfaces. Plant Diseases 83: 469-473.

Wharton PS, Kirk WW, Berry DR, Tumbalam PG (2007) Seed treatment application-timing options for control of *Fusarium* decay and sprout rot of cut seedpieces. Am J Potato Res 84:237–244

Young GK, Cooke LR, Kirk WW, Tumbalam P, Perez FM, Deahl KL (2009) The influence of competition and host plant resistance on selection of *Phytophthora infestans* populations in Michigan State and Northern Ireland. Plant Pathol doi:10.1007/BF02986273

COLORADO POTATO BEETLE RESEARCH UPDATE

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The Colorado potato beetle is the most widespread and destructive insect pest of potato crops in the eastern United States and Canada. Its ability to develop resistance to insecticides makes it very important to continue testing the efficacy of both new insecticide chemistries and existing compounds. Such tests provide data on comparative effectiveness of products and data to help support future registrations and use recommendations.

Objective 1. Field evaluations of registered insecticides for managing Colorado potato beetle on potatoes
METHODS. Twenty-seven insecticide treatments and an untreated check (Table 1) were tested at the MSU Montcalm Research Farm, Entrican, MI for control of Colorado potato beetle. 'Atlantic' potato seed pieces were planted 12 in. apart, with 34 in. row spacing on 13 May 2010. Treatments were replicated four times in a randomized complete block design. Plots were 40 ft. long and three rows wide with untreated guard rows bordering each plot.

Admire Pro, *Platinum 75SG*, and *Regent 4SC* treatments were applied as in-furrow sprays at planting, using a single-nozzle hand-held boom (30 gallons/acre and 30 psi). Seed treatments (*HGW86 60 FS* treatments, *Titan 60 SL*, *Admire Pro*, and *Cruiser Max*) were applied by mixing seed pieces for each row with the corresponding amount of product in a small plastic bag and shaking until seed pieces were thoroughly coated. Foliar treatments were first applied at greater than 50% Colorado potato beetle egg hatch on 17 June. Based on the economic threshold of more than one large larva per plant, only the *Agri-Flex 1.55 SC* treatment required an additional first generation spray, applied on 1 July. Post-spray counts of Colorado potato beetle adults, small larvae (1^{st} and 2^{nd} instars), and large larvae (3^{rd} and 4^{th} instars) of four randomly selected plants form the middle row of each plot were made 5 or 6 days after each foliar application. The numbers of small larvae, large larvae and adults were transformed (log + 0.1) prior to analysis. Multivariate analysis of variance was used for data analysis, with block and date as random factors and insecticide treatment as fixed factor. Ad-hoc *Tukey* means comparison was used to compare treatment means when the overall model was significant ($P < 0.01$).

Plots were visually rated for defoliation weekly by estimating total defoliation per plot. Percent defoliation values were arcsine transformed prior to analysis, and an analysis of variance was done with block and date as random factors and insecticide treatment as fixed factor in the model. Ad-hoc *Tukey* means comparison was used to compare treatment means when the overall model was significant ($P < 0.05$). On 14 September, the middle row of each plot was harvested mechanically and the tubers were weighed. Data were analyzed using analysis of variance with treatment as fixed and block as random factor in the model and significant treatment differences were determined with *Tukey* post-hoc means separation test ($P < 0.05$).
RESULTS. All treatments significantly reduced the numbers of small larvae, large larvae, and adults on plants compared to the untreated plots (Table 1). Beetle pressure was higher in 2010 than in 2009, but comparing to previous years, insect pressure was low overall. Nevertheless, the untreated plots had significantly greater defoliation compared to all other treatments ($F = 11.46$; $df = 27, 446$; $P < 0.01$). The seasonal defoliation average was 13% in untreated plots, compared to less than 2% for all other treatments (there were no statistically significant differences between insecticide treatments). Growing conditions were favorable this season, with dry, hot weather leading to rapid plant growth, likely outpacing the impacts of Colorado potato beetle feeding damage. Overall average yield was 33,211.7 lb/A, with no significant differences between any of the treatments ($F = 0.72$; $df = 27, 110$; $P = 0.8285$).

While neonicotinoid insecticides are still providing sufficient Colorado potato beetle control for Michigan farmers, it is reassuring to see other chemical classes also providing adequate control (i.e.: *Coragen*, *Regent*, *Agri-Mek*, and *Rimon*). *Regent* is currently registered for use in potato for wire-worm control. *Rimon* is only effective when applied to larvae that still need to grow and molt since this product contains a hormone that inhibits development to the next growing stage.

With the slow increase in neonicotinoid resistance seen in Michigan (see the section below for more details on this), it remains important to have effective non-neonicotinoid compounds available for second generation control and/or for future use if neonicotinoid resistance becomes a significant problem.

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Objective 2. Insecticide resistance monitoring of Colorado potato beetles in Michigan potato fields

Imidacloprid (*Admire Pro*) and thiamethoxam (*Platinum*, *Actara*) continue to be the most common means of Colorado potato beetle control. Today, greater than 75% of the acres in the northeastern and midwestern United States are protected by these compounds (NASS 2006). Such consistent and heavy dependency on any compound sets the stage for resistance development. Further complicating the issue is the availability of generic imidacloprid formulations; these formulations drive down product cost, which will likely lead to even greater field exposure to these compounds. All of these reasons strongly support the need to continue monitoring resistance development and to encourage growers to adopt strong resistance management strategies.

Our objective was to continue gathering data on susceptibility to imidacloprid and thiamethoxam in Colorado potato beetle populations collected from commercial potato fields in Michigan and other regions of the United States. To accomplish this objective, 15 Colorado potato beetle populations (10 Michigan populations and 5 populations collected in other states) were bioassayed with imidacloprid and/or thiamethoxam.

METHODS. During 2010, 10 Colorado potato beetle populations were collected from 4 Michigan counties (Mecosta, Montcalm, St. Joseph, and Tuscola). Cooperators also provided a population from New York and two each from Maine and Virginia. One laboratory strain was also tested (Table 2).

Adult Colorado potato beetles were treated with 1 µl of acetone/insecticide solution of known concentration applied to the ventral surface of the abdomen using a 50 µl Hamilton® microsyringe. A range of five to nine concentrations was selected for each population, depending on the number of available beetles and known resistance history for each population. In each bioassay, 20-30 adults were treated with each concentration (nine to 10 beetles per dish and two to three dishes per concentration). Following treatment, beetles were placed in 100 mm diam. petri dishes lined with Whatman® No. 1 filter paper and provided with fresh potato foliage. They were kept at 25±1°C and the foliage and filter paper were checked daily and changed as needed.

Beetle response was assessed 7 days post treatment. A beetle was classified as dead if its abdomen was shrunken, it did not move when its legs or tarsi were pinched, and its elytra were darkened. A beetle was classified as walking and healthy if it was able to grasp a pencil and walk forward normally. A beetle was classified as poisoned if its legs were extended and shaking, it was unable to right itself or grasp a pencil, and it was unable to walk forward normally at least one body length. Beetles that had died due to *Beauvaria* spp. infection were excluded from analysis; these beetles were easily recognized by their pale, petrified appearance and/or presence of white filamentous fungi. Dead and poisoned beetle numbers were pooled for analysis. Data were analyzed using standard log-probit analysis (SAS Institute, 2009).

RESULTS. The imidacloprid LD_{50} value (dose lethal to 50% of the beetles) for the susceptible laboratory strain was 0.208 µg/beetle (Table 3), statistically higher than in previous years. The LD_{50} values from the field for imidacloprid ranged from 1.573 µg/beetle (Sackett Ranch field VG) to 12.738 µg/beetle (Tuscola) for Michigan populations (Figure 1). However, the St. Joseph sample had 100% mortality at the lowest dose tested (0.3 µg/beetle); since all doses tested caused 100% mortality, the analysis was unable to calculate an LD_{50} value, but clearly this is the most susceptible population tested. On the other hand, the Tuscola population showed almost no response to all doses tested, resulting in a projected LD_{50} value of 12.738 µg/beetle, but lacked confidence limits, a very high value for the Midwest. The imidacloprid LD_{50} values from the out-of-state populations ranged from 0.104 µg/beetle (Painter, VA) to 20.428 (Jamesport, NY).

LD_{50} values were generally higher this year, with all but one population (Fryeburg, ME) having significantly higher values than the susceptible laboratory strain. One possible cause for the elevated values was a change in methodology from previous years. In 2010, we did not put beetles in cold-storage prior to testing, whereas in previous years, populations were subjected to a week or more of cold-storage (11±1°C). Instead, beetles were maintained at room temperature and fed daily until bioassays were conducted. Regardless, as in 2009, all Michigan imidacloprid LD_{50} values were significantly higher than the susceptible comparison. In 2010, 60% of the Michigan samples were greater than 10-fold resistant to imidacloprid, compared to 85% in 2009 and 90% in 2008.

The thiamethoxam LD_{50} value for the susceptible laboratory strain was 0.112 µg/beetle, also statistically higher than in previous years. LD_{50} values for thiamethoxam in Michigan ranged from 0.152 µg/beetle (St. Joseph) to 3.248 µg/beetle (Montcalm), and from 0.134 µg/beetle (Bridgewater, ME) to 1.152 µg/beetle (Jamesport, NY) for out-of-state populations (Figure 1). Unlike the past two years, where no Michigan populations showed greater than 10-fold resistance to thiamethoxam, two populations tested (Montcalm and

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Tuscola) were more than 10-fold resistant to thiamethoxam. The 3.248 µg/beetle value from Montcalm is particularly high, representing the highest field thiamethoxam value we've recorded.

Thiamethoxam resistance remains uncommon and has probably been delayed by the more prevalent use of imidacloprid in the field. However, now that some Michigan sites are showing greater than 10-fold resistance to thiamethoxam, it will be important to monitor thiamethoxam resistance even closer, even more important to avoid multiple applications of neonicotinoids in a single growing season, and essential to alternate with other chemical classes for Colorado potato beetle control.

Objective 3. Understand the molecular genetic processes of resistance in CPB.

In April 2010, a postdoctoral researcher joined our laboratory specifically to work on understanding the molecular genetic causes of insecticide resistance in CPB. So far, we have extracted RNA from CPB kept in our laboratory colonies. Currently, there are two populations that we will focus on in our genetic analyses, one imidacloprid resistant and another highly susceptible to insecticides. From the resistant population, we extracted RNA from CPB guts before and after selection with imidacloprid, in order to compare gene expression profiles before and after induction. RNA is sequenced at the MSU Genomic Core Facility on an Illumina sequencer. Each treatment is replicated three times, and this will provide us with information on the individual variation in the genetic basis of insecticide resistance. Our goal is to identify genes that are involved with insecticide resistance. Once we get the sequence data from the genomic core facility, we will use bioinformatics to evaluate gene expression. In addition, the postdoctoral researcher is currently conducting bioassays to test the role of different enzymes in helping the insect metabolize insecticides. These experiments involve the inhibition of well-known insecticide metabolism enzymes in insects and measuring the response of the treated insects to insecticides. Through the response of enzyme-inhibited insects to insecticide treatment, we will be able to identify which enzymes take active part in insecticide metabolism. For this objective, additional funding was attained in 2010 for three years from the Rackham Foundation.

Table 1. Seasonal mean number of different Colorado potato beetle life stages in an insecticide field-trial conducted by the MSU vegetable entomology laboratory.

Treatment	Insecticide class	Application mode	Rate	Adult[1]	Small Larva[1]	Large Larva[1]
Untreated				0.7 a	1.4 a	4.8 a
Admire Pro	neonicotinoid	seed treatment	9.4 g ai/100 kg	0.0 b	0.0 b	0.1 b
Cruiser Max	neonicotinoid	seed treatment	4.7 g ai/100 kg	0.0 b	0.0 b	0.0 b
HGW86 60 FS	cyantraniliprole	seed treatment	9.0 g ai/100 kg	0.0 b	0.2 b	0.1 b
HGW86 60 FS + Titan 60 SL	cyantraniliprole + lambdacyahalothrin	seed treatment	6.8 g ai/100 kg +6.3 g ai/100 kg	0.1 b	0.0 b	0.0 b
HGW86 60 FS + Titan 60 SL	cyantraniliprole + lambdacyahalothrin	seed treatment	9.0 g ai/100 kg +6.3 g ai/100 kg	0.0 b	0.0 b	0.0 b
HGW86 60 FS + Titan 60 SL	cyantraniliprole + lambdacyahalothrin	seed treatment	6.8 g ai/100 kg +3.1 g ai/100 kg	0.1 b	0.3 b	0.0 b
HGW86 60 FS + Admire Pro	cyantraniliprole + neonicotinoid	seed treatment	6.8 g ai/100 kg +9.4 g ai/100 kg	0.0 b	0.0 b	0.0 b
HGW86 60 FS + Admire Pro	cyantraniliprole + neonicotinoid	seed treatment	9.0 g ai/100 kg +9.4 g ai/100 kg	0.0 b	0.1 b	0.2 b
Titan 60 SL	lambdacyhalothrin	seed treatment	6.3 g ai/100 kg	0.0 b	0.2 b	0.1 b
HGW86 10 OD	cyantraniliprole	foliar#	3.4 fl oz/A	0.0 b	0.3 b	0.0 b
HGW86 10 OD	cyantraniliprole	foliar#	6.8 fl oz/A	0.0 b	0.1 b	0.0 b
HGW86 10 OD	cyantraniliprole	foliar#	10.1 fl oz/A	0.0 b	0.3 b	0.0 b
HGW86 10 OD	cyantraniliprole	foliar#	13.5 fl oz/A	0.1 b	0.0 b	0.0 b
Coragen 1.67 SC	ryanodine receptor modulator	foliar	7 fl oz/A	0.0 b	0.0 b	0.1 b
Voliam Flexi 40 WG	neonicotinoid + ryanodine receptor modulator	foliar	4 oz/A	0.1 b	0.1 b	0.0 b
Agri-Flex 1.55 SC	neonicotinoid + chloride channel activator	foliar	0.79 fl oz/A	0.01 b	0.3 b	0.1 b
Voliam Xpress 1.25 ZC	pyrethroid + ryanodine receptor modulator	foliar	7 fl oz/A	0.1 b	0.4 b	0.7 b
Endigo 2.06 ZC	pyrethroid + neonicotinoid	foliar	4 fl oz/A	0.0 b	0.1 b	0.1 b
Leverage 360	pyrethroid + neonicotinoid	foliar	2.8 fl oz/A	0.1 b	0.4 b	0.4 b
Leverage 2.7	pyrethroid + neonicotinoid	foliar	3.8 fl oz/A	0.0 b	0.1 b	0.4 b
Agri-Mek 0.15 EC	chloride channel activator	foliar	16 fl oz/A	0.0 b	0.0 b	0.1 b
Rimon 0.83EC	growth inhibitor	foliar	12 fl oz/A	0.1 b	0.1 b	0.1 b
Scorpion 35 SL	neonicotinoid	foliar	3.0 fl oz/A	0.1 b	0.2 b	0.2 b
Scorpion 35 SL Radiant SC	neonicotinoid + spinetoram	foliar (alternated weekly)	3.0 fl oz/A 8.0 fl oz/A	0.0 b	0.1 b	0.0 b
Admire Pro	neonicotinoid	infurrow	8.7 fl oz/A	0.1 b	0.0 b	0.0 b
Platinum 75 SG	neonicotinoid	infurrow	2.67 oz/A	0.1 b	0.0 b	0.0 b
Regent 4 SC	chloride channel modulator	infurrow	3.2 fl oz/A	0.0 b	0.5 b	0.1 b

[1] Different letters within a column denote statistically significant differences among treatments.

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Table 2. Colorado potato beetle populations tested for susceptibility to imidacloprid and thiamethoxam in 2010.

Michigan populations
Montcalm Farm Summer adults were collected on 14 July 2010 from untreated potatoes at the Michigan State University Montcalm Potato Research Farm, Entrican, MI.
Paul Main Farm Summer adults were collected by Mark Otto, Argi-Business Consultants, Inc. from commercial potato fields in Mecosta County.
Field H6 (old field number HB-Hen) Adults were collected just north of Lakeview on 12 July 2010; adults were migrating from volunteer potatoes in field H5 (old field number HB-NS) corn. Field H6 is NW of Paul Main's field H4 (old field number HB-S [Shurlow]) that had a very high summer adult LD50 value a few years ago.
Field R13 Adults were collected in Rodney on 12 July 2010; adults were migrating from volunteer potatoes in field R1 corn.
Sackett Potatoes Summer adults were collected by Mark Otto, Argi-Business Consultants, Inc. from commercial potato fields in Mecosta and Montcalm Counties.
Field 14 Adults were collected from Home farm trap rows, Mecosta County on 12 July 2010.
Field 132 Adults were collected from northeast of Remus, Mecosta County (same population as fields 101-107) on 12 July 2010; adults were migrating from potato volunteers in fields 135-136 corn.
Fields 152-153 Adults were collected in Montcalm County on 17 July 2010. Overwintered adults migrated from field 150-151; food control early from Admire Pro, but should have sprayed 1st generation larvae earlier.
Sackett Ranch Field VG1-2-7 Summer adults were collected on 12 July 2010 from a commercial potato field in southeast Edmore, Montcalm County; adults migrated in from potato volunteers from field VG3-4 corn. There has been no beetle pressure in this area for years and years.
St. Joseph Summer adults were collected by Karl Ritchie, Walther Farms on 13 July 2010 from a commercial potato field in St. Joseph County.
Sturgis Summer adults were collected in August from a commercial potato field near Sturgis, St. Joseph County.
Tuscola Summer adults were collected on 20 July 2010 from a commercial potato field in Tuscola County.
Out-of-state populations
Bridgewater, Maine Overwintered adults were collected in June 2010 by Andrei Alyokhin, University of Maine, from a commercial potato field near Bridgewater, ME.
Fryeburg, Maine Overwintered adults were collected on 2 June 2010 by Andrei Alyokhin, University of Maine, from a commercial potato field near Fryeburg, ME.
Jamesport, New York Overwintered adults were collected on 2 June 2010 by Sandra Menasha, Cornell Cooperative Extension, from a commercial potato field in Suffolk County, NY.
New Church, Virginia Overwintered adults were collected on 13 May 2010 by Tom Kuhar, Virginia Polytechnic Institute and State Universiy, from a commercial potato field near New Church, VA.
Painter, Virginia Summer adults were collected on 14 June 2010 by Tom Kuhar, Virginia Polytechnic Institute and State Universiy, from a commercial potato field in Painter, VA
Laboratory strain
New Jersey Adults obtained in 2008 from the Phillip Alampi Beneficial Insects Rearing Laboratory, New Jersey Department of Agriculture and since reared at Michigan State University without contact to insecticides.

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Table 3. LD_{50} values (µg/beetle) and 95% fiducial limits for Colorado potato beetle populations treated with imidacloprid and thiamethoxam at 7 days post treatment.

IMIDACLOPRID	**LD_{50} (µg/beetle)**	**95% Confidence Intervals**
Michigan populations		
Montcalm	1.909	1.530 – 2.789
Paul Main H6	4.394	2.966 – 10.234
Paul Main R13	2.495	*
Sackett Potatoes 14	2.998	1.810 – 468.790
Sackett Potatoes 132	3.137	2.459 – 4.549
Sackett Potatoes 152-153	3.141	1.625 – 12.937
Sackett Ranch VG1-2-7	1.573	1.324 – 1.898
St. Joseph	N/A	[lowest dose (0.3) had 100% mortality]
Sturgis	0.275	0.241 – 0.312
Tuscola	12.738	*
Out-of-state populations		
Bridgewater, Maine	0.428	0.136 – 0.647
Fryeburg, Maine	3.523	2.832 – 4.668
Jamesport, New York	20.428	*
Painter, Virginia	0.104	0.081 – 0.132
Laboratory strain		
New Jersey	0.208	0.166 – 0.288
THIAMETHOXAM		
Michigan populations		
Montcalm	3.248	1.552 – 411.562
Paul Main H6	0.872	0.753 – 1.014
Paul Main R13	0.671	0.321 – 262.123
Sackett Potatoes 14	0.960	0.670 – 4.686
Sackett Potatoes 132	0.859	0.498 – 2.478
Sackett Potatoes 152-153	0.691	0.608 – 0.780
Sackett Ranch VG1-2-7	0.773	0.687 – 0.871
St. Joseph	0.152	0.122 – 0.180
Sturgis	0.253	0.174 – 0.347
Tuscola	1.304	1.038 – 1.956
Out-of-state populations		
Bridgewater, Maine	0.134	0.087 – 0.177
Fryeburg, Maine	0.730	0.324 – 1.281
Jamesport, New York	1.152	1.011 – 1.324
New Church, Virginia	0.884	*
Laboratory strain		
New Jersey	0.112	0.098 – 0.130

* no confidence limits calculated due to insufficient fit to the model

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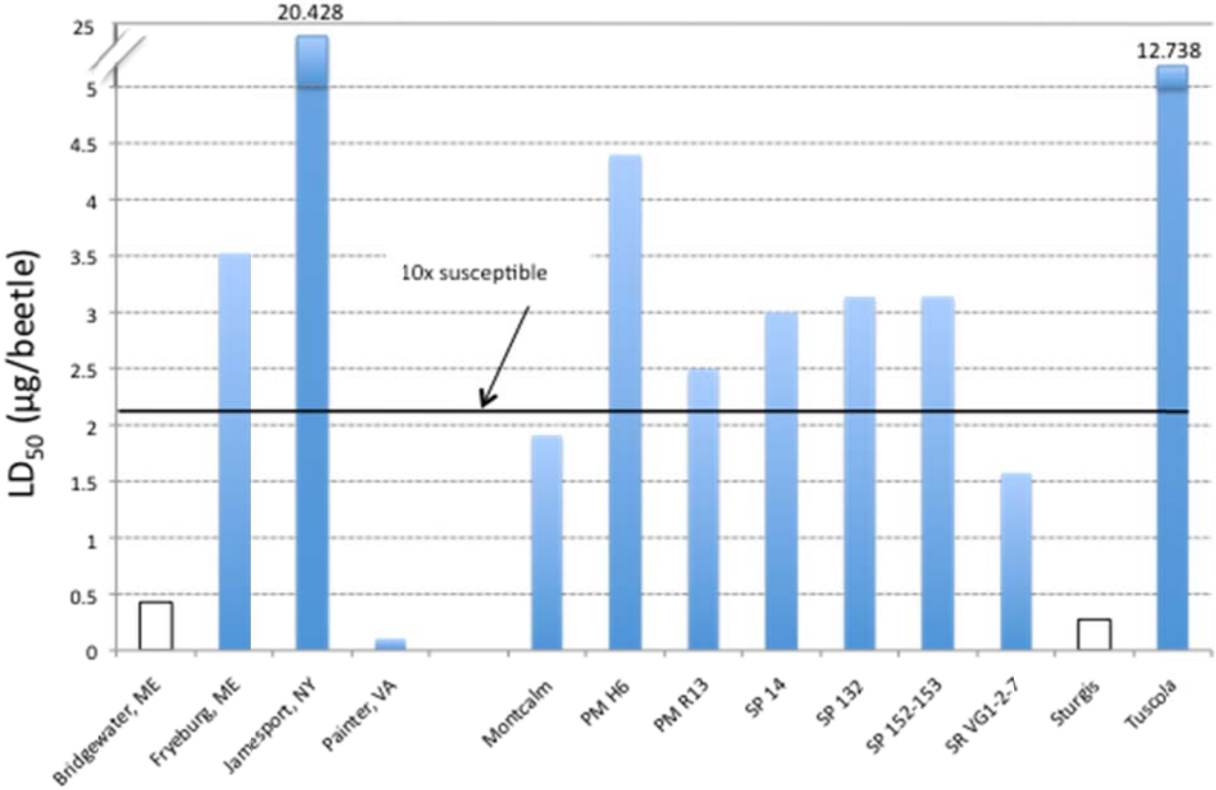

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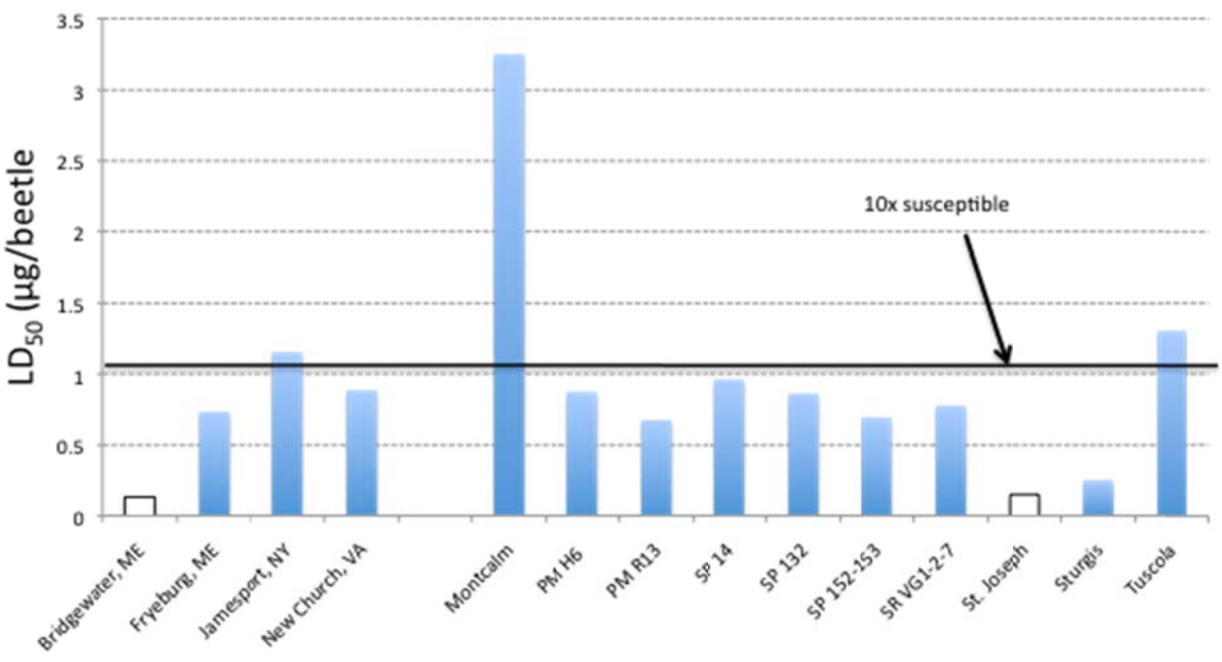

Figure 1. Susceptibility of field populations of Colorado potato beetle to imidacloprid (A) and thiamethoxam (B). Dark bars represent populations that had significantly greater LD_{50} values compared to the susceptible strain.

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Evaluation of fungicide programs for potato early blight, brown leaf spot and tan spot control: 2010.

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Potatoes (cut seed, treated with Maxim FS at 0.16 fl oz/cwt) were planted at Michigan State University Horticultural Experimental Station, Clarksville, MI (Capac loam soil); 42.8733, -85.2604 deg; elevation 895 ft. on 21 May into two-row by 20-ft plots (ca. 10-in between plants to give a target population of 50 plants at 34-in row spacing) replicated four times in a randomized complete block design. Plots were irrigated as needed with sprinklers and were hilled immediately before sprays began. All fungicides in this trial were applied on a 7-day interval from 23 Jun to 17 Aug (8 applications) with an ATV rear-mounted R&D spray boom calibrated to deliver 25 gal/A (80 p.s.i.) using three XR11003VS nozzles per row. Potato late blight was prevented from movement into the plots from adjacent plots inoculated with *Phytophthora infestans* with weekly applications of Previcur Flex at 1.2 pt/A from early canopy closure on 2 Jul to 24 Aug. Weeds were controlled by hilling and with Dual 8E (2 pt/A on 3 Jun), Basagran (2 pt/A on 28 Jun and 11 Jul) and Poast (1.5 pt/A on 11 Jul). Insects were controlled with Admire 2F (20 fl oz/A at planting), Sevin 80S (1.25 lb/A on 11 and 25 Jul), Thiodan 3EC (2.33 pt/A on 1 and 21 Aug) and Pounce 3.2EC (8 oz/A on 11 Jul). Plots were rated visually for combined percentage foliar area affected by early blight and brown leaf spot on 1 Sep [15days after final application (DAFA)]; and Botrytis tan spot on 1 Sep. Vines were killed with Reglone 2EC (1 pt/A on 6 Sep). Plots (2 x 25-ft row) were harvested on 5 Oct and tubers from individual treatments were weighed and graded. Meteorological variables were measured with a Campbell weather station located at the farm from 1 May to harvest (5 Oct). Maximum, minimum and average daily air temperature (^{o}F) were 89.4, 28.8 and 59.7 (May); 86.3, 45.4 and 66.9 (Jun); 90.2, 46.4 and 73.1 and 1-d with maximum temperature >90^{o}F (Jul); 90.6, 46.8 and 71.9 and 2-d with maximum temperature >90^{o}F (Aug); 85.7, 40.2 and 60.1 (Sep); 85.7, 31.0 and 53.4 (to 5 Oct). Maximum, minimum and average relative humidity (%) was 93, 43 and 65 (May); 91, 55 and 73 (Jun); 91, 61 and 81 (Jul); 98, 34 and 72 (Aug); 99, 31 and 73 (Sep); 99, 19 and 69 (to 5 Oct). Maximum, minimum and average daily soil temperature (^{o}F) were 77.8, 53.1 and 66.5 (May); 89.2, 54.6 and 74.0 (Jun); 94.5, 59.8 and 76.7 (Jul); 89.2, 65.2 and 78.5 (Aug); 86.9, 65.7 and 76.8 (Sep); 78.2, 56.6 and 64.9 (to 5 Oct). Maximum, minimum and average soil moisture (% of field capacity) was 38.4, 28.8 and 31.7 (May); 39.9, 32.3 and 34.7 (Jun); 38.6, 34.1 and 35.4 (Jul); 39.5, 32.9 and 35.2 (Aug); 42.0, 31.3 and 34.5 (Sep) and 42.0, 33.4 and 34.2 (to 5 Oct). Precipitation was 3.82 in. (May), 4.48 in. (Jun), 4.33 in. (Jul), 1.4 in (Aug), 5.14 in. (Sep) and 0.7 in. (to 5 Oct). Plots were irrigated to supplement precipitation to about 0.1 in./A/4 day period with overhead sprinkle irrigation. Early blight severity values accumulated from planting to 1 Sep (evaluation date) were 3475.

Weather conditions were conducive for the development of early blight and brown leaf spot and Botrytis tan spot. Early blight and brown leaf spot developed steadily during Aug and untreated controls reached about 46% foliar infection by 1 Sep. All treatments had significantly less combined early blight and brown leaf spot than the untreated control. All fungicide programs had significantly less foliar tan spot values than the untreated control (36.3%). Treatments with greater than US1 yield of 178 cwt/A and total yield of 310 cwt/A were significantly different from the untreated control. Phytotoxicity was not noted in any of the treatments.

Table 1. Efficacy of fungicide programs against foliar leaf spots of potatoes

Treatment and rate/A	Foliar Early Blight + Brown Leaf Spot (%) 1 Sep 15 (DAFA[z])		Foliar Botrytis Tan Spot (%) 1 Sep (15 DAFA)		Yield (cwt/A) US1		Yield (cwt/A) Total	
Dithane Rainshield 75DF 2 lb (A,D[y]); Reason 500SC 4 fl oz + Dithane Rainshield 75DF 2 lb (B); Scala 606SC 7 fl oz + Dithane Rainshield 75DF 2 lb (C,E,F)..	6.3	bc[x]	1.3	d	188	abc	286	abc
LEM17 200EC 12 fl oz (A,C,E,G,I); Tanos 50WG 6 oz + Manzate 75WG 1.5 lb (B,D,F,H,I)……..	5.0	c	5.0	bc	220	a	331	a
LEM17 200EC 16 fl oz (A,C,E,G,I); Tanos 50WG 6 oz + Manzate 75WG 1.5 lb (B,D,F,H,I)……..	6.3	bc	5.5	bc	215	ab	333	a
LEM17 200EC 24 fl oz (A,C,E,G,I); Tanos 50WG 6 oz + Manzate 75WG 1.5 lb (B,D,F,H,I)……..	6.3	bc	3.0	cd	164	cd	234	c
Endura 7WG 2.5 oz (A,C,E,G,I); Tanos 50WG 6 oz + Manzate 75WG 1.5 lb (B,D,F,H,)……...	6.3	bc	5.3	bc	173	bcd	259	bc
Echo ZN 4.17SC 2.12 pt (A,C,E,I); Endura 7WG 6 oz + Echo ZN 4.17SC 1.5 pt (B,F); Headline 2.09EC 2.5 oz + Echo ZN 4.17SC 1.5 pt (D); Dithane Rainshield 75DF 2 lb + Super Tin 80WP 2.5 oz (G,H)………………………………...	6.0	bc	5.0	bc	178	a-d	297	ab
Echo ZN 4.17SC 2.12 pt (A,C,E,I); BAS703 01F 4.17SC 4.1 fl oz + Echo ZN 4.17SC 1.5 pt (B,D,F); Dithane Rainshield 75DF 2 lb + Super Tin 80WP 2.5 oz (G,H)………………………………...	5.0	c	3.0	cd	175	bcd	296	ab
SA-0011401 50SC 2.8 pt (A-I)……………………………….	5.0	c	1.3	d	219	a	317	a
SA-0011401 50SC 2.1 pt (A-I)……………………………….	10.0	b	7.5	b	197	abc	308	ab
Echo ZN 4.17SC 2 pt (A,C,E,I); Luna 500SC 6.84 fl oz (B,D,F); Dithane Rainshield 75DF 2 lb + Super Tin 80WP 2.5 oz (G,H)………………………………...	5.0	c	7.5	b	188	abc	310	ab
Untreated…………………………………………………...	46.3	a	23.8	a	142	d	261	bc
$LSD_{0.05}$	4.18		3.42		42.7		55.0	

[z] Days after final application of fungicide.
[y] Application dates: A= 23 Jun; B= 30 Jun; C= 7 Jul; D= 14 Jul; E= 21 Jul; F= 28 Jul; G= 4 Aug; H= 11 Aug; I= 17 Aug.
[x] Values followed by the same letter are not significantly different at $p = 0.05$ (Fishers LSD).

Population characterization of *P. infestans* in Michigan during 2008 to 2010

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Introduction

Phytophthora infestans (Mont.) de Bary, the causal agent of potato late blight is still a devastating pathogen even after 150 years since the Irish potato famine. Late blight mainly affects potato foliage, but can also significantly affect the tubers and indeed the tubers play a major role in the disease cycle of this pathogen. Potato late blight threatens potato production worldwide, which represents around 323 million tones, equivalent to 40 billion dollars of world production (FAO, 2008). The disease appears year after year causing from low effects to important epidemics like late blight epidemic in eastern USA in 2009. In Michigan, growers rate late blight as the most important disease of the potato crop (Zsofia Szendrei, pers. comm.) with a total planted area of 18,000 ha.

Late blight is considered a re-emergent disease and its causal agent has been broadly studied to understand the infection process at different levels in order to develop effective management of the disease. Population analyses have become more important as aids to understanding the epidemiology, disease progression and the biology of the pathogen and have generally indicated that the population is volatile. In order to characterize the population, different tests based on phenotypic and genotypic traits, such as allelozymes, fungicide resistance, foliar virulence, nuclear DNA fingerprinting, mitochondrial haplotype (Fry, 2008) have contributed to understanding the dynamics of this pathogen.

The complex genetics of *Phytophthora infestans* limited the applicability of these techniques because of their reduced resolution that lead to the underestimation of the variability of the population, thus the requirement of multiple traits or markers to overcome this issue (Fry and Goodwin, 1997). Although, other approaches should be considered to effectively track the population dynamics, single sequence repeats (SSR) have been successfully used to monitor late blight populations in Europe and China (Guo *et al.*, 2009, Knapova and Gisi, 2002). SSR are powerful genetic markers, which are used to analyze population structure over time, in this case in epidemiological framework. In this study, we propose to use SSR as genetic markers to monitor *Phytophthora infestans* outbreaks through Michigan in conjunction with classical methods such as isozyme profile, virulence, mating type, among others (Cooke and Lees, 2004).

Methods

Isolate sources and maintenance

Isolates were recovered from infected leaves, stems, fruits and tubers with visible symptoms of late blight from potato and tomato producing regions in Michigan during 2009 and 2010. The samples were from commercial fields, home gardens or research plots. Samples were place in plastic bags and stored at low temperature before processing. Isolates were obtained from fresh sporangia produced on the tissue and transferred to Rye B media (Caten and Jinks, 1968) amended with ampicillin (100 mg/ml), nystatin (100 mg/ml), rifampicin (50 mg/ml). If the tissue did not present sporulation, it was placed in a humid chamber at 18˚C for 24 to 72 hours to induce sporulation. Plates were incubated in the dark at 18˚C until mycelia was observed. Hyphal tipping or single spore was assessed in clean cultures, if contamination was observed, transfers were made on clean-up media (Forbes, 1997). After isolation, cultures were grown and maintained on rye media.

Mating type determination

Mating type was determined in V8 agar transferring 5mm mycelial plugs of the unknown isolates and reference isolates A1 and A2 mating type. The plugs were placed 4 cm apart from each other. The plates were incubated at 18 ˚C for 14 days and evaluated for the presence or absence of oospores in the contact interface between the isolates and reference strains. Three replications were made for isolate.

Isozyme analysis

Genotype was established by isozyme analysis at glucose–6–phosphate isomerase (GPI) locus. Cellulose acetate gel electrophoresis (Helena Laboratories, Beaumont, TX) was done as reported by Goodwin *et al.* (Goodwin *et al.*, 1995), resolving by overlay. Proteins were extracted from either fresh sporangia on leaf lesion or 10 days old pure cultures by grinding in sterile distilled water. Supernatants were recovered by centrifugation and stored at –20 ˚C prior to use. Five control isolates were used, representing the genotypes US–1, US–8, US-10, US–11 and US-14.

Sensitivity metalaxyl

Isolates sensitivity to the phenylamide fungicide metalaxyl was determined by transfer of mycelial plugs (5 mm diameter) into rye media amended with 0, 0.1, 1, 5, 10, 100 mg/L of active ingredient of metalaxyl fungicide (Ridomil Gold SL; Syngenta Crop Protection, Inc., Greensboro, NC). Plates were incubated at dark at 18 ˚C. Three replications were made for each isolate. Colony diameter were measured at 7, 10, 14 days after inoculation. Isolates were sensitive, intermediate, and resistance if the growth was < 10, 10 – 60, >60 % in comparison to control plate (Shattock, 1988). In addition, relative growth of each isolate (defined as isolate growth divided by growth of the non–amended control) was plotted against the log10 of the metalaxyl concentration. The effective concentration (EC50) for each isolate was calculated by regression analysis. The point on the regression line at which 50% of the isolate growth was inhibited is the EC50 value. Statistical analysis was conducted with the JMP program version 7.0 (SAS Institute Inc., SAS Campus Drive, Cary, North Carolina 27513, USA).

Virulence test

Each isolate was challenged against a R-gene differential set of potato clones, each carrying a single resistance gene (R1 – R11), in order to determine virulence and race of *P. infestans* isolates (Malcolmson and Black, 1966). Four detached leaflets of each differential were placed abaxial side up in moist chambers and inoculated with 20 µL of sporangial suspension (aprox. 20 000 sporangia mL^{-1}) of each isolate. The leaflets were incubated in growth chambers at 18 ˚C, 85% relative humidity and 14 h light. Seven days after inoculation, leaflets were evaluated for presence of sporulation and rated as compatible or incompatible (Flier and Turkensteen, 1999).

Tuber pathogenicity

Tuber late blight was assessed for all *P. infestans* isolates on the variety Red Northland. All tubers were washed in distilled H_2O to remove soil. The tubers were then surface sterilized by soaking in 2% sodium hypochlorite solution for 30 min. Tubers were dried at room temperature. The washed, surface-sterilized tubers were inoculated by a insertion of mycelial plug (5 mm diameter) at the apical end of the tuber about 1 cm maximum depth. Fiver tubers were inoculated with each *P. infestans* isolates and five control tubers were inoculated with non-inoculated rye media. After inoculation, tubers were placed in the dark in sterilized covered plastic crates and returned to controlled environment chambers [Percival Incubator (Model I-36LLVL, Geneva Scientific, LLC, PO Box 408, Fontana, WI)]. The chambers were set at 10^oC and 95% humidity and the sample tubers were incubated for 30 days until evaluation.

A digital image analysis technique was used to assess tuber tissue infection. The method was previously used and standardized (Kirk *et al.*, 2001, Kirk *et al.*, 1999). The image files were analyzed using SigmaScan V3.0 (Jandel Scientific, San Rafael, CA). The area selection cut-off threshold was set to 40 light intensity units, limiting the determination to the non–dark parts of the image. The average reflective intensity (ARI) of all the pixels within the image gave a measurement of infection severity of the tuber tissue of each sample. The ARI was measured in sections from the apical, middle and basal regions of the tuber. The amount of late blight infected tissue per tuber was expressed as a single value (Mean ARI) calculated as the average ARI of the apical, middle and basal sections evaluated 30 days after inoculation (DAI).

The severity of tuber tissue infection was expressed relative to the ARI (described above) of the control tubers for each cultivar/ABL. The relative ARI (RARI) has minimum value of zero (no symptoms) and maximum value of hundred (completely dark tuber surface). Data for all experiments were analyzed by analysis of variance (least squares method) using the JMP program version 7.0 (SAS Institute Inc., SAS Campus Drive, Cary, North Carolina 27513, USA).

DNA extraction

Isolates were grown for 10 to 14 days at 18°C in clear pea broth or V8 broth (Forbes, 1997). The mycelium was filtered, lyophilized, and ground with a mortar and pestle. DNA was extracted according to method of Goodwin *et al.* (1992). DNA concentration and purity were estimated using a NanoDrop® ND-3300 fluorometer (NanoDrop Technologies, Wilmington, DE, USA).

Mitochondrial haplotype

Mitochondrial (mtDNA) haplotypes were determined by RFLP–PCR (Griffith and Shaw, 1998). All isolates were analyzed for mitochondrial haplotypes using the following primer pairs for specific mitochondrial DNA regions: P2 and P4, using the primers P2F 5′-TTCCCTTTGTCCTCTACCGAT-3′, P2R 5′-TTACGGCGGTTTAGCACATACA-3′, P4F 5′-TGGTCATCCAGAGGTTTATGTT-3′ and P4R 5′-CCGATACCGATACCAGCACCAA-3′, respectively. PCR was carried out as follows for all primer combinations in a final volume of 25 µl: 1× PCR buffer, 0.5 mM dNTPs (each), 2.5 mM MgCl2, 0.2 mM each primer, and 0.2 µl of *Taq* DNA polymerase (5 U/µl). The PCR conditions were 1 cycle of 94°C for 4 min and 35 cycles of 94°C for 60 s, 60°C for 45 s, and 72°C for 120 s. PCR products for region P2 and P4 were digested with the restriction enzymes *Msp*I and *Eco*RI, respectively. The digestion products were separated on 2% agarose gels and visualized by staining with ethidium bromide (Griffith and Shaw, 1998).

Microsatellite Analysis

Eight polymorphic microsatellite loci were chosen for analysis. Markers used were Pi4B, Pi4G and PiG11 (Knapova and Gisi, 2002) and Pi04, Pi16, Pi33, Pi56 and Pi70 (Lees *et al.*, 2006), sequences are given in table 1. Microsatellite polymerase reactions were performed in a 25-µl reaction volumes. Each reaction tube contained 1× PCR buffer; 0.2 mM (each) of dNTPs, 1 mM MgCl2, 0.2 mM each forward and reverse primers, and 0.2 µl of Taq (5 U/ml). The thermal cycling parameters were initial denaturation at 94°C for 2 min followed by 35 cycles consisting of denaturation at 94°C for 1 min, annealing at 56°C for 45 s, and extension at 72°C for 2 min. A final extension at 72°C for 7 min was done at the end of the amplification. PCR products were examined by agarose gel electrophoresis using 3% (wt/vol) Metaphor agarose (FMC, Rockland, Maine), containing 0.5 µg/mL ethidium bromide, and the remainder was stored at 4 ˚C for later use. The electrophoretic buffer was 0.5X TBE (89 mmol/L Tris–HCl, pH 7.8; 89 mmol/L boric acid, 2 mmol/L EDTA). After electrophoresis at 98 V for 1.5 h, the image was acquired using the Bio-Rad ChemiDoc XRS imaging system (Bio-Rad, Hercules, CA, USA).

Results and Discussion

Sample collection

From 2008 to 2010, potato and tomato symptomatic samples were obtained from growers of different regions of Michigan (Figure 1). A total of 115 isolates were obtained, most of them isolated from blighted stems and foliage, but a few isolates were isolated directly from blighted tubers. Samples from Alaska and Idaho were also obtained and few isolates were isolated to be included in the study as reference isolates. Both samples were blighted potato leaves and tubers. However, for analysis purposes the isolates were divided in two groups: (i) Isolates obtained from 2008 to 2009 and (ii) isolates obtained during 2010.

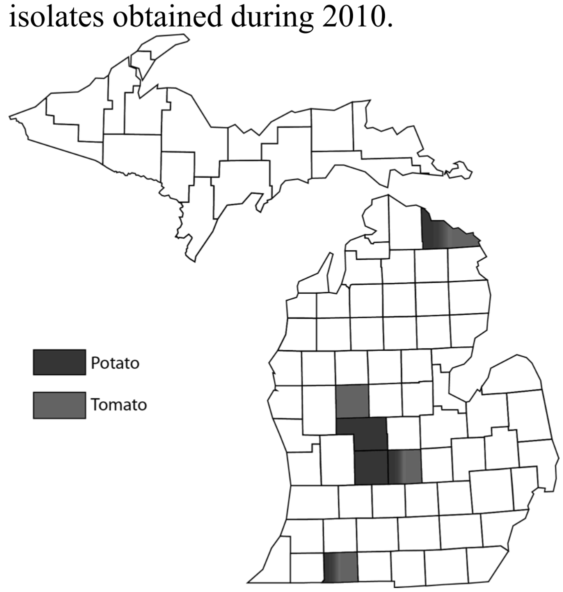

Figure 1. Locations of fields from which isolates of *Phytophthora infestans* were obtained between 2008 - 2010.

Mating type and sensitivity to Metalaxyl

Isolates were evaluated for mating type by two means: oospore production by testing with mating type reference isolates and molecular standard assay of the cleaved amplified region described by Judelson *et al.* (1995). Only one isolate was identified as A1, and it was isolated from tomato; the rest of the population is A2, which is the common mating type in US in the recent years.

Metalaxyl *in vitro* assays on amended media showed different proportions for sensitive, intermediate and resistance isolates from 2008 to 2010. The distribution of isolates for both periods shows a transition from susceptible isolates in 2008-09 to a more homogeneous distribution 2010. In 2008-09, the EC50 values ranged from <0.1 to 52 μg/mL, where 26% of the isolates corresponded to susceptible, 61% were intermediate and 11% were resistant. For 2010, the EC50 values ranged from <0.1 to 91 μg/mL, 45% of the isolates corresponded to sensitive, 50% were classified as intermediate and 4% were resistant (Figure 2a). There is not significant difference between the observed frequencies for both periods, but there is a trend for metalaxyl responses in the population (Figure 2b). There was no association with host or location for metalaxyl resistance. However, 2 out 6 counties had resistant isolates in low frequencies. The rest of isolates from all the counties were sensitive to intermediate to metalaxyl.

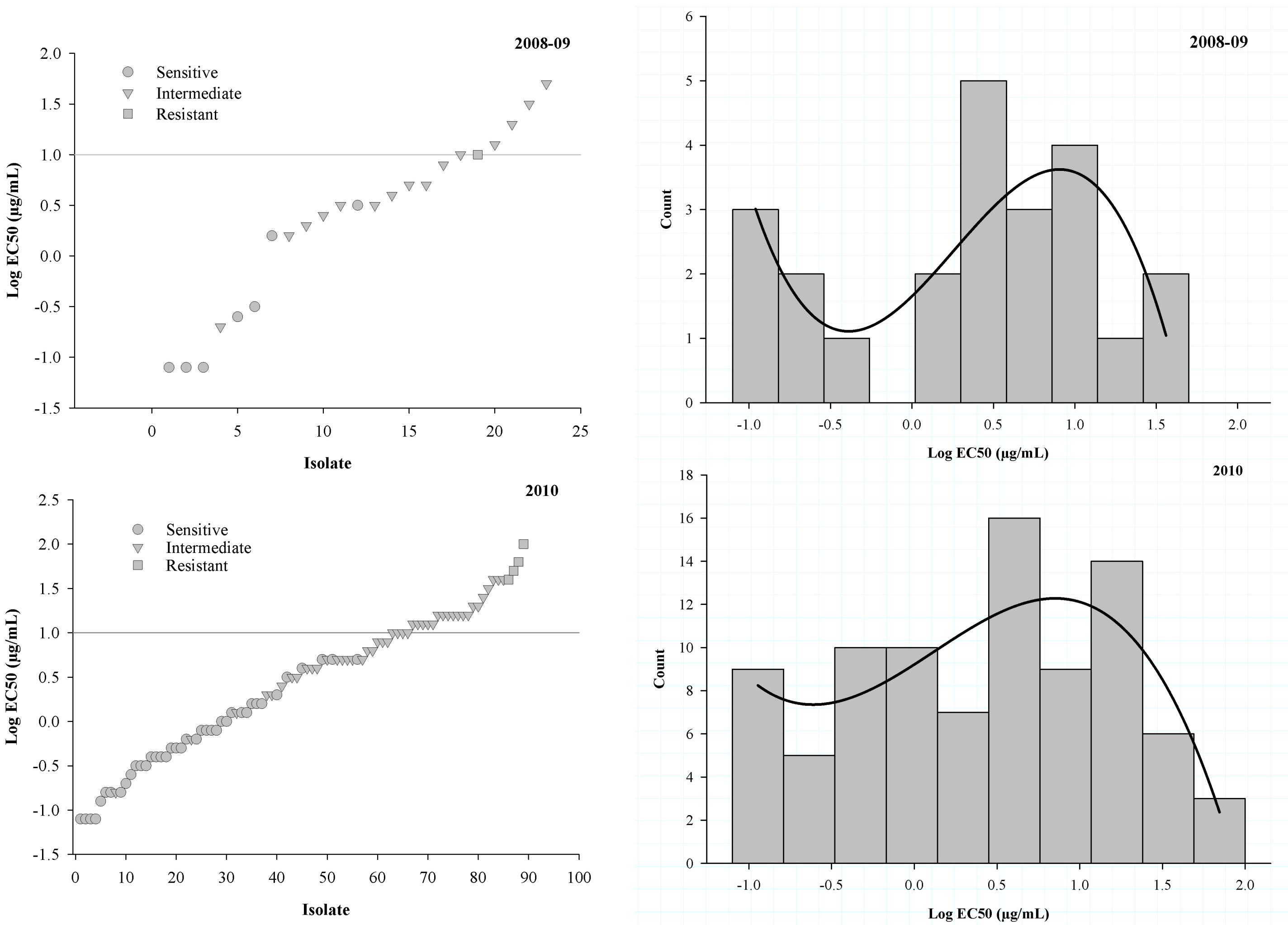

Figure 2. (a) Range of EC50 (µg/mL) obtained during 2008-09 and 2010. (b) Histogram of log-EC50 (µg/mL) of populations of *P. infestans* during 2008-09 and 2010. Trend lines were plotted as regression analysis using polynomial equations.

Mitochondrial haplotype and isozyme analysis

Two isozyme profiles, including 100/100/111 and 100/122 were found during the study for the GPI locus. However, clonal lineage US-8 and the new clonal lineage US-22 share bands in their profiles that can be misread during the analysis. The traditional US-8 profile was described as 100/111/122 is characterized by a five-band pattern, but it has been shown US-8 isolates that reduces to a three-band pattern by asexual variation. US-14 clonal lineage also possesses a three-band profile, resulting in 100/122. All isolates from 2010 were reported as 100/122, but it is necessary to fully review this result in conjunction with other markers.

Mitochondrial DNA haplotypes Ia and IIa were found, but the most frequent haplotype was Ia (Figure 3). The mitochondrial haplotype Ia was the original mitochondrial haplotype found during Irish potato famine and it has been the common in the US.

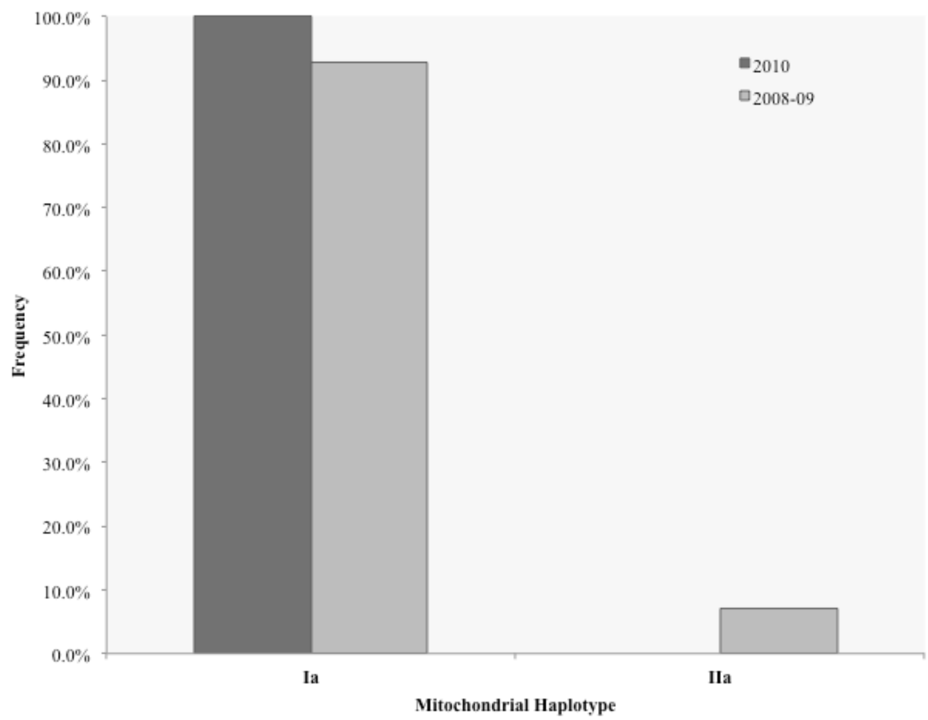

Figure 3. Mitochondrial haplotypes of *P. infestans* isolates in Michigan during 2008 to 2010.

Virulence and Tuber Pathogenicity

The virulence profile for the different isolates shows that at least every single R gene is present in the population in different frequencies. However, the existence of multiple combinations of this gene in one pathogen, denominated as a complex race, suggest the presence of isolates that can easily overcome resistance in the field. Isolates bearing 1 to 4 resistant genes were frequently isolated. The most frequent differentials were R3, R5 and R10 with frequencies close to 30% in the population. Late blight differential 9 was low, which is considered one the highly resistant genotypes.

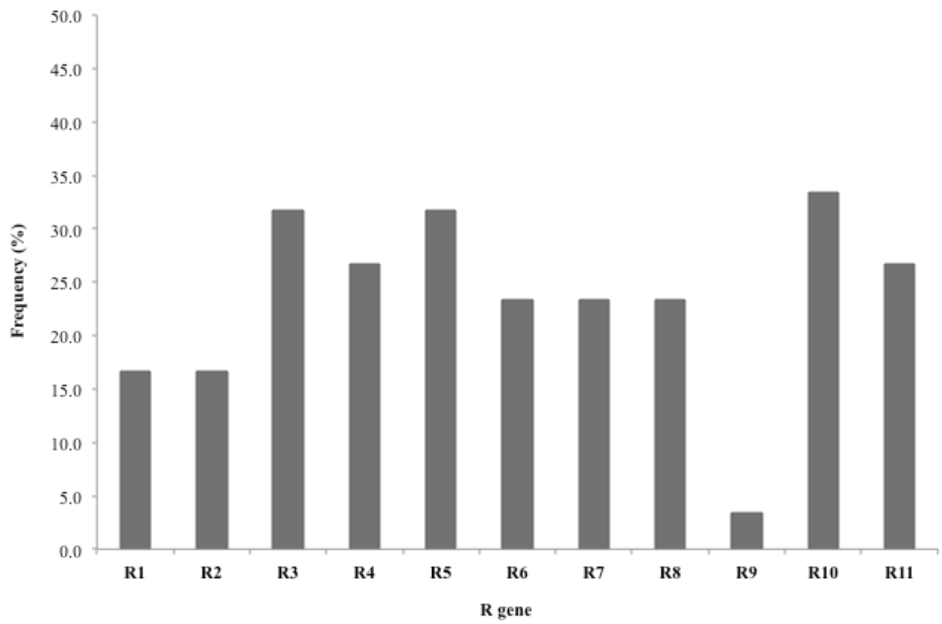

Figure 4. Frequency of virulence for resistance genes in *P. infestans* isolates.

On the other hand, potato pathogenicity among isolates from both periods evaluated ranged from low to moderate pathogenicity. Most of the isolates Relative Area Reflective Index (RARI) ranged form 5 to 30%. Either potato and tomato isolates were moderately pathogenic in tubers, showing values more than 20% RARI. Most isolates from 2010 that have been classified as US-22 clonal lineage showed variable tuber pathogenicity, but it is important to remark that many of them were isolated from tomato samples.

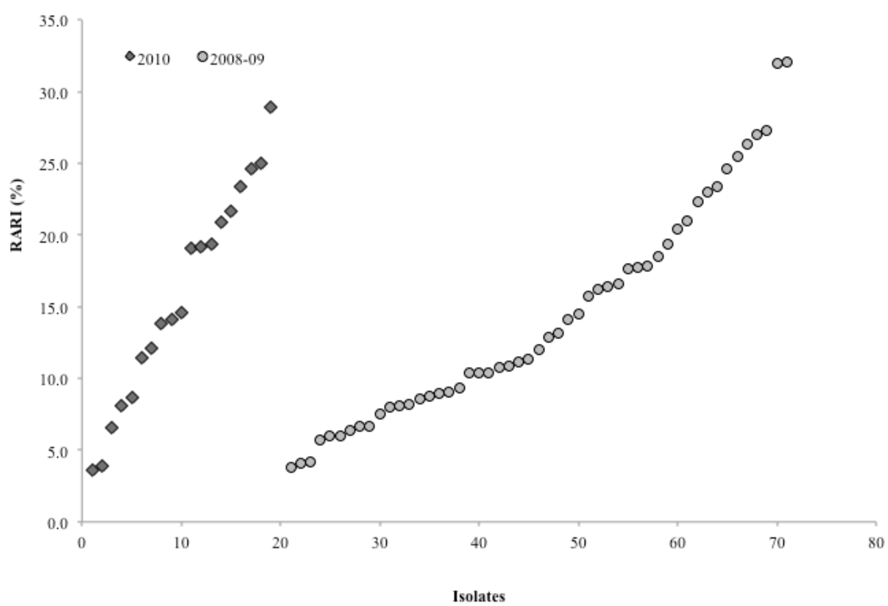

Figure 5. Aggressiveness of different isolates of *P. infestans* collected during 2008 to 2010 tested in susceptible tubers cv. Red Norland. (RARI: Relative Area of Reflection Index).

Microsatellite

Microsatellite or Single-Sequence Repeats (SSR) have recently been used to characterize *P. infestans* populations in Asia and Europe showing a diverse population, which could be suggested as a result of sexual recombination (Gisi *et al.*, 2010, Guo *et al.*, 2009). The application of this molecular markers in Michigan populations could give us an insight of how *P. infestans* populations in Michigan are behaving and also associate this markers to other traits relevant for epidemiology, such as pathogenicity or fungicide resistance.

One of the markers that has been evaluated, The SSR G11 have shown the variability of the recent isolates obtained of *P. infestans*, where 'old' potato isolates just had one allele (160) and tomato isolates two alleles (160 and 156). The new clonal lineage US-22 was also characterized by the presence of these two alleles. Isolates collected in 2010 either from tomato or potato bore the two alleles, showing the shift in the population to new genotypes; only isolates from St. John (South West Michigan) showed the 160 allele. Other SSRs are under analysis to further characterize the composition of Michigan *P. infestans* populations.

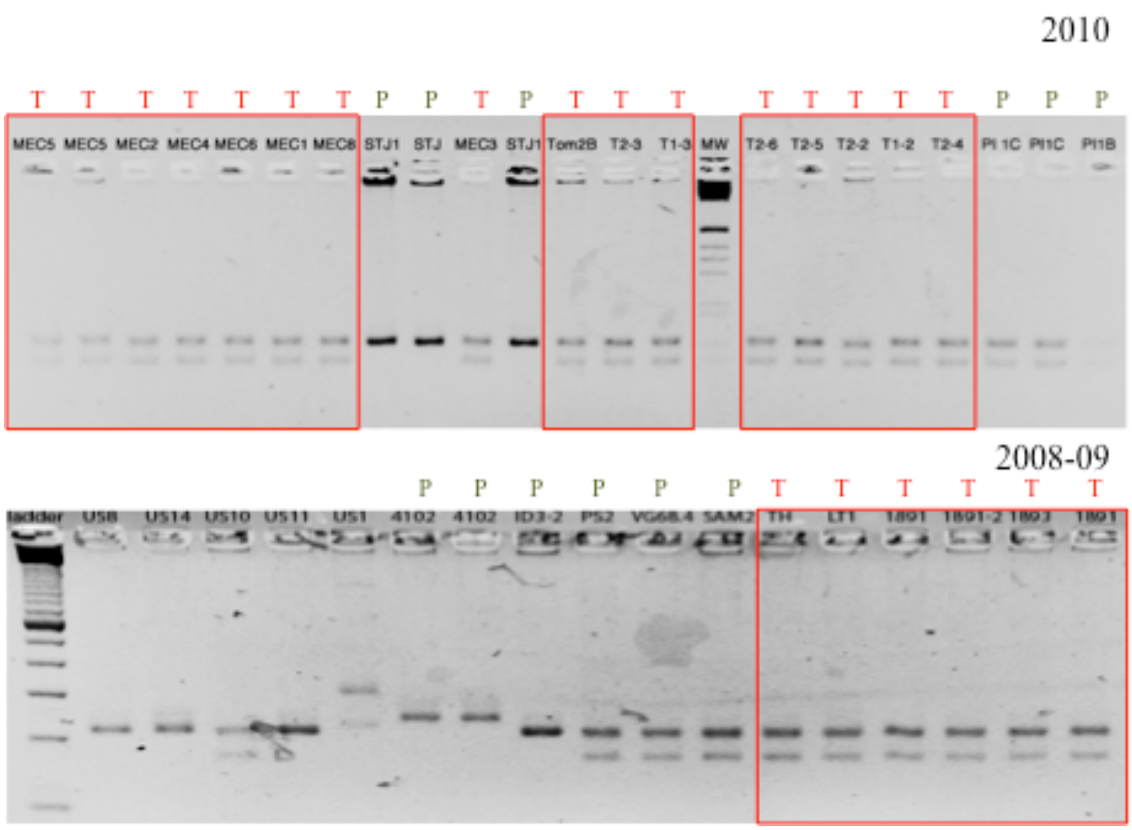

Figure 6. Single-sequence repeat genotyping of *P. infestans* isolates from Michigan during 2008 to 2010 using G11 marker.

Conclusion

Late blight caused by *P. infestans* have shown to be a devastating disease over the last decades, this is mainly caused by the ability of this pathogen to rapid evolve and overcome the different management strategies used in the field, such as fungicides and resistant varieties. Therefore, population studies are required to further characterize isolates affecting a specific region, in order to develop effective solutions and trace how rapidly the pathogen is changing. New methodologies like SSRs have being applied in epidemiology to trace the origin of different isolates. Nonetheless, the fitness of the pathogen is important because it will determine if a specific genotype will remain in the population or not. For that reason, it is also important consider aggressiveness and pathogenicity of new clonal lineages because they can be related to specific markers, like SSRs, that can result in baseline evidence to analyze changes in the future epidemics.

References

Caten, C. & Jinks, J. (1968) Spontaneous variability of single isolates of *Phytophthora infestans*. I. Cultural variation. *Can. J. Bot,* **46:**329-348.

Cooke, D. & Lees, A. (2004) Markers, old and new, for examining *Phytophthora infestans* diversity. *Plant Pathol.,* **53:**692-704.

FAO. Food and Agriculture Organization of the United Nations. FAOSTAT database. In., 2008.

Flier, W. & Turkensteen, L. (1999) Foliar aggressiveness of *Phytophthora infestans* in three potato growing regions in the Netherlands. *Eur. J. Plant Pathol.,* **105:**381-388.

Forbes, G. Manual for laboratory work on *Phytophthora infestans*, 1997.

Fry, W. (2008) *Phytophthora infestans*: the plant (and R gene) destroyer. *Mol. Plant Pathol.,* **9:**385-402.

Fry, W. & Goodwin, S. (1997) Re-emergence of potato and tomato late blight in the United States. *Plant Dis.,* **81:**1349-1357.

Gisi, U., Walder, F., Resheat-Eini, Z., Edel, D. & Sierotzki, H. (2010) Changes of Genotype, Sensitivity and Aggressiveness in *Phytophthora infestans* Isolates Collected in European Countries in 1997, 2006 and 2007. *J. Phytopathol.***:**no-no.

Goodwin, S., Schneider, R. & Fry, W. (1995) Use of cellulose-acetate electrophoresis for rapid identification of allozyme genotypes of *Phytophthora infestans*. *Plant Dis.,* **79:**1181-1185.

Griffith, G. & Shaw, D. (1998) Polymorphisms in *Phytophthora infestans*: Four mitochondrial haplotypes are detected after PCR amplification of DNA from pure cultures or from host lesions. *Appl. Environ. Microbiol.,* **64:**4007-4014.

Guo, J., van der Lee, T., Qu, D., Yao, Y., Gong, X*., et al.* (2009) *Phytophthora infestans* isolates from Northern China show high virulence diversity but low genotypic diversity. *Plant Biol.,* **11:**57-67.

Judelson, H. S., Spielman, L. J. & Shattock, R. C. (1995) Genetic mapping and non-Mendelian segregation of mating type loci in the oomycete, *Phytophthora infestans*. *Genetics,* **141:**503-512.

Kirk, W., Niemira, B. & Stein, J. (2001) Influence of storage temperature on rate of potato tuber tissue infection caused by *Phytophthora infestans* (Mont.) de Bary estimated by digital image analysis. *Pot. Res.,* **44:**87-96.

Kirk, W. W., Niemira, B. A., Stein, J. M. & Hammerschmidt, R. (1999) Late blight (*Phytophthora infestans* (Mont) De Bary) development from potato seed-pieces treated with fungicides. *Pestic. Sci.,* **55:**1151-1158.

Knapova, G. & Gisi, U. (2002) Phenotypic and genotypic structure of *Phytophthora infestans* populations on potato and tomato in France and Switzerland. *Plant Pathol.,* **51:**641-653.

Lees, A., Wattier, R., Shaw, D., Sullivan, L., Williams, N.*, et al.* (2006) Novel microsatellite markers for the analysis of *Phytophthora infestans* populations. *Plant Pathol.,* **55:**311-319.

Malcolmson, J. & Black, W. (1966) New R genes in *Solanum demissum* lindl. and their complementary races of *Phytophthora infestans* (Mont.) de Bary. *Euphytica,* **15:**199-203.

Shattock, R. (1988) Studies on the inheritance of resistance to metalaxyl in *Phytophthora infestans*. *Plant Pathol.,* **37:**4-11.

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Evaluation of fungicide programs for potato late blight control: 2010.

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Potatoes (cut seed, treated with Maxim FS at 0.16 fl oz/cwt) were planted at Michigan State University Horticultural Experimental Station, Clarksville, MI (Capac loam soil); 42.8733, -85.2604 deg; elevation 895 ft. on 21 May into two-row by 20-ft plots (ca. 10-in between plants to give a target population of 50 plants at 34-in row spacing) replicated four times in a randomized complete block design. Plots were irrigated as needed with sprinklers and were hilled immediately before sprays began. All rows were inoculated (3.4 fl oz/25-ft row) with a zoospore suspension of *Phytophthora infestans* [US-8 biotype (insensitive to mefenoxam, A2 mating type)] at 10^4 spores/fl oz on 28 Jul. All fungicides in this trial were applied on 7 day interval from 29 Jun to 18 Aug (8 applications) with an ATV rear-mounted R&D spray boom calibrated to deliver 25 gal/A (80 p.s.i.) using three XR11003VS nozzles per row. Weeds were controlled by hilling and with Dual 8E (2 pt/A on 3 Jun) and Poast (1.5 pt/A on 11 Jul). Insects were controlled with Admire 2F (20 fl oz/A at planting), Sevin 80S (1.25 lb/A on 11 and 25 Jul), Thiodan 3EC (2.33 pt/A on 1 and 21 Aug) and Pounce 3.2EC (8 oz/A on 11 Jul). Plots were rated visually for percentage foliar area affected by late blight on 17, 24 Aug and 1 Sep [20, 27 and 34 days after inoculation (DAI)] when there was about 100% foliar infection in the untreated plots. The relative area under the late blight disease progress curve was calculated for each treatment from the date of inoculation to 1 Sep, a period of 34 days. Vines were killed with Reglone 2EC (1 pt/A on 6 Sep). Plots (2 x 25-ft row) were harvested on 18 Oct and tubers from individual treatments were weighed,graded, and 50 tubers were evaluated for tuber blight. Samples of 50 tubers per plot were stored after harvest in the dark at 50^{o}F and incidence of tuber late blight was evaluated after 20 days in storage (8 Nov). Meteorological variables were measured with a Campbell weather station located at the farm from 1 May to harvest (5 Oct). Maximum, minimum and average daily air temperature (^{o}F) were 89.4, 28.8 and 59.7 (May); 86.3, 45.4 and 66.9 (Jun); 90.2, 46.4 and 73.1 and 1-d with maximum temperature >90^{o}F (Jul); 90.6, 46.8 and 71.9 and 2-d with maximum temperature >90^{o}F (Aug); 85.7, 40.2 and 60.1 (Sep); 85.7, 31.0 and 53.4 (to 5 Oct). Maximum, minimum and average relative humidity (%) was 93, 43 and 65 (May); 91, 55 and 73 (Jun); 91, 61 and 81 (Jul); 98, 34 and 72 (Aug); 99, 31 and 73 (Sep); 99, 19 and 69 (to 5 Oct). Maximum, minimum and average daily soil temperature (^{o}F) were 77.8, 53.1 and 66.5 (May); 89.2, 54.6 and 74.0 (Jun); 94.5, 59.8 and 76.7 (Jul); 89.2, 65.2 and 78.5 (Aug); 86.9, 65.7 and 76.8 (Sep); 78.2, 56.6 and 64.9 (to 5 Oct). Maximum, minimum and average soil moisture (% of field capacity) was 38.4, 28.8 and 31.7 (May); 39.9, 32.3 and 34.7 (Jun); 38.6, 34.1 and 35.4 (Jul); 39.5, 32.9 and 35.2 (Aug); 42.0, 31.3 and 34.5 (Sep) and 42.0, 33.4 and 34.2 (to 5 Oct). Precipitation was 3.82 in. (May), 4.48 in. (Jun), 4.33 in. (Jul), 1.4 in (Aug), 5.14 in. (Sep) and 0.7 in. (to 5 Oct). Plots were irrigated to supplement precipitation to about 0.1 in./A/4 day period with overhead sprinkle irrigation. The total number of late blight disease severity values (DSV) over the disease development period from 28 Jul to 1 Sep was 55 using 90% ambient %RH as bases for DSV accumulation.

Late blight developed steadily after inoculation and untreated controls reached on average 100% foliar infection by 1 Sep. Up to 24 Aug, all fungicide programs had significantly less foliar late blight than the untreated control. Programs with less 12.5% foliar late blight were most effective. Application programs that persisted beyond 4 Aug generally maintained the best foliar late blight control by 1 Sep. By 1 Sep, programs with greater than 93.8% foliar late blight were not significantly different form the untreated control. All other programs had significantly better foliar late blight than the untreated control and programs with 15 to 21.3% had the most effective foliar late blight control. All fungicide programs had significantly lower RAUDPC values in comparison to the untreated control (37.6). Programs with

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RAUDPC values from 3.2 to 5.6 had the most effective late blight control over the season. At harvest, there were significant differences in the incidence of tuber late blight and treatments with less than 5.3% of tuber blight were significantly different from the untreated control. Some tubers had close to 0% incidence of tuber late blight at harvest. On the 8 Nov (20 days after harvest) the percent incidence of infected tubers from untreated plots was 11.8%. Several treatments had very low incidence of tuber blight and ranged from 1.3 to 3.0% in the most effective treatments. Treatments with greater than 9.3% incidence were not significantly different from the untreated check. There were no significant differences in US1 or total yield among treatments. Phytotoxicity was not noted in any of the treatments.

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Treatment and rate/A	Foliar potato late blight 17 Aug 20 DAI[z]	24 Aug 27 DAI	1 Sep 34DAI	RAUDPC[y] 34 DAI	Tuber blight (%)[x] 18 Oct 150 DAP[w]	8 Nov 171 DAP	Yield US1	Total
BravoWS 6SC 1.5 pt (A-H[v])……………...	1.5 ef[u]	6.5 gh	20.0 ghi	4.6 jkl	2.3 def	3.8 de	228	308
Gavel 75DF 2 lb (A,C,E,F); BravoWS 6SC 1.5 pt (B,D,G,H)…………	1.8 ef	6.5 gh	21.3 f-i	4.8 i-l	2.0 def	2.0 def	276	370
Revus Top 4.17SC 7 fl oz (A,C,E,F); BravoWS 6SC 1.5 pt (B,D,G,H)…………	2.5 ef	5.0 gh	15.0 i	4.0 kl	1.5 d-g	3.0 def	266	371
Zampro 4.38SC 14 fl oz (A,C,E,F); BravoWS 6SC 1.5 pt (B,D,G,H)…………	1.5 ef	4.3 h	16.3 hi	3.6 kl	1.8 d-g	2.8 def	243	331
BravoWS 6SC 1.5 pt (A,C,E,F); Zampro 4.38SC 14 fl oz (B,D,G,H)…..…	1.1 f	3.3 h	16.3 hi	3.2 l	0.8 fg	2.0 def	240	313
Tanos 50WG 2.75 oz (A,C,E,F); BravoWS 6SC 1.5 pt (B,D,G,H)…………	3.6 ef	6.3 gh	20.0 ghi	5.3 h-l	1.0 efg	1.8 ef	230	310
Ranman 400SC 2.1 fl oz (A,C,E,F); Dithane 75DF 1.0 lb (B,D,G,H)……..…	5.0 de	16.3 def	41.3 c	10.8 e	1.5 d-g	2.3 def	260	356
BravoWS 6SC 1.5 pt (A,C,E,F); Revus Top 4.17SC 7 fl oz (B,D,G,H)……	4.3 def	12.5 efg	28.8 ef	8.1 e-h	1.3 efg	3.0 def	260	356
Regalia Max 20SC 2 pt + Tanos 50WG 6 oz (A,C); BravoWS 6SC 1.5 pt (B,D,F,H); Regalia Max 20SC 2 pt + Revus Top 4.17SC 7 fl oz (E,G)………………………	3.0 ef	16.3 def	38.8 cd	9.8 ef	0.3 g	2.8 def	246	360
Tanos 50WG 6 oz (A,C); Regalia Max 20SC 2 pt + BravoWS 6SC 1.5 pt (B,D,F,H); Revus Top 4.17SC 7 fl oz (E,G)………………………………………	4.5 def	18.5 de	37.5 cd	10.7 e	1.5 d-g	2.3 def	262	369
Tanos 50WG 6 oz (A,C); BravoWS 6SC 1.5 pt (B,D,F,H); Revus Top 4.17SC 7 fl oz (E,G)………….	4.3 def	12.5 efg	31.3 de	8.4 efg	1.5 d-g	2.8 def	271	358
CX-9030 100WG 0.5 lb (A-H)…………...	3.0 ef	21.3 d	86.3 b	16.9 d	4.8 b	10.8 ab	267	381
CX-9030 100WG 0.5 lb + Cueva 100AL 4 pt (A-H)…………………	7.5 d	30.0 c	95.0 a	21.7 c	4.3 bc	9.3 b	257	335
CX-9080 100WP 1.0 lb + Kocide 3000 46.1WG 1.5 lb (A-H)………	11.5 c	21.3 d	93.8 ab	21.0 c	5.3 ab	12.5 a	253	355
SA-0011401 50SC 2.8 pt (A-H)………….	1.5 ef	9.0 fgh	23.8 e-h	5.6 g-l	1.0 efg	2.0 def	274	384
SA-0011401 50SC 2.1 pt (A-H)………….	4.8 def	12.5 efg	27.5 efg	8.1 e-h	3.0 cd	6.8 c	293	384
BravoWS 6SC 1.0 pt (A,C,E); Ranman 3.33SC 2.08 fl oz + Penncozeb 4F 2 fl oz + NIS 4 fl oz (B,D,F)……………………..	2.3 ef	6.5 gh	41.3 c	7.5 f-i	1.8 d-g	2.5 def	294	403
BravoWS 6SC 1.5 pt (A,C,E); Ranman 3.33SC 2.73 fl oz + Penncozeb 4F 2.88 fl oz + NIS 4 fl oz (B,D,F)…………………..	2.8 ef	5.0 gh	43.8 c	7.7 f-i	2.5 de	1.3 f	321	424
BravoWS 6SC 1.5 pt (A,B,C); Ranman 3.33SC 2.73 fl oz + NIS 4 fl oz (D,E,F)….	1.0 f	4.3 h	45.0 c	7.0 f-j	2.0 def	4.3 d	244	355
BravoWS 6SC 1.5 pt + Ranman 3.33SC 2.08 fl oz (A,B,C); Gavel 75DF 2 lb (D); Ranman 3.33SC 2.73 fl oz + Penncozeb 4F 2.88 fl oz + NIS 4 fl oz (E,F)………….	2.8 ef	3.3 h	37.5 cd	6.5 g-k	2.5 de	4.0 de	270	377
BravoWS 6SC 1.5 pt + Ranman 3.33SC 2.08 fl oz (A,B); Gavel 75DF 2 lb (C); Ranman 3.33SC 2.73 fl oz + Penncozeb 4F 2.88 fl oz + NIS 4 fl oz (D,E,F)……….	3.3 ef	4.0 h	40.0 c	7.2 f-j	1.5 d-g	4.3 d	241	328
Oxidate 27SC 2 pt + Kocide 3000 46.1WG 1.5 lb (A-H)……….	17.5 b	43.8 b	93.8 ab	28.5 b	5.3 ab	10.8 ab	243	345
Untreated Check…………………………..	22.5 a	71.3 a	100 a	37.6 a	6.8 a	11.8 a	229	332
$LSD_{0.05}$	3.96	8.24	8.70	3.03	1.64	2.31	61.3	72.0

[z] Days after inoculation of *Phytophthora infestans* on 28 Jul.
[y] RAUDPC, relative area under the disease progress curve calculated from day of appearance of initial symptoms.
[x] Incidence of tuber late blight at harvest and after storage for 20 days at 50°F.
[w] Days after planting.
[v] Application dates: A= 29 Jun; B= 7 Jul; C= 14 Jul; D= 21 Jul; E= 28 Jul; F= 4 Aug; G= 11 Aug; H= 18 Aug.
[u] Values followed by the same letter are not significantly different at $p = 0.05$ (Fishers LSD).

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Effect of different genotypes of *Phytophthora infestans* (Mont. de Bary) and temperature on tuber disease development

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Introduction

Phytophthora infestans causes potato late blight in foliage and tubers and is a severe constraint on potato production. Late blight is readily transmitted by seed-borne inoculum and consequently, immature stems and leaves may be exposed to late blight from infected seed pieces (Kirk et al 2009). The transmission dynamics of late blight inoculum from seed to sprout and ultimately to the stem are still largely unknown and have been tested with only a limited number of varieties of potato and isolates of *P. infestans*. Direct loss of tuber yield occurs in the growing crop following reduction in photosynthetic capacity and tuber infection and also in the stored crop.

Three major components contribute to late blight resistance in tubers; 1) a physical barrier consisting of several layers of phellem cells, known as the periderm; 2) the outer cortical cell layers that retard the growth of lesions and can completely block hyphal growth; and 3) medulla storage tissues characterized by reduced hyphal growth and sporulation of *P. infestans* (Flier et al. 1998; Flier et al. 2001; Pathak and Clarke 1987). Recent work has indicated that the new immigrant *P. infestans* clones, especially the US-8 genotype, are more aggressive in tubers and sprouts (Kirk et al. 2001; Lambert and Currier 1997). The dynamics of potato blight development in tubers are largely influenced by temperature (Kirk et al. 2001) and can result in decay in storage at currently used processing storage temperatures (e.g. 10^{o}C for chip-processing) or non-emergence of plants due to seed and sprout rot (Kirk et al. 2009). The objective of this study was to use tubers from advanced breeding lines (ABL) and challenge them with different genotypes of *P. infestans* at three different temperatures used in storage (3, 7 and 10˚C) in four production seasons. These results showed the importance of different components involved in the disease development and inoculum source, including the pathogens variability. This study is an important approach to overcome aggressive *P. infestans* genotypes such as the US−8 genotype.

Methods

Tubers for this study were obtained from the potato breeding programmes at Michigan State University, the University of Wisconsin, the University of Minnesota and North Dakota State University. Potato tubers from cultivars/ABL harvested during the previous growing seasons were stored at 3^{o}C in the dark at 90% relative humidity until used. Tubers were warmed to 15^{o}C in incremental steps of 2^{o}C for 7 d before inoculation. Tubers for the experiments were within the size grade range 50–150 mm diameter (any plane). Visual examination of a random sample of tubers from each entry for disease symptoms indicated that tubers were free from late blight. The sample was further tested with the ELISA immunodiagnostic Alert multiwell kit (Alert multiwell kit– *Phytophthora sp*., Neogen, Lansing, MI, USA). *P. infestans* was not detected in any of the tubers. Prior to inoculation, all tubers were washed with water to remove soil. The tubers were then surface-sterilized by soaking them in 2% sodium hypochlorite (Clorox) solution for 30 min. Tubers were dried in a controlled environment with continuous airflow at 15 °C in dry air (30% relative humidity) for 4 h prior to inoculation.

Cultures of *P. infestans* isolates corresponding to clonal lineages US−1 (Pi95-3), US−1.7 [Pi88 (2002-06)], US-6 [Pi95-2 (2006-07)], US−8 [Pi02-007 (2002-05), Pi06-02 (2006-07)], US−10 [SR83-84 (2005-06), Banam AK (2006-07)], US−11 (Pi96-1), US−14 [Pi98-1 (2002-05), Pi00-001 (2006-07)] were selected based on the aggressiveness criteria (Young et al. 2009). The isolates were grown in rye B media for 14 days in the dark at 18^oC for sporangia production, and transferred to the light for 2 days to encourage sporulation. Sporangia and mycelium were harvested by flooding with cold sterile water (4^oC) and gentle scraping of the surface of the culture using a rubber policeman. The mycelium/sporangia suspension was stirred with a magnetic stirrer for 1 h. The suspension was strained through four layers of cheesecloth and sporangia concentration was measured with a hemacytometer and adjusted to about 1×10^6 total sporangia ml^{-1} (discharged and non-discharged). The sporangial suspensions were stored for 6 h at 4^oC to encourage zoospore release from the sporangia.

The washed, surface-sterilized tubers were inoculated by a sub-peridermal injection of a sporangia suspension of 2×10^{-5} ml (delivering zoospores released from about 20 sporangia inoculation^{-1}) with a hypodermic syringe and needle at the apical end of the tuber about 1 cm from the dominant sprout to a maximum depth of 1 cm. Ten tubers of each cultivar/ABL were inoculated with each *P. infestans* genotype per temperature. Ten control tubers per cultivar/ABL were inoculated with cold (4^oC) sterile distilled H_2O. After inoculation, tubers were placed in the dark in sterilized covered plastic crates and returned to controlled environment chambers [Percival Incubator (Model I-36LLVL, Geneva Scientific, LLC, PO Box 408, Fontana, WI)]. The chambers were set at 3, 7 or 10^oC and 95% humidity and the sample tubers were incubated for 40 days until evaluation.

A digital image analysis technique was used to assess tuber tissue infection. The method was previously used and standardized (Kirk et al. 2001a; Niemira et al. 1999). The image files were analyzed using SigmaScan V3.0 (Jandel Scientific, San Rafael, CA). The amount of late blight infected tissue per tuber was expressed as a single value (Mean ARI) calculated as the average ARI of the apical, middle and basal sections. The severity of tuber tissue infection was expressed relative to the ARI (described above) of the control tubers for each cultivar/ABL. The relative ARI (RARI %) has minimum value of zero (no symptoms) and maximum value of hundred (completely dark tuber surface).

Data for all experiments were analyzed by analysis of variance (least squares method) using the JMP program version 7.0 (SAS Institute Inc., SAS Campus Drive, Cary, North Carolina 27513, USA).

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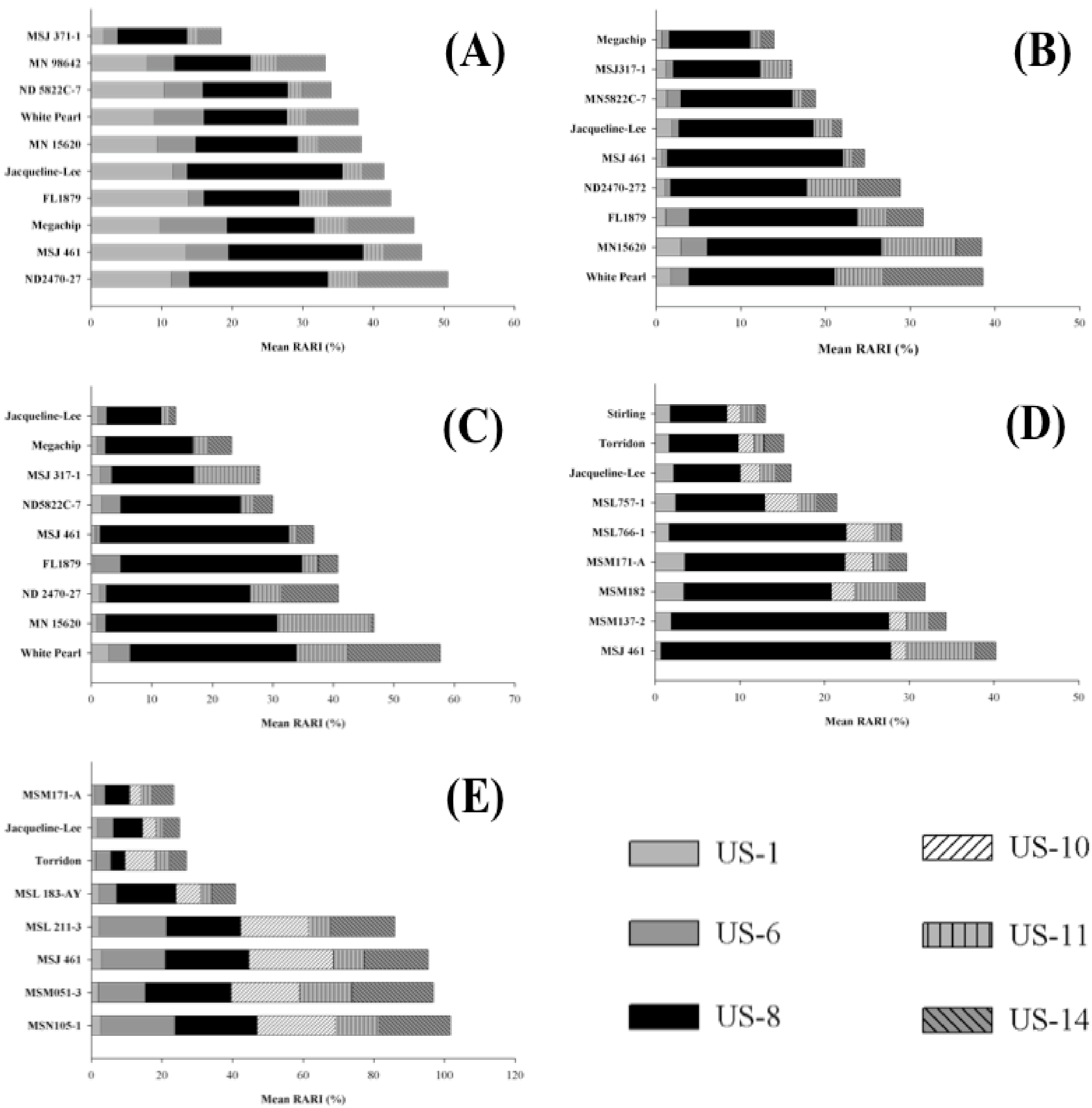

Figure 1. Tuber late blight, as mean RARI (%), evaluated across cultivars and advanced breeding lines inoculated with different *P. infestans* genotypes. The analysis was developed on (a) 2003, (b) 2004, (c) 2005, (d) 2006 and (e) 2007.

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Table 1. Effect of storage temperature on tuber tissue late blight as mean Relative Average Reflection Intensity [RARI (%)] in different cultivars and advanced breeding lines (ABL) of potatoes after inoculation with different genotypes of *Phytophthora infestans* by year.

Year	Variety	Mean RARI (%)[a]	Genotype of *P. infestans*	Mean RARI (%)[a]	Temperature (°C)	Mean RARI (%)a
2002-2003	ND2470-27	10.12 a	US-8	14.59 a	10	10.23 a
	MSJ 461	9.38 ab	US-1	9.8 b	7	9.12 b
	Megachip	9.15 abc	US-14	6.76 c	3	4 c
	FL1879	8.5 bcd	US-6	4.64 d		
	Jacqueline-Lee	8.3 cd	US-11	3.13 e		
	MN15620	7.67 de				
	White Pearl	7.57 de				
	ND 5822C-7	6.81 e				
	MN 98642	6.65 e				
	MSJ 371-1	3.69 f				
	LSD 0.05	**3.164**		**2.728**		**2.344**
2003-2004	White Pearl	7.72 a	US-8	15.93 a	10	7.79 a
	MN15620	7.68 a	US-11	3.73 b	7	7.71 a
	FL1879	6.31 b	US-14	3.32 b	3	0 b
	ND2470-27	5.77 bc	US-6	1.49 c		
	MSJ 461	4.92 cd	US-1	1.38 c		
	Jacqueline-Lee	4.38 de				
	MN5822C-7	3.76 def				
	MSJ317-1	3.2 ef				
	Megachip	2.78 f				
	LSD 0.05	**3.103**		**2.729**		**2.345**
2004-2005	White Pearl	11.55 a	US-8	21.97 a	10	7.06
	MN 15620	9.34 ab	US-11	5.51 b		
	ND2470-27	8.17 bc	US-14	4.39 b		
	FL1879	8.15 bc	US-6	2.13 c		
	MSJ 461	7.35 bcd	US-1	1.31 c		
	ND 5822C-7	6 cde				
	MSJ 371-1	5.56 de				
	Megachip	4.64 ef				
	Jacqueline-Lee	2.79 f				
	LSD 0.05	***3.107***		***2.732***		
2005-2006	MSJ461-1	8.05 a	US-8	15.97 a	10	7.23 a
	MSM137-2	6.87 b	US-11	3 b	7	4.53 b
	MSM182	6.37 b	US-10	2.5 bc	3	3.63 c
	MSM171-A	5.94 b	US-1	2.11 c		
	MSL766-1	5.82 b	US-14	2.07 c		
	MSL757-1	4.28 c				
	Jacqueline-Lee	3.21 cd				
	Torridon	3.03 d				
	Stirling	2.6 d				
	LSD 0.05	***3.103***		***2.729***		***2.345***
2006-2007	MSN105-1	16.95 a	US-8	16.14 a	10	13.06 a
	MSM051-3	16.16 a	US-10	13.28 b	7	10.19 b
	MSJ461-1	15.9 a	US-14	12.71 b	3	7.76 c
	MSL 211-3	14.33 b	US-6	10.81 c		
	MSL 183-AY	6.82 c	US-11	7.04 d		
	Torridon	4.48 d	US-1	2.04 e		
	Jacqueline-Lee	4.17 d				
	MSM171-A	3.89 d				
	LSD 0.05	***3.032***		***2.85***		***2.344***

[a] Normalized tuber tissue darkening score expressed as RARI (%) = [1- Mean ARI $_{treatment}$ / Mean ARI $_{control}$] *100; % RARI has a minimum value of zero (no darkening, but if the value is negative the tuber tissue was lighter than the control) and maximum value of 100 (cut tuber surface is completely blackened). The numbers are derived from the mean average reflective intensity of three surfaces cut latitudinal at 25, 50 and 75% from the apex of n = 10 tubers per treatment combination.

[b] Values followed by the same letter are not significantly different at $p = 0.05$ for comparisons of mean RARI values within different *P. infestans* genotypes of cultivar/ABL combinations and temperature treatments (Based on Fishers protected LSD).

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Results and Discussion

Different varieties/ABLs of potatoes showed a broad range of responses to the infection with different *P. infestans* genotypes for each year. Interaction between storage temperature, genotype aggressiveness and cultivar/ABL resistance were the different factors of interest in this experiment.

Tuber late blight development measured as mean RARI (% Relative Average Reflective Intensity) over the range of factors (variety and temperature). Effect of different temperatures and genotypes of *Phytophthora infestans* on tuber disease development was evaluated by repeating the experiment for 5 consequent years.

In most of the years, *P. infestans* genotype US – 8 caused most tuber rotting genotypes followed by US – 11 and US – 14 (Figure 1 and Table 1). Also, the storage conditions had a great effect on the disease development, affecting the tuber late blight development because of the survival of the inoculum at lower temperatures.

Different storage temperatures (3, 7 and 10ºC) were used to evaluate tuber infection and late blight development. The disease rate was high at 10ºC for every year (Figure 2), consequently the response is affected by the other two factors: cultivar/ABL resistance and the aggressiveness of the *P. infestans* genotype. Late blight symptoms were also observed in 3ºC and 7ºC in different isolates and varieties.

The results showed that US−8 genotype was the most aggressive, regardless of the variety or temperature (Table 1 and Figure 1, 2).

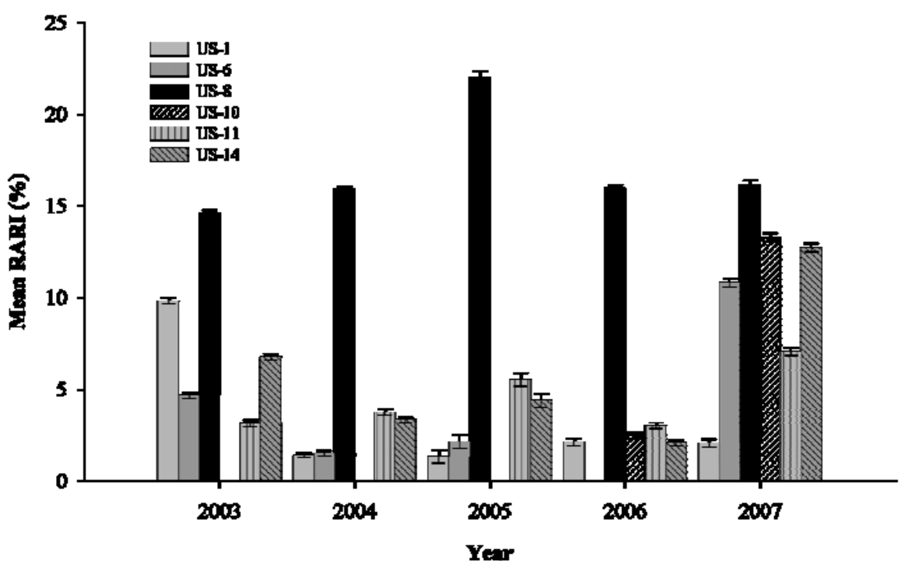

Figure 2. Tuber late blight measured as mean RARI (%) for the different *P. infestans* genotypes across evaluated years.

Among the different varieties and ABL's, Jacqueline – Lee and Stirling were one of the most resistant varieties with mean RARI ranged from 2% to 4%. On the other hand, the most susceptible varieties were White Pearl and MSN 105-1, which had mean RARI values from 10% to 17%.

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Conclusions

The mean RARI (%) is an excellent measure of tuber late blight disease and the range of RARI responses show that different *P. infestans* genotypes respond differently to host resistance and storage conditions. The most recently appeared genotypes of *P. infestans* produce severe symptoms in most cultivars/ABL to the different storage temperature conditions.

The US – 8 genotype was consistently the most aggressive isolate causing high tuber discoloration and rotting. In addition, the aggressiveness of US−8 genotype increased with temperature, and the mean RARI (%) values were greater than in any other *P. infestans genotypes*. US−11 and US−14 genotypes caused less disease in tubers, and US−1 genotype being the least.

References

Flier, W.G., L.J. Turkensteen, and A. Mulder. 1998. Variation in tuber pathogenicity of *Phytophthora infestans* in the Netherlands. *Potato Research* 41: 345-354

Flier, W.G., L.J. Turkensteen, G.B.M. van den Bosch, P.F.G. Vereijken, and A. Mulder. 2001. Differential interaction of *Phytophthora infestans* of potato cultivars with different levels of blight resistance. *Plant Pathology* 50: 292-301

Kirk, W., Rojas, A., Tumbalam, P., Gachango, E., Wharton, P., El-Samen, F., Douches, D., Coombs, J., Thill, C., and Thompson, A. Effect of different genotypes of *Phytophthora infestans* (mont. de bary) and temperature on tuber disease development. Am. J. Pot. Res. DOI: 10.1007/s12230-010-9156-1

Kirk WW, Niemira BA and Stein JM (2001) Influence of storage temperature on rate of potato tuber tissue infection caused by *Phytophthora infestans* (Mont.) de Bary estimated by digital image analysis. Potato Res 44: 86-96

Kirk W, Abu-El Samen F, Tumbalam P, Wharton P, Douches D, et al. 2009. Impact of Different US Genotypes of *Phytophthora infestans* on Potato Seed Tuber Rot and Plant Emergence in a Range of Cultivars and Advanced Breeding Lines. Potato Res 52:121-40.

Lambert, D.H., and A.I. Currier. 1997. Differences in tuber rot development for North American clones of *Phytophthora infestans*. *American Potato Journal* 74: 39-43.

Niemira BA, Kirk WW and Stein JM (1999) Screening for late blight susceptibility in potato tubers by digital analysis of cut tuber surfaces. Plant Diseases 83: 469-473.

Pathak, N., and D.D. Clarke. 1987. Studies on the resistance of the outer cortical tissues of the tubers of some potato cultivars to *Phytophthora infestans*. *Physiol. Mol. Plant Pathol.* 31: 123-32.

Young GK, Cooke LR, Kirk WW, Tumbalam P, Perez FM, Deahl KL (2009) The influence of competition and host plant resistance on selection of *Phytophthora infestans* populations in Michigan State and Northern Ireland. Plant Pathol doi:10.1007/BF02986273

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Potatoes (cut seed, treated with Maxim FS at 0.16 fl oz/cwt) were planted at the Michigan State University Horticultural Experimental Station, Clarksville, MI (Capac loam soil); 42.8733, -85.2604 deg; elevation 895 ft. on 5 May into two-row by 25-ft plots (ca. 6-in between plants to give a target population of 100 plants at 34-in row spacing) replicated four times in a randomized complete block design. The trial area was inoculated with *Pythium ultimum* and *Phytophthora erythroseptica*-infected tubers from at a rate of about 400 cwt tubers/A. Plots were irrigated as needed with sprinklers and were hilled immediately before sprays began. In-furrow applications were applied with an R&D spray boom delivering 8 gal/A (80 p.s.i.) and using one XR11003VS nozzle per row. Foliar applications were applied with an ATV rear-mounted R&D spray boom calibrated to deliver 25 gal/A (80 p.s.i.) using three XR11003VS nozzles per row. Previcur Flex was applied at 0.7 pt/A on a seven-day interval, total of four applications, starting one day after inoculation of adjacent plots with *Phytophthora infestans*. Weeds were controlled by hilling and with Dual 8E (2 pt/A on 25 May), and Poast (1.5 pt/A on 11 Jul). Insects were controlled with Admire 2F (20 fl oz/A at planting), Sevin 80S (1.25 lb/A on 11 and 25 Jul), Thiodan 3EC (2.33 pt/A on 1 and 21 Aug) and Pounce 3.2EC (8 oz/A on 11 Jul). Emergence was rated up to 44 days after planting and final plant stand and relative rate of emergence (relative area under the emergence progress curve – RAUEPC) were evaluated. Vines were killed with Reglone 2EC (1 pt/A on 1 Oct). Plots (2 x 25-ft row) were harvested on 15 Oct and individual treatments were weighed and graded and tuber number in size grades US-1 and b-grade determined. Samples of four plants were collected at desiccation and harvest from each plot and the percentage of tubers with symptoms of Pythium leak evaluated. Yield samples from each plot (n = 50 tubers) were stored in the dark at 50^{o}F and 95% RH for 21 days after harvest and the percentage of tubers with Pythium leak determined to give measurements of incidence. Meteorological variables were measured with a Campbell weather station located at the farm from 1 May to harvest (15 Oct. Meteorological variables were measured with a Campbell weather station located at the farm from 1 May to harvest (5 Oct). Maximum, minimum and average daily air temperature (^{o}F) were 89.4, 28.8 and 59.7 (May); 86.3, 45.4 and 66.9 (Jun); 90.2, 46.4 and 73.1 and 1-d with maximum temperature >90^{o}F (Jul); 90.6, 46.8 and 71.9 and 2-d with maximum temperature >90^{o}F (Aug); 85.7, 40.2 and 60.1 (Sep); 85.7, 31.0 and 53.4 (to 5 Oct). Maximum, minimum and average relative humidity (%) was 93, 43 and 65 (May); 91, 55 and 73 (Jun); 91, 61 and 81 (Jul); 98, 34 and 72 (Aug); 99, 31 and 73 (Sep); 99, 19 and 69 (to 5 Oct). Maximum, minimum and average daily soil temperature (^{o}F) were 77.8, 53.1 and 66.5 (May); 89.2, 54.6 and 74.0 (Jun); 94.5, 59.8 and 76.7 (Jul); 89.2, 65.2 and 78.5 (Aug); 86.9, 65.7 and 76.8 (Sep); 78.2, 56.6 and 64.9 (to 5 Oct). Maximum, minimum and average soil moisture (% of field capacity) was 38.4, 28.8 and 31.7 (May); 39.9, 32.3 and 34.7 (Jun); 38.6, 34.1 and 35.4 (Jul); 39.5, 32.9 and 35.2 (Aug); 42.0, 31.3 and 34.5 (Sep) and 42.0, 33.4 and 34.2 (to 5 Oct). Precipitation was 3.82 in. (May), 4.48 in. (Jun), 4.33 in. (Jul), 1.4 in (Aug), 5.14 in. (Sep) and 0.7 in. (to 5 Oct). Plots were irrigated to supplement precipitation to about 0.1 in./A/4 day period with overhead sprinkle irrigation.

Pythium developed in the trial at moderate levels but the reduction in yield at harvest was likely due to loss of tubers to both pink rot and Pythium leak. Pink rot could be detected but Pythium leak overwhelmed infected tubers. Although some treatments had a significant effect on final plant stand no treatment had a final plant stand below 95%. The application of Phostrol at planting significantly increased the relative rate of emergence (RAUEPC) in comparison to the untreated control but no other treatments were different from the untreated control. All treatments had significantly lower incidence of Pythium incidence in comparison with the untreated in tubers at desiccation timing and 21 days after harvest but there was no difference among treatment at the harvest evaluation. All treatments had significantly higher marketable and total yield of tubers in comparison with the untreated (Table 1).

Table 1. Efficacy of soil applied fungicides against Pythium leak.

Treatment and rate/A or rate/1000 row ft	Final plant stand 44 DAP	RAUEPC[z] 0 – 44 DAP Max = 100	Pythium Leak Incidence (%)[y] At Desiccation	At harvest	21 days after harvest	Yield (cwt/A) US-1	Total
Presidio 4SC 0.264 fl oz/1000 row ft (A[x]); Presidio 4SC 0.264 fl oz/1000 row ft (B)……….	96a[w]	31.2ab	1.8b	1.3a	1.8b	210ab	317a
Ranman 3.33SC 0.183 fl oz/1000 row ft (A); Ranman 3.33SC 2.75 fl oz/A (C)………………..	96a	26.6de	0.0c	0.8a	1.5b	203ab	312a
Ridomil Gold 4EC 0.42 fl oz 1000 row ft (A)…..	97a	24.1e	1.0bc	1.8a	1.8b	243a	323a
Presidio 4SC 0.264 fl oz/1000 row ft + Ridomil Gold 4EC 0.42 fl oz 1000 row ft (A)…	96a	30.7abc	1.0bc	0.8a	1.8b	218ab	300a
Ranman 3.33SC 0.183 fl oz/1000 row ft (A); Ranman 3.33SC 2.75 fl oz/A (B); Phostrol 53.6SC 1.25 gal/A (C)………………….	98a	27.2cde	0.8bc	0.5a	2.5b	199b	287a
Phostrol 53.6SC 0.42 fl oz 1000 row ft (A); Phostrol 53.6SC 1.25 gal/A (B,C)………………	99a	33.9a	1.5b	1.0a	2.8b	232ab	323a
Untreated..	99a	28.8bcd	3.3a	3.3a	6.0a	152c	233b
$LSD_{0.10}$	3.1	3.67	1.02	1.85	1.42	42.4	53.2

[z] RAUEPC, relative area under the emergence progress curve calculated from day of planting to 95% emergence in untreated check plots.

[y] Incidence of pythium leak determined by tuber number.

[x] Application dates: A= 5 May (in-furrow at planting per 1000 row ft); B= 9 Jun (hilling); C= 16 Jun (hooking, rate/A)

[w] Values followed by the same letter are not significantly different at *p* = 0.10 (Fishers protected LSD).

Funding: MPIC

Fusarium Species Responsible for Dry Rot of Seed Potato Tubers in Michigan

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Introduction

Potato dry rot is a postharvest disease caused by several *Fusarium* species and is of worldwide importance (Secor and Salas, 2001). So far twelve species have been implicated in causing dry rot worldwide (Hide et al., 1992), and among them eight species have now been reported in northern united States (Hanson et al., 1996). The most prevalent species are, *F. sambucinum* Fuckel (=*Fusarium sulphureum* Schlechtend; teleomorph: *Gibberella pulicaris* (Fr.:Fr) Sacc.), *F. solani* (Mart.) Sacc. var. coeruleum (Lib. ex Sacc.) C. Booth (=*F. coeruleum*; teleomorph: *Nectria haematococca* Berk. & Broome), and *F. oxysporum* Schlechtend. Fr.(Hanson et al., 1996). In Michigan seed potato production, dry rot has been reported in most of the seed lots (Kirk and Wharton, 2008) and *F. sambucinum* is the most predominant species affecting potato in storage and causing seed piece decay after planting (Lacy and Hammerschmidt, 1993). However, there has been no assessment of composition of *Fusarium* species causing dry rot in Michigan.

Materials and methods

- **Isolation:** 260 dry rot symptomatic tubers were collected from seed lots in Michigan potato growing area in summer 2009. Small pieces were cut from the margins of the necrotic region with a sterile scalpel, surface-disinfected in 10% bleach solution for 10 s, rinsed twice in sterile distilled water, and blotted with sterile filter paper. The tissue pieces were then plated on half strength potato dextrose agar (PDA; Difco, Detroit, Michigan) amended with 0.5 g/L streptomycin sulfate. The Petri dishes were incubated at 23°C for 5 to 7 d. Cultures resembling *Fusarium* species were transferred onto water agar; hyphal tip transfer was done from the margin of actively growing isolates with a sterile probe and plated on carnation leaf agar (CLA) and half strength PDA to generate pure cultures. Pure cultures on CLA were identified based on conidial morphology and production of chlamydospores, while those on PDA were identified based on colony pigmentation. The species of each *Fusarium* isolate was determined using techniques described by Leslie et al. (2006). To confirm species identity, lyophilized mycelium from pure cultures grown on PDA were used for DNA extraction, followed by amplification and sequencing of the translation elongation factor (EF-1α) gene region. The Fusarium-ID.v (Geiser et al., 2004) and the NCBI database were used to obtain the closest match to previously sequenced materials.

- **Fungicide Sensitivity Testing:** EC_{50} value, defined, as the concentration of fungicide that inhibited colony radius on PDA by 50% was determined for 169 isolates using the spiral gradient endpoint (SGE) method for thiabendazole (TBZ), fludioxonil and difenoconazole. This aimed at establishing baselines for future studies. Agar plates 15cm in diameter were prepared 48h before fungicide solutions were applied with a spiral plater using the exponential deposition mode. For all the fungicides, the stock concentration was 10000ppm. The plates were incubated for 3h to allow fungicides to diffuse into the medium and form a gradient of concentrations along the radius of the plate. Conidial suspension (10^6 conidia/ml) per isolates was streaked across the radial lines guided by an SGE template placed under the plate. Three replicates per isolate were used. The plates were incubated at 25°C for 3 days, after which the radius of the mycelial growth was determined and used to calculate the EC_{50}.

- **Pathogenicity Testing:** All isolates obtained were tested for pathogenicity on disease-free potato tubers, cv. Red Norland. The tubers were surface sterilized for 10 min in 10% bleach solution and rinsed twice in distilled water. Three tubers per isolates were injected with 20µl of conidial suspension (10^6 conidia/ml) made from *Fusarium* cultures grown on PDA for 7 days. The tubers were incubated for 30 days at 10°C. Tubers were cut into half and any isolate that produced lesions on tuber surface was considered pathogenic. The tuber lesions were scanned and using the SigmaScan Pro 5 program, the area of the lesion was determined relative to the total area of the tuber surface to give the level of aggressiveness.

Results and Discussion

- A total of 169 *Fusarium* isolates (Fig 1) were recovered from the infected tubers. *F. oxysporum, F. equiseti*, and *F. sambucinum* were the most common species comprising 28.4, 23.6, and 14.4% of the isolates respectively.
- *F. avenaceum, F. solani, F. cerealis* and *F. acuminatum*, were less common comprising 10.9, 9.9, 6.1, and 3.9% of the isolates respectively.
- The other species identified were, F. sporotrichioides, F. torulosum, and F. tricinctum, all found in very low percentage.
- All the *Fusarium* isolates recovered were pathogenic to potato tubers (Fig 1).
- *F. sambucinum* was the most aggressive based on percentage of the infected area.
- Isolates of the same species depicted different levels of aggressiveness for *F. sambucinum, F. avenaceum* and *F. acuminatum*.

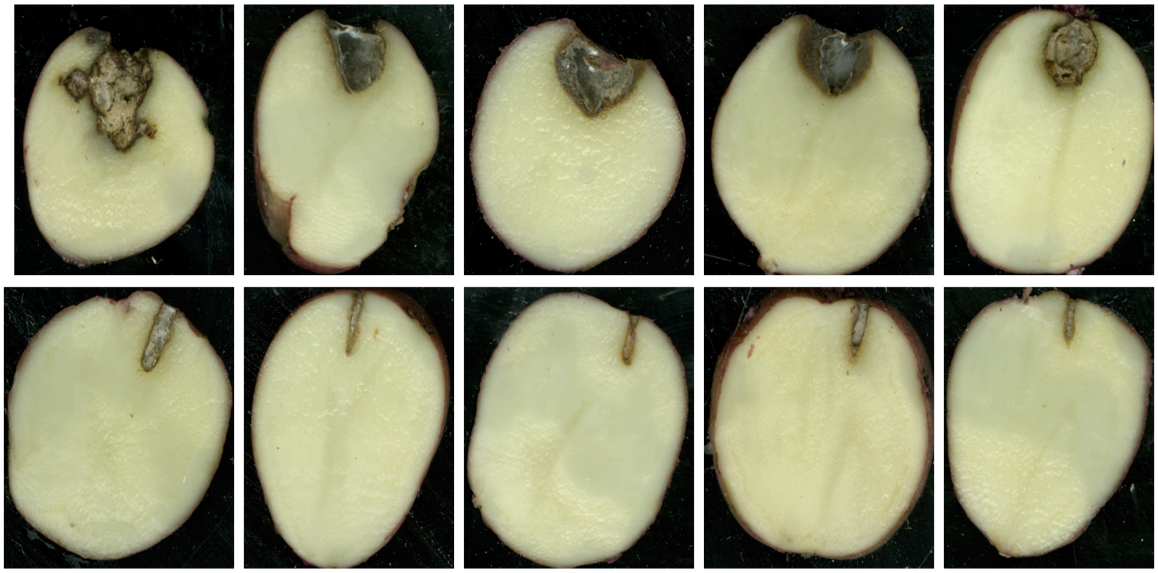


Figure 1: Aggressiveness of *Fusarium* isolates on potato tubers (cv. Red Norland) inoculated with *F. sambucinum, F. avenaceum, F. tricinctum, F. acuminatum, F. cerealis, F. sporotrichioides, F. solani, F. equiseti, F. oxysporum, F. torulosum* respectively.

- All isolates of *F. sambucinum* were resistant to TBZ with an EC_{50} greater than 136 mg/L. This also applied to the known TBZ-resistant isolates of *F. sambucinum* (R-09271 -Desjardins YG-1 U7200A).
- However, the rest of the isolates as well as the known *F. sambucinum*-TBZ susceptible (R-00738, Cetas, R.C) were sensitive to TBZ with EC_{50} ranging from 0.9- 4.9 mg/L (Fig 2).

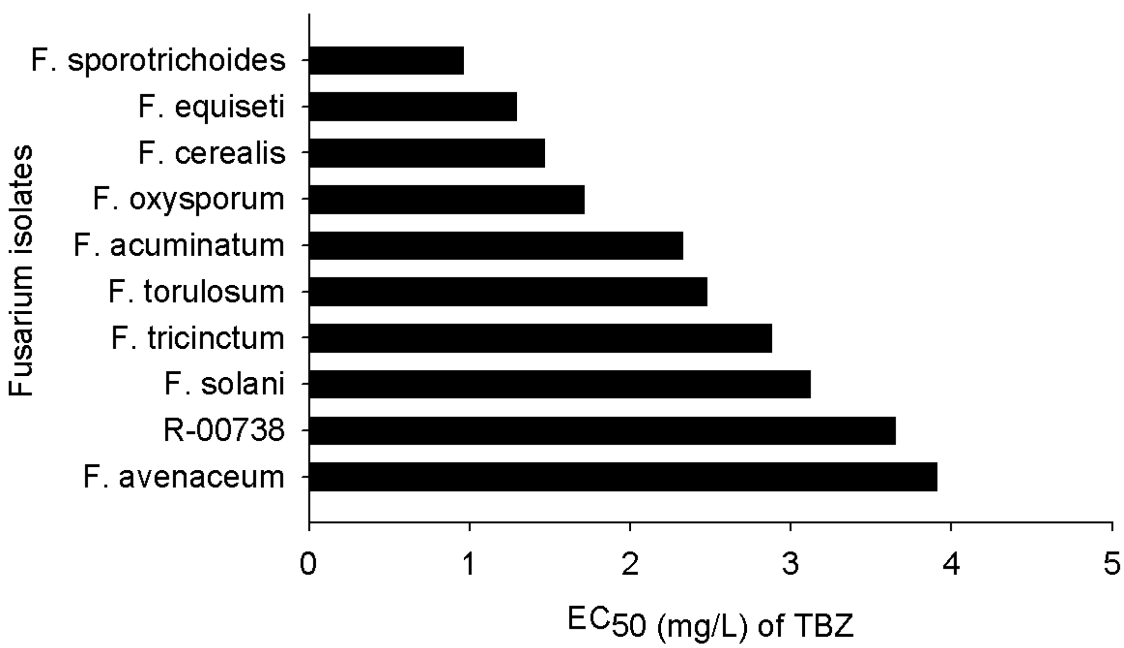


Figure 2: EC_{50} of TBZ against sensitive *Fusarium* isolates. R-00738= *F. sambucinum* TBZ susceptible

- All the Fusarium isolates were sensitive to difenoconazole with an EC_{50} ranging from 0.69-4.2 mg/L (Fig 3).

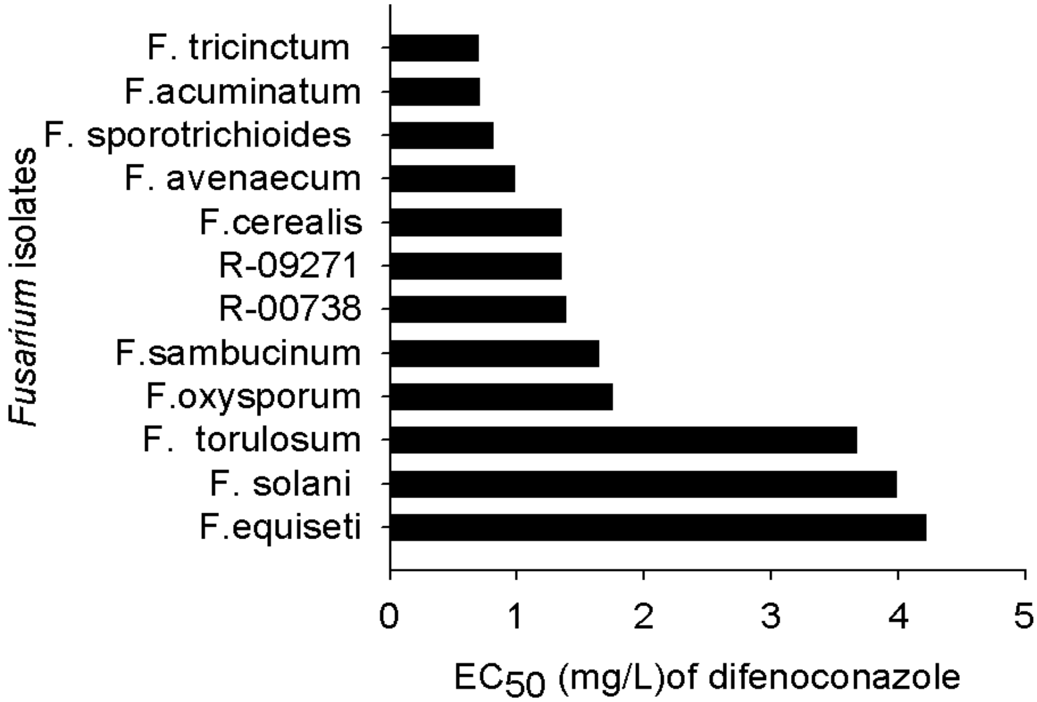


Figure 3: EC_{50} of difenoconazole against different Fusarium isolates. R-00738 = *F. sambucinum* TBZ susceptible; R-09271= *F. sambucinum* TBZ –resistant

- Both resistant (EC_{50}>100mg/L) and sensitive isolates of *F. sambucinum* and *F. oxysporum* to fludioxonil were reported.
- *Fusarium* isolates sensitive to fludioxonil had EC_{50} ranging from 0.8-4.9 mg/L (Fig 4).

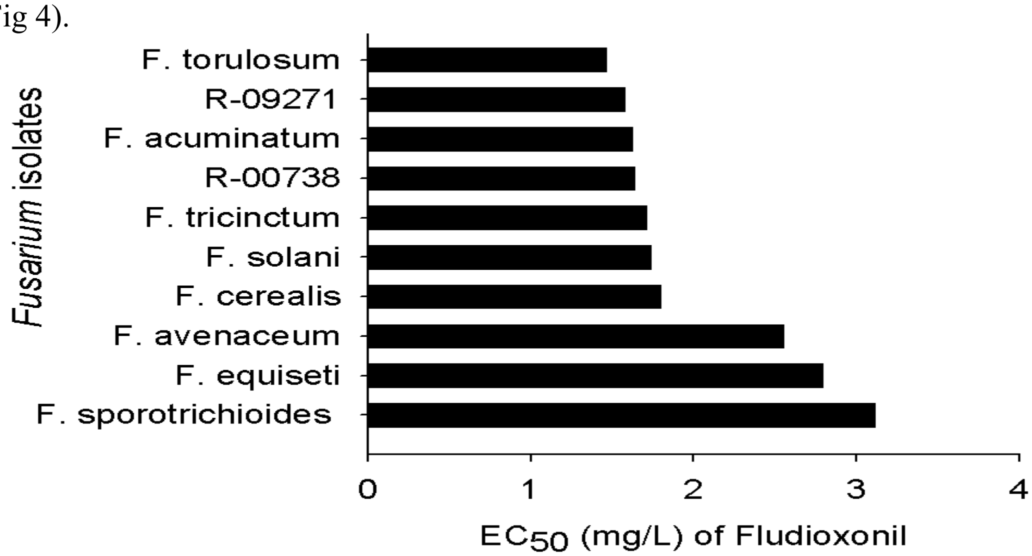


Figure 4:EC_{50} of fludioxonil against sensitive *Fusarium* isolates, R-00738 = *F. sambucinum*-TBZ susceptible, R-09271= *F.sambucinum* TBZ resistant

Conclusions

- Ten *Fusarium* species are responsible for dry rot of potato in Michigan.
- *F. sambucinum* is the most aggressive, although found in a lower frequency compared to *F. oxysporum*.
- TBZ can still be used to control dry rot caused by other *Fusarium* species apart from TBZ resistant- *F. sambucinum*.
- Difenoconazole can also be used to control *Fusarium* dry rot, while fludioxonil can only be used to control the sensitive isolates of *F. sambucinum* and *F. oxysporum,* or other *Fusarium* species causing dry rot
- The baseline sensitivity levels can be used to determine sensitivity shifts in future.

Reference

Geiser, D., del Mar Jiménez-Gasco, M., Kang, S., Makalowska, I., Veeraraghavan, N., Ward, T., Zhang, N., Kuldau, G. & O'Donnell, K. (2004) Fusarium-ID v. 1.0: A DNA sequence database for identifying *Fusarium*. *Eur J Plant Pathol,* **110:**473-479.

Hanson, L. E., Schwager, S. J. & Loria, R. (1996) Sensitivity to thiabendazole in *Fusarium* species associated with dry rot of potato. *J Phytopathol,* **86:**378-384.

Hide, G. A., Read, P. J. & Hall, S. M. (1992) Resistance to thiabendazole in *Fusarium* species isolated from potato tubers affected by dry rot. *Plant Pathol,* **41:**745-748.

Kirk, W. W. & Wharton, P. (2008). Fusarium dry rot posing problems in potatoes. Vegetable Crop Advisory Team Alert Retrieved July 23, 2010, from http://www.potatodiseases.org/pdf/Disease-update-2008-Fusarium-dry-rot.pdf

Lacy, M. L. & Hammerschmidt, R. (1993). Fusarium dry rot. Retrieved May 23, 2010, from http://web1.msue.msu.edu/msue/iac/onlinepubs/pubs/E/E2448POT.PDF

Leslie, J., Summerell, B. & Bullock, S. *The Fusarium laboratory manual*, Wiley-Blackwell, 2006.

Secor, G. A. & Salas, B. Fusarium dry rot and Fusarium wilt. In: W.R. Stevenson., R. Loria., G.D Franc., a. & D.P. Weingartner (eds), Compendium of Potato Diseases. St. Paul, MN, American Phytopathological Society Press, 2001, pp. 23-25.

2010 Research Report to MPIC Research Committee

PROJECT TITLE: Managing potato common scab using biomaterials and beneficial microorganisms

Jianjun Hao, William Kirk, David Douches, Qingxiao Meng, and Noah Rosenzweig

STATEMENT

Potato common scab (PCS) continues to be a threat to the Michigan potato industry, due to the lack effective control methods. The disease suppressive soil that we have identified is a valuable resource for basic study and ultimately improved management of potato common scab. Understanding the suppressiveness phenomenon will also help to understand the interaction between plant host and the major PCS pathogen, and help clarify the interactions between the pathogen and other microorganisms in the soil. Moreover, we continued to study promising biomaterials, such as plant extracts, and beneficial microorganisms to reduce PCS in greenhouse conditions with the eventual goal of effective in-field deployment.

1. Diversity of pathogenic Streptomyces species in Michigan

To investigate the diversity of Streptomyces spp. in major potato production areas, soil samples were collected and Streptomyces was isolated. By comparing the 16S rRNA gene sequences, and BOX-PCR, it is the first confirmed report of *S. stelliscabiei* in Michigan (Figure 1). This information expands the knowledge of pathogen diversity in Michigan in addition to DS3024 (previously reported).

2. Characterization soil microbial community of common scab suppressive soil using pyrosequencing

Pyrosequencing is a new more comprehensive high-throughput DNA sequencing technology (next generation sequencing) capable of a greater depth of detection of soil organisms. Soil was collected from the disease suppressive and conducive soils. Total DNA was extracted from the soil using a DNA extraction kit. The ribosome considered the workhorse of protein synthesis in the cell offers an ideal target (16S rRNA gene) for DNA characterization of microbes in the environment. A pyrosequencing-based approach was used to analyze amplicon libraries from polymerase chain reaction (PCR) amplification of the phylogenetically informative 16S rRNA gene region (variable across taxa). The resulting bacterial 16S/mycorrhizal 18S rDNA sequences will eventually be deposited in the GenBank Short Read Archive. Data were analyzed using an operational taxonomic unit (OTU)-based and a taxon-based approach to determine microbial community composition (e.g. pathogens and beneficial microbes). Additionally indicator taxon analysis and richness estimates of bacterial sequences originating from different samples will be determined. OTU analyses will be performed using various computer software packages.

Results showed that one third of the soil microbial community inhabitants are shared between disease suppressive and conducive soils (Figure 1). Disease suppressive soil had significantly higher populations of pseudomonads, *Lysobacter*, and *Rhodanobacter*, which are all groups of bacteria considered beneficial microorganisms or having antagonistic activities.

Streptomyces spp., including pathogenic and nonpathogenic types, were found to be at similar levels for both soil types. Interestingly, *Bacillus* spp. was much lower in the disease suppressive soil (Table 1). Based on the current data and previous results, it is most likely that bacteria such as florescent pseudomonads and lysobacter, play important roles for suppressing pathogens in soil.

3. Management of potato common scab using biological and plant-derived products

In the greenhouse, several products for the control of potato common scab will be evaluated. Products include *i*) biological control agents, *Bacillus* spp. (BAC1 to 3), Telnet (*Trichoderma asperellum* & *T. gamsii*, SipCam Advan); *ii*) disease resistance inducer, Regalia ® (giant knotweed extract, Marrone Organic); *iii*) soil amendments, chestnut shells; and *iv*) the chemical PCNB. In the field, materials BAC03, Regalia, chestnut amendment, chicken manure, Tenet, and PCNB will be applied for potato common scab control. This will be conducted at Montcalm and Michigan State University, with a randomized complete block design with four replications. All the products except Regalia will be applied in-furrow, immediately followed by planting potato seed tubers. Regalia will be sprayed on the foliage after seedling emergence. At harvest, potato tubers will be evaluated for yield, and disease severity. Data will be analyzed using SAS statistical package.

Chestnut extracts from shell, leaf, and pellicle had antimicrobial activity against a broad range of microorganisms, and pellicle had the highest concentration of antimicrobial compounds. All the test pathogenic *Streptomyces* spp. were sensitive to the extract and had lower effective concentration for 50% growth inhibition (ED_{50}) (Table 2). In the greenhouse, chestnut tissue incorporated in potting soil significantly reduced the disease intensity of scab symptoms in both potato and radish (Figure 3). There was a linear or curve linear relationship between the application rate of chestnut tissue and disease reduction; higher application rates resulted in less disease, vise versa (Figure 3).

Bacillus spp. isolated from the disease suppressive soil was positively correlated to a reduction in scab disease. In the greenhouse, when soil was treated with strains of *Bacillus* spp., radish biomass or weight was significantly higher (Figure 4) and disease intensity (Figure 5) was lower than that treated with PCNB (the standard chemical for scab control), indicating a potential for biological scab disease control. In the field, none of the products performed better than PCNB for scab control (Figure 5), although yield from PCNB treatment was the lowest (Figure 6). These results will be further explored and addressed and re-tested during the next growing season.

Horseradish had significantly reduced the growth of *Streptomyces* spp. (all were pathogens to potato) in Petri plates by volatiles (Figure 7), and potato common scab in the greenhouse (Figure 8). Strain 3024 was the most sensitive, and 2794 was least sensitive, but ED50 was all bellow 0.5 g dry plant material per plate.

To summarize, pyrosequencing result will provide detailed information for finding beneficial microorganisms and healthy soil microbial community. BAC03 strain and horseradish have potential for controlling potato common scab. Field data will be pursed in the future.

Table 1. Selected genera identified from pyrosequencing.

	Conducive soil	***Suppressive soil***
Pseudomonas	1.2	22.4
Lysobacter	1.6	9.6
Rhodanobacter	471.8	1205.2
Streptomyces	11.8	10.4
Bacillus	54.8	5.2

Table 2. Effect of chestnut pellicle extract on test pathogens.

Pathogen	**EC50 (ug/uL)**
Clavibacter michiganensis subsp. *Michiganensis*	21.5
Erwinia carotovora	20.5
Pseudomonas syringae	6.1
Streptomyces scabies	12.0
Streptomyces acidiscabies	9.2
Streptomyces bottropensis	13.3
Streptomyces aureofaciens	5.6
Streptomyces stelliscabiei	14.4
Streptomyces europaeiscabiei	13.0
Cladosporium cucumerinum	16.4
Phytophthora capsici	32.6
Phytophthora infestans	28.5
Pythium irregulare	18.7
Verticillium dahliae	13.4

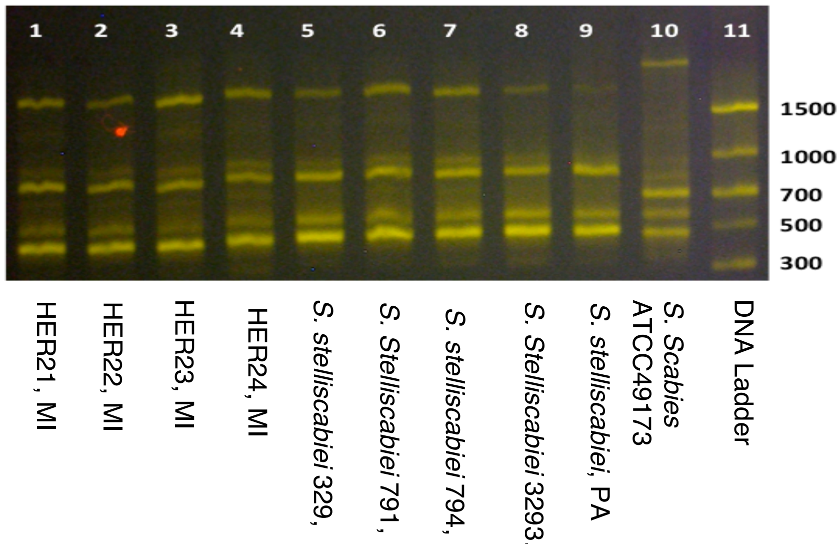


Figure 1. Electrophoresis of PCR products on agarose gel (1.2%). Genomic DNAs of the isolates were amplified using BOX-PCR. Isolates HER21 to 24 were from Michigan, and the rest were from New Your (NY), Wisconsin (WI), Massachusetts MA).

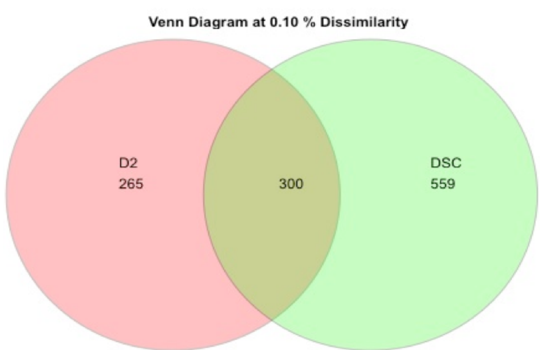


Figure 2. Venn diagram indicating shared and unique observed bacterial taxa between disease suppressive- and disease conducive- soil. Number of tax based on 10% DNA sequence dissimilarity. D2: disease conducive-soil and DSC: disease suppressive-soil. The number of taxa in groups D2, DSC and shared between groups was 565, 859, and 300 respectively. 26.69% of taxa are shared in groups D2 and DSC and the total taxa among all groups is 1,124.

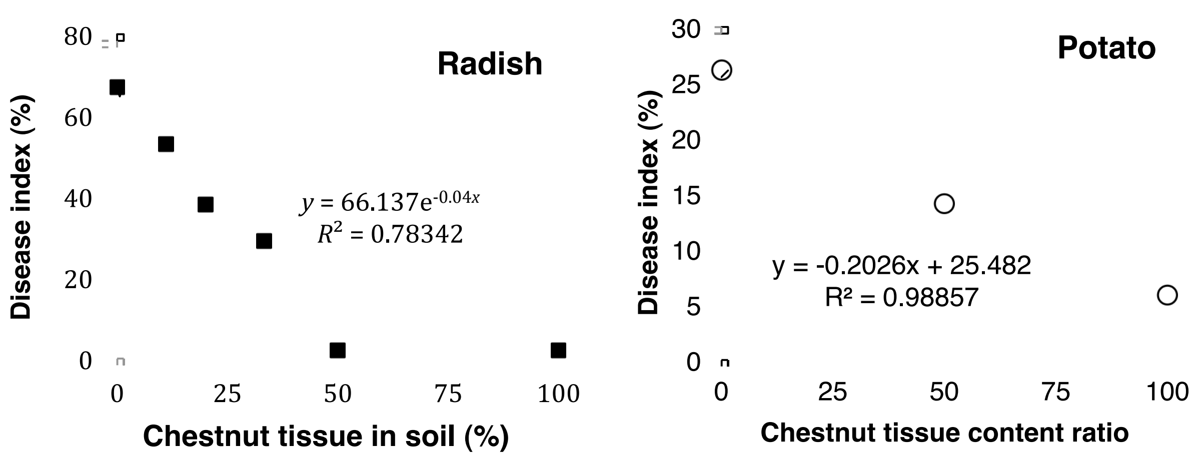


Figure 3. Effect of chestnut tissue incorporated in soil on scab disease (*Streptomyces scabies*) in potato and radish in the greenhouse.

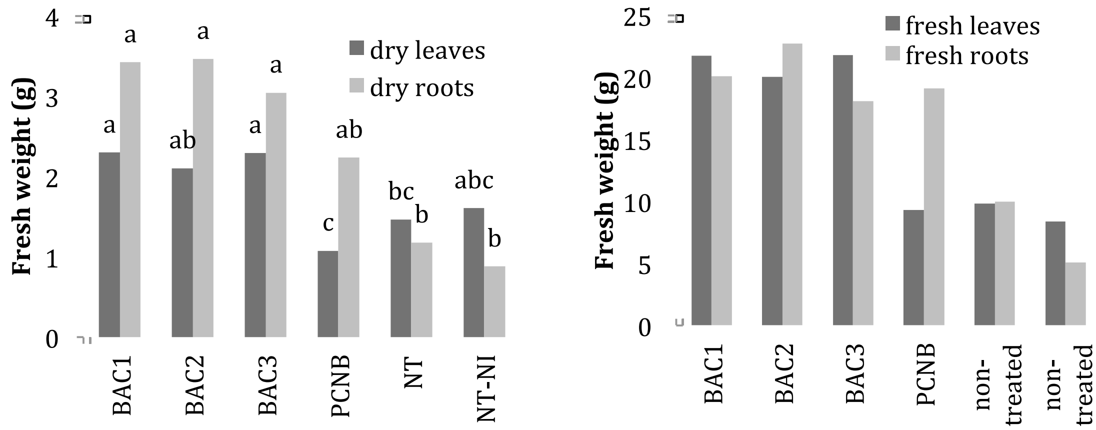


Figure 4. Effect of *Bacillus* spp. on scab caused by *Streptomyces scabies* in radish (left panel), and potato (right panel). Controls included PCNB treatment, and non treatment (NT). All pots were infested with *S. scabies* before soil treatment, except NT-NI. Multiple pair-wise comparisons were performed for leaf and root weight separately, using Fisher's least significance difference (LSD). Values followed by same letters were not significantly different at $\alpha = 0.5$.

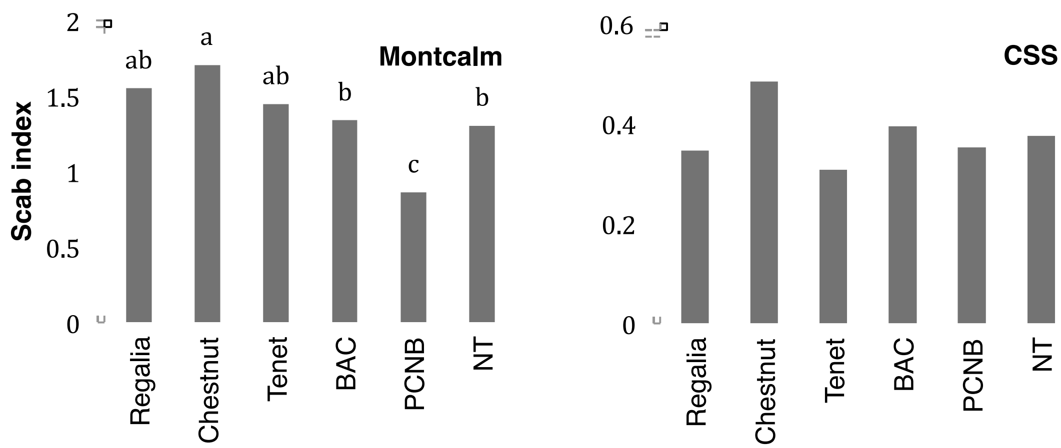


Figure 5. Soil treatment on potato common scab. Yields from different treatments were compared using Fisher's least significance difference (LSD) method at different at $\alpha = 0.5$. Values followed by the same letter were not significantly different.

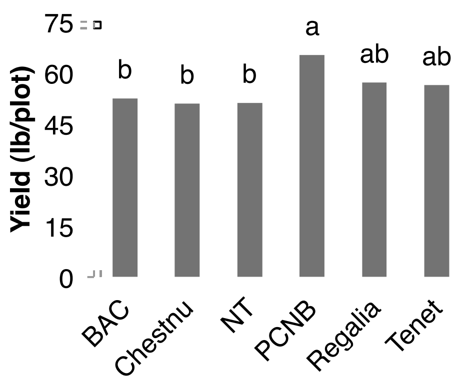


Figure 6. Effect of soil treatment on potato yield at Montcalm, 2010. Eighteen plants were harvested in each plot. Yields from different treatments were compared using Fisher's least significance difference (LSD) method at $\alpha = 0.5$. Values followed by the same letter were not significantly different.

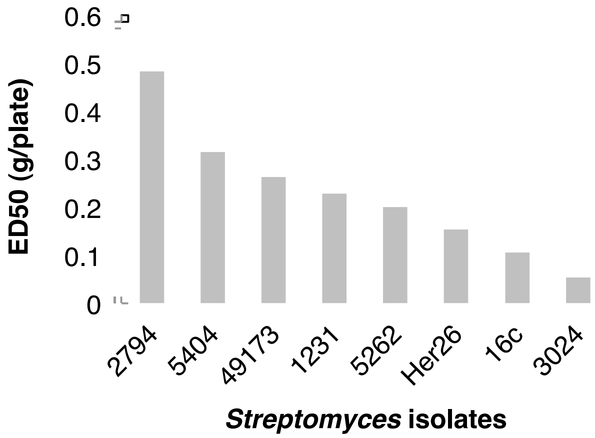


Figure 7. Effective dose of horseradish volatiles for 50% of growth inhibition (ED50) on *Streptomyces* spp. on Petri plates. A series of doses of dried horseradish were placed in a flipped Petri plate (with lip placed on the bottom and the bottom part on the top), which contained YME medium on the top and culture of Streptomyces spp. Regression was calculated based on the responses against the dosage, and ED50 was calculated using the regression equation.

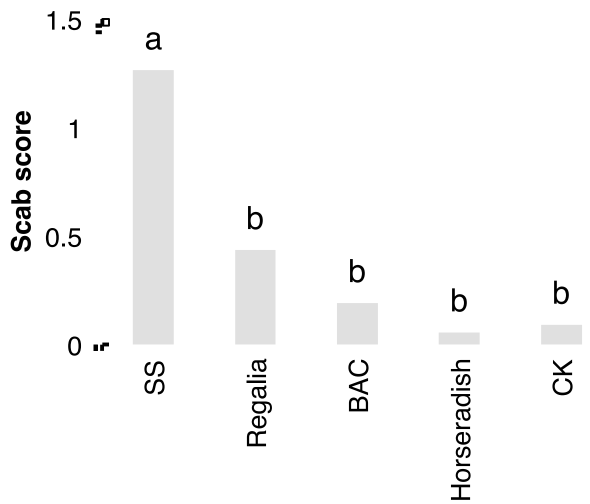


Figure 8. Effect of non-chemical compounds against potato common scab in the greenhouse. Treatments included SS: non-treatment; Regalia (5%); BAC (*Bacillus* strain BAC03) at 10^8CFU/cm^3; Horseradish @5g/gallon soil; and CK (non-treated). Prior to the treatment, soil was all infested with *S. scabies*, except CK.

2010 Research Summary

Loren G. Wernette and George W. Bird

Corky Ring-spot disease of potato (CRSD) has been detected in two Michigan potato fields, one in St. Joseph Co. and the other in Saginaw Co. The infectious agent is the Tobacco Rattle Virus (TRV) that is vectored by the Stubby-Root nematode (*Paratrichodorus pachydermus*). This virus, which can reside asymptomatically in most crop and weed species, causes sprang or necrotic brown ringing and arching in the tissue of the tuber. It does not display foliar symptoms in field settings leaving the grower unaware of any problem until the harvest is complete. The disease is not known to cause any yield loss but can reduce quality to a point that loads may be rejected from the processor if the symptom expression is severe enough or if CRSD is compounded with defects of other kinds.

The vector *P. pachydermus* is a migratory nematode that shows up in low population densities quite frequently in many sandy soils across the state of MI. Generally *P. pachydermus* is ignored, as the threshold for treatment is significantly higher than what is commonly seen (≈100/100cm^3 soil). It has the capacity to feed on most if not all rotational crops grown in a potato system including corn and wheat. It is generally found closer to the soil surface in the spring of the year when soils are higher in moisture and lower in temperature. As the soils dry and warm the nematodes move deeper into the soil profile and thus out of the range of standard sampling.

In 2009 the CRSD research that began in 2008 was continued. The location of the 2009 field site was adjacent to the field site that had been used for the 2008 CRSD research. In 2008 it had been planted to field corn, and in 2009 was planted by Walther's Farms to c.v. FL 1879. Prior to planting (May 30) specific areas of the field were fumigated with Sectagon 42 (metam sodium) at the highest labeled rate of 75 gallons/ acre. Two weeks later Vydate C-LV (Oxymyl) was applied in furrow. Throughout the growing season; starting at tuber initiation, foliar applications of Vydate C-LVwas applied at two week intervals for a total of four foliar applications. The plots were 180 feet long by 36 feet wide and were designed in a randomized block design with seven treatments being replicated four times (Table 1).

At the end of the growing season the field was desiccated and harvested (Oct. 5) with the help of Chris Long and Rob Schafer. Each plot had four ten foot sections harvested which were then placed in crates and taken to the Clarksville Research Station where they were put in storage at 50°F. One month following harvest grade A yields of each ten foot section were determined for each plot. Ten tubers were also randomly selected from each crate, a total of 40 tubers per plot. These tubers were cut bud end to stem end, and were visually inspected for the symptom expression of CRSD. The symptom expression measurements were done again three more times, at one month intervals to make sure there was no increase in symptom expression as storage time increased. Any tubers that showed symptom expression were taken back to the lab and one of three molecular test were run on them to determine the presence of the TRV virus in the tuber. RT-PCR was used in Dr. Kirk's lab, Transmission electron microscopy (TEM) was preformed to observe virus particles present in the tuber tissue, and tubers were sent to Pest Pros Inc. in Plainfield, WI to have real-time PCR run on them to determine the present and quantity of TRV.

In the 2009 study our yield ranged from 442 cwt to 488 cwt with no significant differences between any of our treatments which is what was expected. The symptom expression that was seen throughout the storage season ranged from 2.67% to 0%. The control treatment showed significantly more symptom expression than treatments that incorporated either a Vydate C-LV in furrow treatment or some amount of Vydate C-LV foliar treatment, or had Sectagon 42 applied in the spring at the highest ladled rate. The control was not however, significantly different than the Vydate C-LV alone in furrow or alone applied as a foliar application (Figure 1). When we looked at the percent symptom expression over time in storage we did not see any increase, which corresponds with work that was done by Dr. David out in North Dakota. When TEM was used to look for TRV no virus particles were seen. When Rt-PCR was used positive confirmations were rare. When symptomatic tubers were sent to Pest Pros Inc. only 33% of the tubers that were sent, came back positive for TRV and the amount of TRV that was picked up was at very low levels. This could describe the lack of TRV that was found in both the TEM and the RT-PCR.

Following the calculation of grade A yield and symptom expression the percent of symptom expression was removed from the Grade A yield and economics were run using an average potato price of $10/cwt Vydate C-LV costing $68/gallon and Sectagon 42 at $4.5/gallon. We showed that the control had the lowest economic return at only $4040, while the Vydate C-LV in furrow + 2 foliar treatments of Vydate C-LV had the highest economic return at $4672 (Table 2).

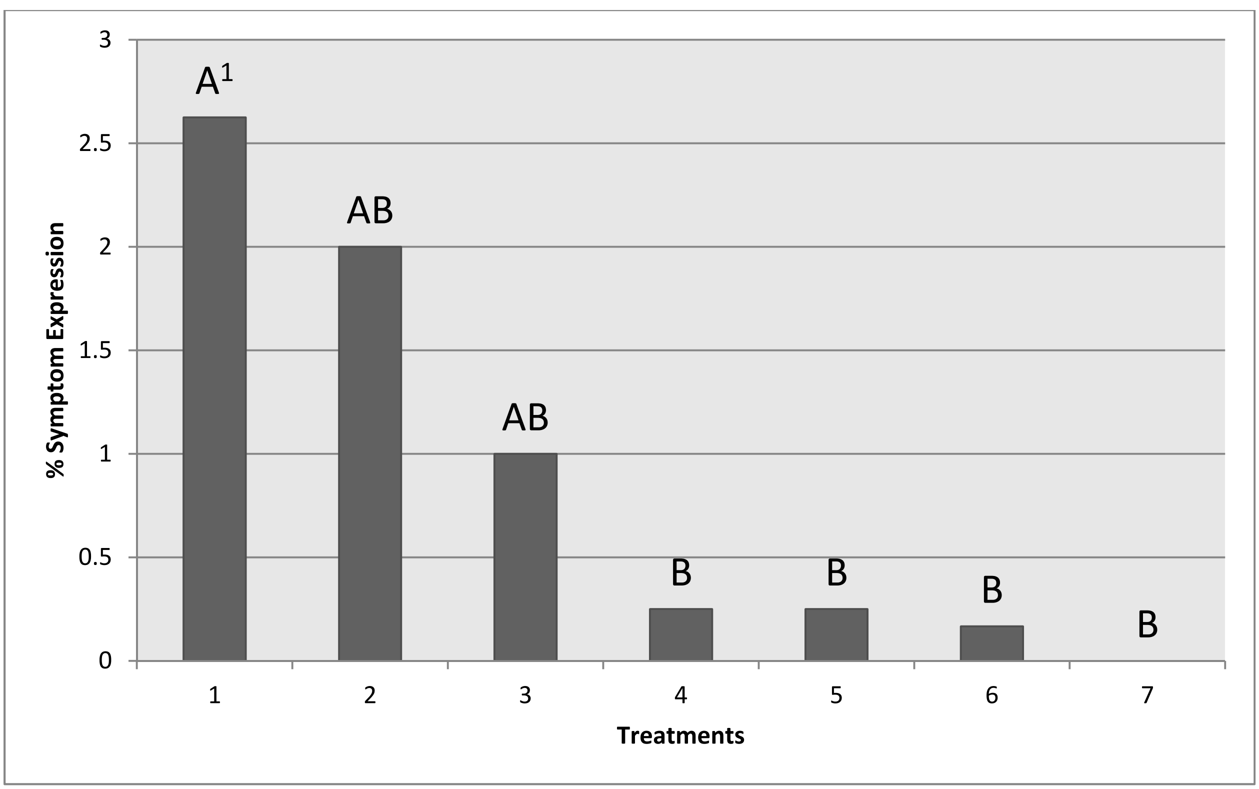
Following our 2009 research, we questioned why so few virus vectors were seen in our sampling throughout the growing season. So in the fall of 2010 a vertical distribution study was performed on both known infested fields in MI. Field 1 in St. Joseph Co. was split into five sections, 20-30 soil probes at three different depths (0-6 in, 6-12 in and 12-18 in) were sampled for each section. Two other fields were sampled at two depths (0-6 in. and 6-12 in.) in an ongoing fumigation study being conducted by Dr. Bird. The field in Saginaw Co was split into ten sections and sampled in the same way at the same three depths. Samples were taken back to the lab where the nematodes were extracted and the *Pratylenchus penetrans* (Root lesion nematode) and *Paratrichodorus pachydermus* (Stubby-root nematode) were identified and counted for each section at each depth.

We found that in the fall of the year the majority of P. pachydermus the primary vector of TRV is found below 12 inches far outside the range of standard agronomic soil sampling (Table 3). While the root lesion nematode, a major component in the Potato-Early Die complex, population densities were highest in the top 12 inches of soil (Table 4). These results will be followed up in the 2010-11 fumigation study that is being conducted by Dr. Bird.

Table 1 2009 Corky Ring-Spot Disease Research treatments

Treatment #	Chemical application (rate)
1	Control
2	4 foliar applications Vydate C-LV(2 pts/A)
3	Vydate C-LV in furrow (4 pts/A)
4	Vydate C-LV in furrow(4pts/A) + 4 foliar applications Vydate C-LV (2 pts/A)
5	Vydate C-LV in furrow (4 pts/A) + 2 foliar applications Vydate C-LV (2 pts/A)
6	Sectagon 42 (75 gallons/A)
7	Sectagon 42 (75 gallons/ Acre) + Vydate C-LV in furrow (4 pts/A)+4 foliar applications Vydate C-LV (2 pts/A)

Figure 1 2009 Corky Ring-Spot Disease Symptom expression for seven treatments



[1] Different letters indicate statistical significant differences (<0.05)

Table 2 2009 Economic returns on Corky Ring-Spot Disease Research after removing percent Symptom expression

Treatment #	Treatment	Net Return ($)/A [1]
	Control	**$4040**
	4 foliar applications Vydate C-LV	$4202
	Vydate in furrow	$4266
	Vydate in furrow **+** 4 foliar applications	$4558
	Vydate in furrow **+** 2 foliar applications	**$4672**
	Vapam 75 gallons/acre	$4543
	Vapam**+** Vydate in furrow **+** 4 foliar applications	$4401

[1] Numbers figured using a average potato price of $10/cwt, Vydate C-LV at $68/gallon and Sectagon 42 at $4.5/gallon

Table 3. Absolute and relative population densities of the vertical distribution of *Paratrichodorus pachydermus* at three soil depths associated with four potato fields in Michigan.

Location[1]	Soil Depth (cm)	Mean (range)[2] Nematodes/100 cm^3	Relative density	S.E.
Field 1				
	0-15 cm	0 (0-0) c	0.0	±0.00
	15-30 cm	2.4 (2-3) b	34.3	±0.24
	30-45 cm	4.6 (2-7) a	65.7	±0.81
Field 2				
	0-15 cm	0 (0-0) c	0.0	±0.00
	15-30 cm	0.2 (0-2) b	14.3	±0.20
	30-45 cm	1.2 (0-5) a	85.7	±0.49
Field 3				
	0-15 cm	0 (0-0) b	0.0	±0.00
	15-30 cm	0.75 (0-4) a	100.0	±0.40
Field 4				
	0-15 cm	0 (0-0)	0.0	-
	15-30 cm	0 (0-0)	0.0	-

[1] Field 1 in St. Joseph Co. (41.770256N, -85.683557W), Field 2 in Saginaw Co. (43.371647N, -84.266406W), Field 3 in Tuscola Co. (43.530707N, -83.22839W), and Field 4 in Mecosta Co. (43.514355N,-85.365533W)

[2] Column group means followed by the letters are not statistically different (P=0.05) according to Tukey's test.

Table 4. Population of *Pratylenchus penetrans* in Absolute and relative population densities four Michigan fields at multiple soil depths.

Location[1]	Soil Depth (cm)	Mean (range)[2] Nematodes/100 cm^3	Relative density	S.E.	P Value
Field 1					
	0-15 cm	28.2 (13-49) a	35.6	±6.24	
	15-30 cm	31.8 (17-46) a	40.2	±4.81	0.269
	30-45 cm	19.2 (8-35) a	24.2	±4.91	
Field 2					
	0-15 cm	3.8 (0-10) a	49.4	±1.05	
	15-30 cm	3.1 (0-8) ab	40.3	±0.85	0.035
	30-45 cm	0.8 (0-3) b	10.4	±0.33	
Field 3					
	0-15 cm	20 (0-40) b	34.2	±2.94	0.006
	15-30 cm	38.5 (12-88) a	65.8	±5.33	
Field 4					
	0-15 cm	4.6 (0-13) b	24.3	±0.80	0.001
	15-30 cm	14.3 (4-37) a	75.7	±2.52	

[1] Field 1 in St. Joseph Co. (41.770256N, -85.683557W), Field 2 in Saginaw Co. (43.371647N, -84.266406W), Field 3 in Tuscola Co. (43.530707N, -83.22839W), and Field 4 in Mecosta Co. (43.514355N,-85.365533W)

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2009-2010 DR. B. F. (BURT) CARGILL POTATO DEMONSTRATION STORAGE ANNUAL REPORT MICHIGAN POTATO INDUSTRY COMMISSION

Chris Long, Coordinator

Introduction and Acknowledgements

Round white potato production leads the potato market in the state of Michigan. Michigan growers continue to look for promising new, round white varieties that will meet necessary production and processing criteria. There are many variety trials underway in Michigan that are evaluating chipping varieties for yield, solids, disease resistance and chipping quality with the hope of exhibiting to growers and processors the positive attributes of these lines. Extended storage chip quality and storability are areas of extreme importance in round white potato production. Due to the importance of these factors, all new varieties that have the potential to become a commercial chip processor will have storage profiles developed. Being able to examine new varieties for long-term storage and processing ability is a way to keep the Michigan chip industry at the leading edge of the snack food industry. This information can position the industry to make informed decisions about the value of adopting these varieties into commercial production.

The Michigan Potato Industry Commission (MPIC) Burt Cargill Potato Demonstration Storage facility currently consists of two structures. The first building, constructed in 1999, provides the Michigan potato industry the opportunity to generate storage and chip quality information on newly identified chip processing clones. This information will help to establish the commercial potential of these new varieties. This demonstration storage facility utilizes six, 550 cwt. bulk bins (Bins 1-6) that have independent ventilation systems. The second structure built in 2008, has three 600 cwt. bulk bins that are independently ventilated. The first of these bulk bins, bin seven, has been converted into box bin storage that holds 36, 10 cwt. box bins to provide storage profiles on early generation potato varieties. The box bin is an entry level point in storage profiling that allows the industry to learn about a varieties' storability before advancing to the bulk bin level. We would typically have 4-6 years' worth of agronomic data on a variety before entering box bin testing. In the variety development process, little information has been collected about a varieties' storability or storage profile prior to being included in the box bin trial. A storage profile consists of bi-weekly sampling of potatoes to obtain; sucrose and glucose levels, chip color and defect values. In addition, each variety is evaluated for weight loss or shrinkage and pressure bruise. With this information, the storage history of a variety can be created, providing the industry with a clearer picture of where a line can or cannot be utilized in the snack food industry. The Michigan potato industry hopes to use these storage profiles to improve in areas such as long-term storage quality, deliverability of product and, ultimately, sustained market share.

The two remaining 600 cwt. bulk bins in the second structure are designed to be used to evaluate the post-harvest physiology of the potato. The facility can be used to evaluate storage pathology or sprout inhibitor products. The Michigan industry recognizes the importance of being able to control disease and sprout development in storage and is committed to doing research in these areas.

This ninth annual Demonstration Storage Report contains the results of the storage work conducted in the facility during the 2009-2010 storage season. Section I, “2009-2010 New Chip Processing Variety Box Bin Report”, contains the results and highlights from our 10 cwt. Box Bin study. Section II, “2009-2010 Bulk Bin (500 cwt. Bin) Report”, shows bulk bin results including information from commercial processors regarding these new varieties.

The storage facility and the work done within it is directed by the MPIC Storage and Handling Committee and Michigan State University (MSU) faculty. The Chair of the committee is Brian Sackett of Sackett Potatoes. Other members of the committee include: Bruce Sackett, Steve Crooks, Todd Forbush, Chris Long, Troy Sackett, Dennis Iott, Randy Styma, Keith Tinsey, Ben Kudwa and Tim Young. The funding and financial support for this facility, and the research that is conducted within it, is largely derived from the MPIC. The committee occasionally receives support for a given project from private and/or public interests.

We wish to acknowledge all the support and investment we receive to operate and conduct storage research. First, we express our gratitude for the partnership we enjoy between the MPIC and Michigan State University. Thank you to the MPIC Storage & Handling Committee for their investment of time, guiding the decisions and direction of the facility. Brian Sackett, Sackett Potatoes; Larry and Troy Sackett, Sackett Ranch, Inc.; Steve, Norm and John Crooks, Crooks Farms, Inc.; Tim and Todd Young, Sandyland Farms and Kim and Kyle Lennard, Lennard Ag Co.; these are the growers that provided the material to fill the bulk bins this year and without their willingness to be involved, we could not have accomplished our objectives. Equal in importance are the processors who invested in this research. They are; Gene Herr, Herr Foods Inc., Nottingham, PA; Mitch Keeny of UTZ Quality Foods, Inc., Hanover, PA; Al Lee and Paul Geiser of Better Made Snack Foods, Detroit , MI. It has been a great pleasure to work with all of you. Special thanks to Butch and William Riley (Gun Valley Ag. & Industrial Services, Inc.) for their annual investment in the sprout treatment of the storage facility. We would also like to acknowledge a long list of additional contributors who invested much time to help foster a quality storage program: Dr. Dick Chase (MSU Professor Emeritus), Dr. Dave Douches and the MSU potato breeding program, Todd Forbush (Techmark, Inc), Larry Jensen (Chief Wabasis Potato Growers), and Tim Wilkes (Potato Services of Michigan). All played a role in making this facility useful to the Michigan potato industry.

Overview of the production season *

The overall 6-month average maximum temperature during the 2009 growing season was two degrees lower than the 6-month average maximum temperature for the 2008 season and was one degree lower than the 15-year average. There were three recorded temperature readings of 90 °F or above in 2009. This high temperature event was recorded during a period of time from June 23rd to June 25th, prior to tuber bulking. There were no recorded daytime temperatures above 90 °F or night time temperatures above 70 °F in the month of August. There were two days in May that the air temperature was below 32 °F. This occurred on May 11th and 18th. The average maximum temperatures for July, and August 2009 were six and three degrees below the 15-year average, respectively. In October 2009, there were 15 days with measureable rainfall and eight daytime highs below 50 °F. Six of these eight days fell on days with no recorded rainfall, leaving only 10 days in October that had no rain and temperatures above 50 °F.

Rainfall for April through September was 16.82 inches, which was 2.4 inches below the 15-year average. Rainfall recorded during the month of August was the highest recorded for that month since the year 2002. In October 2009, 3.79 inches of rain were recorded. Overall, the 2009 growing season resulted in above average specific gravity with average overall yields. The early part of the season was cool and dry. The harvest season was generally wet and cool.

* Weather data collected at the MSU, Montcalm Research Farm, Entrican, MI.

I. 2009-2010 New Chip Processing Variety Box Bin Report

(Chris Long and Brian Sackett)

Introduction

The purpose of this project is to evaluate new chip processing varieties from national and private breeding programs for their ability to process after being subjected to storage conditions. A variety's response to pile temperature, as reflected in sucrose and glucose levels, is evaluated. Weight loss and pressure bruise susceptibility of each variety is also evaluated. Bin 7 contained 36, 10 cwt. boxes. Thirty-six boxes were placed in six stacks of six. The boxes were designed for air to travel in from a header or plenum wall through the forklift holes of each box, up through the potatoes within it and onto the next box above until the air reaches the top and is drawn off the top of the chamber, reconditioned and forced back through the header wall plenums and up through the boxes again. Each box contains a sample door facing the center aisle from which tubers can be removed to conduct bi-weekly quality evaluations.

Procedure

Sixteen new varieties were evaluated and compared to the check variety Snowden. The 16 varieties were chosen by the MPIC Storage and Handling Committee. Once the varieties were chosen, 1 cwt. of each variety was planted on May 12th at the MSU, Montcalm Research Farm, Entrican, MI. The varieties were planted at a 10" spacing with the Snowden check variety being planted at 12". All varieties received a rate of fertilizer recommended to achieve a 350 to 400 cwt/A yield (270 lb. N/A). The varieties were vine killed after 114 days and allowed to set skins for 20 days before harvest on September 23, 2009; 134 days after planting. Variety maturity is not taken into account in the harvest timing due to storage and handling restrictions.

Approximately ten cwt. of each variety was placed in each box bin, labeled and stacked in Bin 7. The average storage temperature for all the box bins (Bulk Bin 7) was 55 ºF for the 2009-2010 season. At harvest, nine, 20 lb. samples from each variety were collected for weight loss and pressure bruise evaluation. Some additional tuber samples were taken and shipped to regional chip plants for evaluation throughout the storage season. A description of the varieties tested, their pedigree and scab ratings are listed in Table 1. Yield, size distribution, chip quality, and specific gravity were recorded at harvest (Table 2). All 17 varieties were graded to remove all "B" size tubers and pick-outs and entered the storage in good physical condition.

The storage season began September 23, 2009 and ended June 1, 2010. Bin 7 was gassed with CIPC on November 2nd 2009 and again on December 7th 2009. Variety evaluation began October 7th 2009 followed by a bi-weekly sampling schedule until June. Thirty tubers were removed from each box every two weeks and sent to Techmark, Inc. for sucrose, glucose, chip color and defect evaluation. Nine pressure bruise sample bags were taken for each variety, weighed and placed in one of the bulk bins at the storage facility. Three bags were placed at each of 3', 6' and 9' from the pile floor. When that bin was unloaded, the sample bags were weighed and percent weight loss was calculated. A 25 tuber sample was taken from each of the nine bags and was evaluated for the presence or absence of pressure bruise. The number of tubers and severity of bruise were recorded. All pressure bruises were evaluated for discoloration.

This report is not intended to be an archive of all the data that was generated for the box bin trial, but a summary of the data from the most promising lines. The purpose of this report is to present a summary of information from 2-4 lines from this trial that will be moved along the commercialization process. If more detailed information is desired, please contact Chris Long at Michigan State University in the Crop and Soil Sciences Department for assistance (517) 355-0271 ext. 1193.

Table 1. 2009 MPIC Demonstration Box Bin Variety Descriptions

Entry	Pedigree	2009 Scab Rating*	Characteristics
Snowden (W855)	B5141-6 X Wischip	2.3	High yield, late maturity, late season storage check variety, reconditions well in storage, medium to high specific gravity
A00188-3C	A91790-13 X Dakota Pearl	1.3	High U.S. No. 1 yield, scaly buff skin, high specific gravity
A01143-3C	COA95070-8 X Chipeta	1.3	High yielding, scaly buff chipper; smaller tuber size
CO00188-4W	A90490-1W X BC0894-2W	2.0	Medium-high yield potential, small tuber size, minimal grade defects, medium-early maturity, high specific gravity, some ability to recondition out of 40º F
CO00197-3W	A91790-13W X NDTX4930-5W	3.1	High yield potential, small size profile, minimal grade defects, early maturity, medium-high specific gravity, some ability to recondition out of 40º F
CO00270-7W	BC0894-2W X A91790-13W	2.8	Medium-high yield potential, minimal grade defects, medium-early maturity, medium-high specific gravity, ability to recondition out of 40º F
MSH228-6	MSC127-3 X OP	1.3	Average yield, mid-season maturity, blocky flat tuber type, shallow eyes, medium specific gravity
MSJ126-9Y	Penta X OP	1.3	Medium-high yield, cold chipper from 45º F, uniform A-size tubers, attractive appearance, good internal quality, long term storage potential, medium specific gravity
MSL007-B	MSA105-1 X MSG227-2	1.0	Average yield, early to mid-season maturity, uniform tuber type, medium specific gravity, scab resistant
MSL292-A	Snowden X MSH098-2	2.3	Above average yield, scab susceptible, late blight susceptible, medium-high specific gravity, long storage potential
MSN170-A	MSI055-5 X MSG227-2	1.3	Flattened blocky round type, some early bulking, scab resistant
MSP459-5	Marcy X NY121	1.8	Bright chips, low incidence of defects, medium specific gravity
MSQ070-1	MSK061-4 X Missaukee	1.3	Round tuber type, late maturity, scab and late blight resistant, high specific gravity, strong vine and roots
MSQ279-1	Boulder X Pike	1.4	High yield, large round tubers, good internal qualities
MSR061-1	W1201 X NY121	1.1	Average yield, round tuber type with netted skin, low sugars, PVY resistant, moderate late blight resistance

*Scab rating based on 0-5 scale; 0 = most resistant and 5 = most susceptible

Entry	Pedigree	2009 Scab Rating*	Characteristics
NY 139 (Y28-9)	NY120 X NY115	1.5	High yield, mid-late season maturity, medium specific gravity
W5015-12	Brodick X W1355-1	-	Relative high tuber set and yield, medium-late vine maturity, uniform size tubers, tubers tend toward flat shape, very flat in some environments

*Scab rating based on 0-5 scale; 0 = most resistant and 5 = most susceptible

Table 2. 2009 Michigan Potato Industry Commission Box Bin Processing Potato Variety Trial

2009 MPIC Box Bin Processing Potato Variety Trial
Montcalm Research Farm, Montcalm County, MI

Harvest 23-Sep-09 134 Days

DD, Base 40[6] 2703

	CWT/A		PERCENT OF TOTAL[1]						CHIP	TUBER QUALITY[2]				TOTAL	VINE	VINE		CHIP
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	SCORE[3]	HH	VD	IBS	BC	CUT	VIGOR[4]	MATURITY[5]	COMMENTS	COMMENTS
MSH228-6	297	315	94	6	89	5	0	1.079	1.0	1	2	0	0	10	2.0	4.5	flat oval, tr surface scab	1 SED
NY139	263	296	89	11	89	0	0	1.083	1.0	0	2	0	0	10	3.0	3.5	tr surface scab	
MSQ279-1	238	301	79	20	67	12	1	1.084	2.0	1	0	0	0	10	2.0	4.5	gc in pickouts, tr surface scab, sheep nose	many chips with discoloration
A00188-3C	228	302	76	24	74	2	0	1.082	1.0	2	1	0	5	10	2.5	3.5		
CO00197-3W	226	297	76	20	76	0	4	1.080	1.0	0	3	0	0	10	2.0	3.5	gr and misshapen in pickouts	
A01143-3C	225	297	76	21	74	2	3	1.078	1.0	0	0	0	0	10	2.0	4.5	misshapen in pickouts	
MSN170-A	219	242	91	8	79	12	1	1.084	1.0	0	0	0	0	10	1.5	3.5	misshapen in pickouts, nice size and profile	
MSQ070-1	214	274	77	23	74	3	0	1.090	1.0	2	0	0	0	10	2.0	4.5	round uniform type	4 SED
MSL292-A	207	257	81	19	79	2	0	1.081	1.0	1	1	0	0	10	2.5	3.5	uniform type	
Snowden	**196**	**234**	**84**	**16**	**84**	**0**	**0**	**1.085**	**1.0**	**1**	**2**	**0**	**0**	**10**	**2.0**	**3.5**		
CO00270-7W	183	221	83	16	81	2	1	1.079	1.0	0	2	0	0	10	2.0	2.5	pitted scab	
W5015-12	178	247	72	26	69	3	2	1.086	1.0	0	3	0	0	10	2.0	4.5	russeted skin	
MSL007-B	176	231	76	24	76	0	0	1.080	1.0	0	1	0	0	10	1.5	3.5	nice uniform type	
MSP459-5	170	219	78	21	76	2	1	1.080	1.0	1	0	0	0	10	1.5	2.5	sl sheep nose	
MSR061-1	155	219	71	29	68	3	0	1.082	1.0	2	0	0	0	10	2.0	3.5		
MSJ126-9Y	118	152	78	16	78	0	6	1.077	1.5	0	0	0	0	10	1.0	2.5	misshapen in pickouts, small size	3 SED
CO00188-4W	92	181	51	49	51	0	0	1.083	1.0	0	0	0	0	10	2.5	1.5	small bright appearance	
MEAN	**199**	**252**	**78**					**1.082**										

tr = trace, sl = slight, N/A = not applicable

SED = stem end defect, gc = growth crack

[1]SIZE	[2]TUBER QUALITY (number of tubers per total cut)	[3]CHIP COLOR SCORE - Snack Food Association	[4]VINE VIGOR RATING	[5]VINE MATURITY RATING		
					Planted:	12-May-09
Bs: < 1 7/8"	HH: Hollow Heart	(Out of the field)	Date Taken: 15-Jun-09	Date Taken: 14-Aug-09	Vines Killed:	3-Sep-09
As: 1 7/8" - 3.25"	VD: Vascular Discoloration	Ratings: 1 - 5	Ratings: 1 - 5	Ratings: 1 - 5	Days from Planting to Vine Kill:	114
OV: > 3.25"	IBS: Internal Brown Spot	1: Excellent	1: Slow Emergence	1: Early (vines completely dead)	Seed Spacing:	10"
PO: Pickouts	BC: Brown Center	5: Poor	5: Early Emergence (vigorous vine, some flowering)	5: Late (vigorous vine, some flowering)	No Fumigation	

[6]MAWN STATION: Entrican
Planting to Vine Kil

Results: 2009-2010 New Chip Processing Box Bin Report

MSH228-6

MSH228-6 is a Michigan State University (MSU) developed common scab resistant, chip processing variety. This variety has a tuber set of six to eight tubers that are round to oval in shape with a strong netted skin. The specific gravity was medium and was the highest recorded yielding variety in the 2009 Box Bin Trial (Table 2). The variety appeared to have a late maturity and a small set suggesting that this variety should be planted at an eight inch in-row seed spacing and managed for a 130 to 140 growing day maturity. This variety has a Snowden-like storage profile, exhibiting the ability to store well into March in most years. During the 2009-2010 storage season, MSH228-6 was placed into storage on September 23rd 2009 having a sucrose value of 0.634 mg/g (X10) and a glucose value of 0.005 mg/g. These values decreased quickly until early March 2010 when the sucrose levels began to increase. A chip picture is included from March 15th 2010 to show the chip quality during this period. Tuber weight loss data that was collected during the storage season showed a 1.86 percent average weight loss in the sample collected with 2.2 percent of the tubers exhibiting pressure bruising and discoloration under the bruises. Overall, this variety performed well enough to warrant further large scale commercial testing in hopes of replacing some Snowden acreage with a variety that has common scab resistance. The storability of MSH228-6 is similar to Snowden but the common scab tolerance of this variety is its big advantage.

MSL292-A

This MSU variety exhibited an average yield of "A" sized tubers with a good processing specific gravity. The 2009 Box Bin Trial recorded this clone yielding 207 cwt./A US#1 (Table 2). The tuber type and size of MSL292-A is uniform and round. The overall Box Bin Trial in 2009 performed below expectations, possibly due to a colder growing season. The long term chip quality of MSL292-A has been excellent. The vine maturity for MSL292-A is medium-late. A ten inch in-row seed spacing would be recommended for this variety. On September 23rd 2009, this variety was put into storage with a 0.819 mg/g (X10) sucrose rating and a 0.005 mg/g glucose value. Sucrose and glucose levels came down to their lowest points in mid-March at 0.488 and 0.001, respectively. At this point in storage, the sucrose values began to rise to 0.785 in early June 2009. From late March 2010 until June 1st 2010, the glucose level remained at or below 0.005 mg/g. Total defects recorded for this variety on May 24th 2010 were 6.9 percent, resulting largely from free internal glucose present in the tubers which can be observed in the picture above. The percent weight loss recorded for this variety was 2.25 with only 3.1 percent of the tubers evaluated expressing bruise with discoloration under the surface. The only negative aspect to this clone is the lack of strong common scab tolerance. Overall, this variety has great yield potential and excellent long term storability for chip processing. This variety has the potential to store and chip process in early June most seasons.

MSQ279-1

This MSU developed clone is known for good mid-season storage chip quality, as well as common scab tolerance. MSQ279-1 has a large uniform round type, a medium netted skin. The common scab tolerance is similar to Pike. The specific gravity ranges from 1.075 to 1.084. The vine type has tended to be strong and upright. In the 2009 Box Bin Trial, MSQ279-1 was third from the top in yield. It produced 238 cwt./A US#1 (Table 2). The internal tuber quality appeared to be good and the vine maturity of the variety is medium-late. On September 23rd 2009 these tubers were placed into storage. The sucrose level appeared to be elevated at 1.208 mg/g (X10). The sucrose level did come down steadily into early February 2010. The glucose and sugar related defects remained low into early March. During early March 2010, the sucrose rating began to increase. MSQ279-1 is pictured above on March 1st 2010 with a 0.604 sucrose rating and 0.002 glucose value. The percent weight loss recorded was moderate at 3.58 percent, with 14.2 percent of the tubers exhibiting pressure bruise with discoloration under the skin. This number was quite high and the pressure bruise susceptibility of this line needs to be monitored closely as we move forward. Overall, this variety yielded well and the common scab tolerance is good. This variety, although exhibiting a few reasons for concern, has shown good yield, mid-season chip quality and common scab tolerance thus warranting further testing.

NY139

This Cornell University developed clone can have a slightly elongated and pear shaped type, but has great yield potential, excellent chip quality and some moderate common scab tolerance. In the 2009 Box Bin Trial, this variety yielded above the trial average at 263 cwt./A US#1 (Table 2). NY139 expresses better common scab tolerance and longer term chip quality than the check variety Snowden. The vine maturity for NY139 is medium-late. A ten inch in-row seed spacing would be recommended for this variety because it can oversize. NY139 was placed into storage on September 23rd 2009 with a 1.322 mg/g (X10) sucrose rating and a 0.006 mg/g glucose value. The sucrose and glucose levels were at their lowest in early January and by mid-April chip defects began to appear. The picture above shows NY139 in mid-April prior to an increase in chip color related defects. The tuber percent weight loss was the lowest of these four lines reported at 1.84 percent with 4 percent of the tubers having bruise and discoloration under the skin. Overall, this variety has great commercial potential. Its yield and chip quality provide the industry with some potential opportunities.

W5015-12

This University of Wisconsin developed clone has a nice uniform type, great yield potential and good chip quality. In the 2009 Box Bin Trial, this variety yielded below the trial average at 178 cwt./A US#1 (Table 2). This variety did not yield well under the much cooler growing conditions of the 2009 growing season. This variety has exhibited much higher yield potential than it displayed in 2009. W5015-12 has some common scab susceptibility much like the check variety Snowden. The vine maturity for W5015-12 is medium-late. A 10 inch in-row seed spacing would be recommended for this variety. W5015-12 was placed into storage on September 23rd 2009 with a 1.202 mg/g (X10) sucrose rating and a 0.016 mg/g glucose value. The sucrose and glucose levels were at their lowest in late December 2009 and by late February, chip defects cleaned-up and chip quality appeared to be quite good. The picture above shows W5015-12 in early March, prior to an increase in chip color related defects. The tuber percent weight loss was reported at 2.66 percent with 6.2 percent of the tubers having bruise and discoloration under the skin. Overall, this variety has good commercial potential. Its yield and chip quality provide the industry with some potential opportunities, but caution must be taken with the lines common scab susceptibility.

II. 2009 - 2010 Bulk Bin (500 cwt. Bin) Report

(Brian Sackett and Chris Long)

Introduction

The goal of the MPIC Storage and Handling Committee for the 2009-2010 bulk bin storage season was to develop storage profiles on six promising advanced seedlings and evaluate the effectiveness of Ethylene as a sprout inhibitor, for chip processing potatoes, on the Snowden variety. The first variety tested for storage profiling was Kalkaska, a clone from the potato breeding program at Michigan State University (MSU). This clone has a strong yield potential, early die tolerance and good common scab resistance. Kalkaska was also tested in a bulk bin in the 2008-2009 storage season. The second variety, MSH228-6, is an MSU developed clone that has good common scab tolerance, an oval to oblong type and a storage profile similar to Snowden. MSJ126-9Y, the third variety of interest, is an MSU developed clone with good agronomic quality, common scab resistance and yellow flesh. MSJ147-1 was the fourth MSU line tested in the bulk bins in 2009-2010. The variety is uniform in size, a moderate yielding line, with very good late season storage quality for chip processing. The fifth variety tested in the bulk bin storage was CO95051-7W. This University of Colorado developed clone has some common scab tolerance and good long term chip quality from cold storage. Yield potential is moderate with uniform round tuber type. Bulk bin number 6 contained a new promising russet line from Aberdeen, ID. The name of this variety is Classic Russet (A95109-1). Classic Russet has a uniform blocky type, nice uniform russeted skin and good yield potential.

For each of the varieties listed above a brief description of agronomic and storage performance is provided. In addition, a short description of pressure bruise susceptibility, chip color and color defects, sugar accumulation and overall chip quality are given. With this information, a clearer perspective can be obtained regarding the viability of these varieties in commercial production.

The goal of the Ethylene Sprout Inhibitor Study was to determine the commercial viability of ethylene gas as a sprout inhibitor in chip processing potatoes and to evaluate the feasibility of replacing CIPC as the industry standard sprout inhibitor. Of particular interest in this study is the ability of ethylene gas to control sprouts adequately while maintaining tuber quality, but most importantly, to see if the ethylene gas would have a negative effect on tuber sugar quality. Sucrose and glucose was evaluated bi-weekly throughout the study and a sprout evaluation was performed at the time of bin unloading to establish the differences in sprout control between the two sprout inhibitor products.

Procedure

Each bin was filled under contract with potato producers in the state of Michigan. MPIC paid field contract price for the potatoes to be delivered to the demonstration storage. Pressure bruise samples were taken and designated bulk bins were filled. The varieties and their storage management strategies were established by the MPIC Storage and Handling Committee. For each bulk bin filled, a corresponding box bin containing 10 cwt. was filled and placed into Bin 7. Bin 7 was held at a warmer temperature, in most cases, than the corresponding bulk bin of the same variety. Sugar sampling for the box bin was carried out longer into the storage season, in general, than the bulk bin. This allowed the committee to see if the warmer storage temperature in the box bin would reduce storage life and provided information as to how the bulk bin might physiologically age.

In the 2009-2010 storage season; Bin 1 was filled with Kalkaska; Bin 2 was filled with MSH228-6; Bin 3 was filled with MSJ126-9Y; Bin 4 was filled with MSJ147-1; Bin 5 with CO95051-7W and Bin 6 was filled with Classic Russet (A95109-1). The Snowden's in Bin 8 were treated with the industry standard CIPC sprout treatment while Bin 9 was exposed to ethylene gas under controlled conditions.

Kalkaska was grown by Sackett Potatoes and was loaded into Bin 1 on September 18, 2009. It was planted April 18, 2009, and vine killed on August 19, 2009 (124 DAP, GDD_{40} 2660). The variety was harvested September 18, 2009; 154 days after planting. The pulp temperature for Kalkaska at bin loading was 68.0 ºF. A blackspot bruise sample was taken on this variety at the time of bin loading. The results indicated that the tubers were 87% bruise free.

MSH228-6 was grown by Lennard Ag. Co. and was loaded into Bin 2 on September 28, 2009. It was planted May 22, 2009, vine killed September 15, 2009 (117 DAP, GDD_{40} 2832) and harvested September 27, 2009; 129 days after planting. MSH228-6 pulp temperature at bin loading was 56.0 ºF. A blackspot bruise sample was taken on this variety at the time of bin loading and indicated that the tubers were 68% bruise free.

MSJ126-9Y was grown by Thorlund Brothers and was loaded into Bin 3 on October 21, 2009. It was planted May 23, 2009, and vine killed on September 18, 2009 (119 DAP, GDD_{40} 2883). The variety was harvested October 21, 2009; 152 days after planting. The pulp temperature for MSJ126-9Y at bin loading was 63.0 ºF. A blackspot bruise sample was taken on this variety at the time of bin loading. The results indicated that the tubers were 81% bruise free.

MSJ147-1, in Bin 4, was grown by Sandyland Farms and was loaded into storage on October 20, 2009 with a pulp temperature of 50.0 ºF. It was planted May 30, 2009, vine killed September 16, 2009 (110 DAP, GDD_{40}

2714) and harvested October 20, 2009; 144 days after planting. A blackspot bruise sample was taken on this variety at the time of bin loading and indicated that the tubers where 75% bruise free.

CO95051-7W was grown by Sackett Ranch and was loaded into Bin 5 on October 22, 2009. It was planted May 20, 2009, vine killed September 4, 2009 (108 DAP, GDD_{40} 2618) and harvested October 22, 2009; 156 days after planting. The pulp temperature of CO95051-7W at bin loading was 54.0 ºF. A blackspot bruise sample was taken on this variety at the time of bin loading and indicated that the tubers were 78% bruise free.

Classic Russet was grown by Sandyland Farms and was loaded into Bin 6 on October 21, 2009. It was planted May 18, 2009, and vine killed on September 2, 2009 (108 DAP, GDD_{40} 2608). The variety was harvested October 21, 2009; 157 days after planting. The pulp temperature for Classic Russet at bin loading was 54.0 ºF. A blackspot bruise sample was taken on this variety at the time of bin loading. The results indicated that the tubers were 67% bruise free.

The potatoes placed in Bins 8 and 9 were grown by Johnson Farms, Howard City, MI. Bin 8, Snowden, (Standard CIPC Sprout Treatment) was planted May 20, 2009 and vine killed on September 12, 2009 (116 DAP, GDD_{40} 2822). Harvest took place on October 8, 2009; 142 days after planting. The potatoes were loaded into the bin on October 8, 2009 with a pulp temperature of 54.2 ºF. A blackspot bruise sample was taken on this variety at the time of bin loading and indicated that the tubers where 70% bruise free. The potatoes in Bin 9, Snowden (Ethylene Treated), were identical to the potatoes in Bin 8, thus planting, vine kill, harvest and bin loading dates are identical. A blackspot bruise sample was taken on these Snowdens as they went into Bin 9 and indicated that the tubers were 73% bruise free. The pulp temperature, at filling, remained the same for both Bins 8 and 9 at 54.2 ºF.

Bulk Bin 8 was the control bin for the ethylene versus CIPC study. The Snowden potatoes in this bin were managed in a manner consistent with commercial grower storage practices. Bin 9 was the treatment bin. The ethylene concentration in this bin was regulated by an “Ethylene Management Unit” (EMU) developed by the BioFresh Co., United Kingdom. The EMU measured baseline ethylene levels of the inlet air, as well as, the ethylene concentration in the return air of the treatment bin. The EMU had a 200 liter cylinder of commercial grade ethylene gas connected to it. The EMU regulated the injection of this gas into the supply air of the storage to maintain an ethylene set point concentration measured in parts per million (ppm). The tubers were loaded into both Bins 8 and 9 the same day (October 8, 2009) and allowed to wound heal at 54.0 ºF for two weeks. The relative humidity was maintained at 98 percent in both bins. The ethylene injection began on October 20, 2009 and was maintained at 0.1 ppm continually for 7 days (7 Days After First Treatment (DAFT)). At the conclusion of this time period the concentration of ethylene was increased to 0.3 for 7 days (14 DAFT). The ethylene concentration was increased every 7 days from October 20, 2009 until November 24, 2009. This time period represents 5 increases in ethylene concentration. The ethylene concentration in ppm was increased based on the following ranges; 0.1, 0.3, 0.6, 1.0 and 2.0 ppm. Bin 9 remained at each of these ethylene levels for 7 days. On November 24, 2009, the ethylene concentration was increased again to 4.0 ppm and remained at this level for 14 days (49 DAFT). On December 8, 2009, the ethylene level was increased to 8.0 ppm and remained at this level until December 22, 2009 (63 DAFT). Finally, on the 63rd day after the first treatment, the ethylene level was increased for the last time to 10.0 ppm and remained there for the duration of the study.

Sucrose and glucose values were evaluated and compared across treatments for both Bins 8 and 9 throughout the sprout inhibitor study. A comparison of sprout suppression was made between treatments by evaluating 3 replicates of 10 tubers from five locations in the potato bulk pile for each treatment. These locations were identified as the following; the sample door, 3 feet above the pile floor, 6-8 feet above the pile floor, 12-14 feet above the pile floor and the top of the pile. At bin loading, three, 25 pound tuber samples were placed in the pile, for sprout evaluation, at each of these locations. At the time of sprout evaluation on January 18, 2010, each of the 10 tuber replicate samples were weighed (150 tubers total per treatment), the number of eyes present were recorded, the number of eyes that were sprouted and 2-5 mm in length were recorded, the number of eyes sprouted greater than 5mm were recorded and the length of the longest sprout was recorded. The sprouts that were recorded as 2 mm and greater in length were removed by hand and the 10 tuber samples were weighed again. The mean was established for; the mass of sprouts, the number of eyes, the number of eyes sprouting 2-5 mm, the number of eyes sprouting greater than 5 mm and the length of the longest sprout in mm. The means of the two treatments were compared to establish effectiveness of sprout control for the two products.

Bins 1,2 and 8 were gassed with CIPC on November 2, 2009. On November 25, 2009 Bins 3, 4, 5 and 6 were gassed with CIPC. Bin monitoring began the day the tubers were placed into storage and were evaluated on a two week sampling schedule thereafter. Forty tubers were removed from the sample door in each bin every two weeks and sent to Techmark, Inc. for sucrose, glucose, chip color and defect evaluation. The sample door is located in the center back side of each storage bin and is an access door that allows samples to be taken from the pile three feet above the bottom of the pile. Pressure bruise evaluation began by collecting nine 20 to 25 lb. tuber samples as each bin was being filled. Three samples were placed at each of three different levels within the bulk bin pile at 3, 6, and 9 feet from the storage floor.

The pressure bruise samples were evaluated 3 to 5 days after the bin was unloaded. A set of 25 tubers were randomly selected from each bag and visually inspected for pressure bruise. Each bruise was evaluated for discoloration by removing the tuber skin with a knife. A visual rating was given to the bruise for the presence or absence of flesh color (blackening of flesh). Percent weight loss in each tuber sample was calculated as it was removed from the storage.

Objective

The Storage and Handling committee's objective in testing the varieties in Bins 1-6 was to determine what the optimal storage temperature was for each variety, while maintaining acceptable storage and chip quality. Also of interest was the level of pressure bruise damage that may be incurred by each variety at a given storage temperature. The goal for the Kalkaska variety was to evaluate longevity at a given storage temperature while maintaining chip quality. Based on blackspot bruise numbers, sugar accumulation and stem end defect, this variety was left warm and slated for a November, December shipping window. MSH228-6 was evaluated for duration of storability. As the chip quality improved in this variety, the pile would be cooled to extend storage life in hopes of reaching a March to April shipping window. Bin 3, MSJ126-9Y, was tested to evaluate the storability of this line. The variety appeared to have vascular and stem end related defects. Sugar accumulation was watched closely around the defect areas before cooling the potatoes to a longer-term storage profile temperature. MSJ147-1 in Bin 4 has long term storage potential into May and June. The sugar and chip quality was good early and the variety was slated for long-term storage. The CO95051-7W, much like the MSJ147-1, has excellent long-term chip quality. The variety was slated for long-term storage quality testing and storage. The Classic Russet in Bin 6 was evaluated for tuber quality and storability for the freshpack market. Resistance to weight loss and Silver Scurf tolerance are important qualities to evaluate throughout the storage season.

The goal of the Ethylene Sprout Inhibitor Study in Bins 8 and 9 was to determine the commercial viability of ethylene gas as a sprout inhibitor in chip processing potatoes and to evaluate the feasibility of replacing CIPC as the industry standard sprout inhibitor. Of particular interest in this study is the ability of ethylene gas to control sprouts adequately while maintaining tuber quality, but most importantly, to see if the ethylene gas would have a negative effect on tuber sugar quality.

Bulk Bin 1, Kalkaska

Kalkaska is a common scab resistant, round shaped chip processing variety from the Michigan State University (MSU). This variety is much like that of Snowden in regards to its shape and skin type. In the 2008 on-farm variety trials this line yielded 400 cwt/A US#1. It has a three year average from 2006-2008 of 337 cwt/A US#1. The specific gravity of this variety averages between at 1.078 – 1.085. The variety has been observed to have good Early Die tolerance.

For the 2009-2010 storage season, this variety was grown by Sackett Potatoes Mecosta, MI, which is located in Mecosta county. The tuber temperature upon arrival at the storage was 68.0 ºF. The variety was tested and found to be 87 percent black spot bruise free.

SFA chip color and color related defects were acceptable October through December. Sucrose levels were acceptable, but glucose values were elevated and somewhat variable during this storage period. Glucose levels varied from 0.003 to 0.009. This glucose variability is a concern to overall chip quality. These results reflect similar experiences in past storage seasons with Kalkaska. Most of the internal defects recorded in 2009-2010 were stem end defects (SED), see picture in the upper right corner of this page. After 2 months in the storage at 58.0 ºF, it was evident that this bin of potatoes contained a significant amount of stem end vascular discoloration and we would have to maintain the pile temperature at this level to encourage tuber respiration in order to remove the free sugar. At this warm bin pile temperature, over an extended period from October through December, we were unable to cause enough positive change to the amount of chip defects that were present. The sugar related color associated with these defects was not burning off. That prompted the Storage Committee to cut losses in this storage bin and the variety was shipped on December 21, 2009, as an open market load of chip processing potatoes and that ended our evaluations in Bin 1. Tuber weight loss numbers were excellent at 3.44 percent and only 0.4 percent of the tubers that expressed pressure bruise had discoloration under the skin.

Kalkaska has exhibited great agronomic quality, high yield potential, common scab resistance, Early Die tolerance, but the chip quality has been too variable for commercialization to occur. Any available seed of Kalkaska was flushed out of the seed increase system in the Spring of 2010. Kalkaska is now a source of common scab resistance, Early Die tolerance and yield in the MSU breeding program.

Bulk Bin 2, MSH228-6

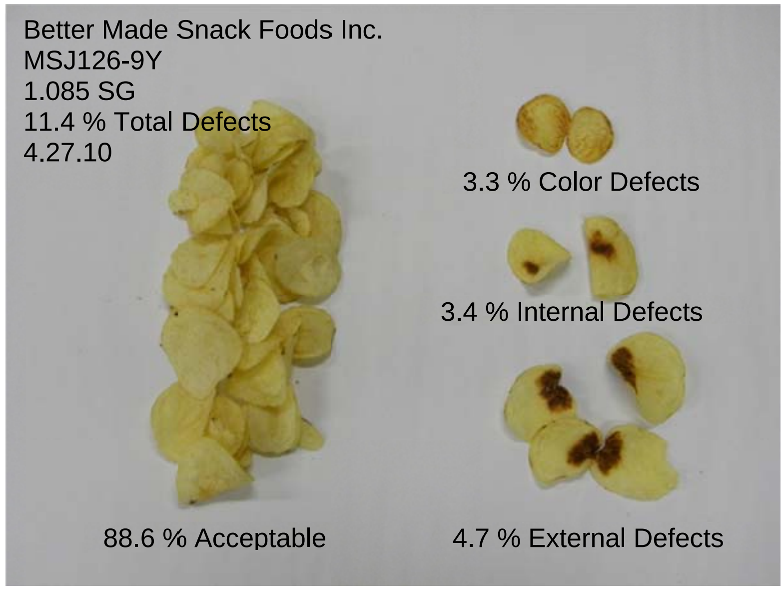
MSH228-6 is a common scab resistant, round to oval shaped chip processing variety from MSU. This variety is much like that of Snowden in regards to its chip quality from mid-season storage. In the 2009 on-farm variety trials this line yielded 407 cwt/A US#1. It has a three year average, from the 2007-2009 growing seasons, of 348 cwt/A US#1. The specific gravity of this variety averages between at 1.078 – 1.085.

For the 2009-2010 storage season, this variety was grown by Lennard Ag. Co. Samaria, MI, which is located in Monroe county. The tuber temperature upon arrival at the storage was 56.0 ºF. The variety was tested and found to be 68 percent black spot bruise free.

SFA chip color and color related defects were acceptable October through January. Pile sucrose and glucose in early December were 0.348 and 0.001, respectively, with a pile temperature of 52.4 ºF. At this time, the pile temperature was further cooled to 50.0 ºF. This resulted in an increase in sucrose and glucose two weeks later to 0.712 and 0.003, respectively. Sucrose and glucose remained elevated through late February. The pile temperature was raised in early March to help clean-up the free glucose in order to improve chip quality. It appears that this variety would be best held at 52.0 ºF or warmer to prevent cold induced sugars from forming. It is unclear, but probable, that this higher storage temperature would reduce longevity in storage. The pile cooling rate in December was 0.2 ºF a day from 52.0 to 50.0 ºF. It does not appear that this variety has the ability to metabolize sugar as quickly as the Snowden variety. In mid-March the sucrose and glucose were 0.542 and 0.005, respectively, with the sugar related defects being at their lowest points since the beginning of the storage season at 1.4 percent. The decision was made to sell the bin based on this marked improvement. Thought was given as to whether two more weeks would have led to even greater improvement. Possibly this can be evaluated in a future storage season. Weight loss numbers at bin unloading were excellent at 3.97 percent while 2.2 percent of the tubers expressed pressure bruise and discoloration under the skin.

Overall, the MSH228-6 processed acceptably at Better Made Snack Foods on March 24, 2010. The picture in the upper right provides a visual of the varieties chip performance. Because the variety exhibited some lateness, we are suggesting that the variety get 130-140 growing days from planting to harvest. The variety appears to only set 6-10 tubers per plant and in order to increase US#1 yield per acre we are suggesting that this variety be planted at an 8-9 inch in-row seed spacing on 34 inch rows. Further testing is needed to verify the commercial potential of this line.

Bulk Bin 3, MSJ126-9Y

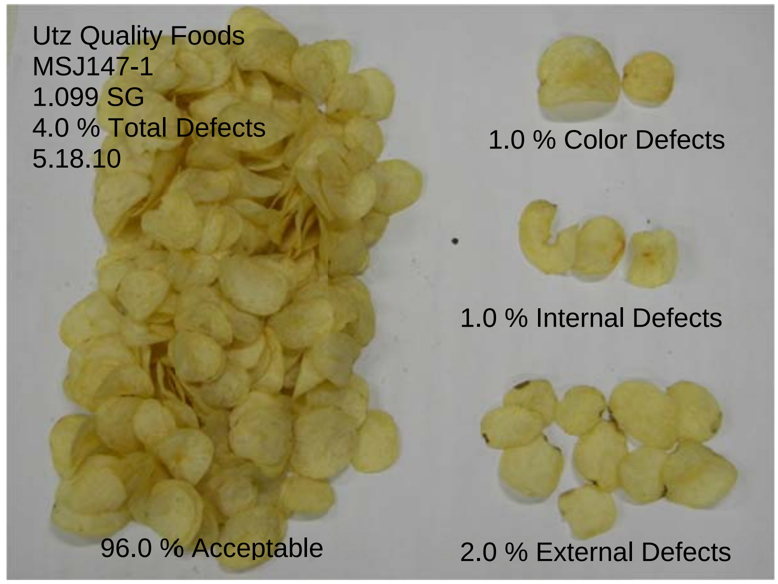


MSJ126-9Y is an MSU variety from the Potato Breeding and Genetics program. This variety has moderate tuber size with a generally round appearance. The common scab tolerance is strong. The US#1 yield for this variety is 350 cwt/A over three years from 2007 -2009. The specific gravity is average, ranging from 1.076 to 1.085 in Michigan. MSJ126-9Y was grown by Thorlund Brothers, Inc. in Greenville, MI, on fumigated ground. 550 cwt. was harvested and loaded into the storage during the fall of 2009. The variety has a good set of medium size tubers that average 2.0 to 3.25 inches in diameter. The storage was filled on October 21st with a pulp temperature of 53.0 ºF. The variety was evaluated to be 81 percent bruise free.

In late December, Bin 3 had a 0.974 sucrose level and a 0.005 glucose level which led the Storage and Handling Committee to believe that this variety was slightly chemically immature at harvest. This was not apparent from pre-harvest sucrose values. The varieties' sucrose values decreased steadily from harvest until mid- March. From harvest until early February, the glucose level in the tubers varied between 0.003 and 0.005 mg/g fresh weight. Most concerning was the dark stem end discoloration (SED) that was visible in the finished chips. The amount of SED that was present was so severe that we wondered if we were ever going to be able to process the bin. Pile temperature was maintained at 52.0 ºF until mid-February. At this time, it was decided to raise the pile temperature to 54.0 ºF in hopes of improving the overall chip quality. By early March, the pile temperature was 54.0 ºF and by mid-March the sucrose and glucose fell to their lowest levels of 0.359 and 0.001, respectively. Chip related defects deceased as well. From mid-March, the sucrose and glucose began to rise, as well as, the chip defect scores. Tuber weight loss numbers at bin unloading were higher than desired at 6.14 percent and 3.6 percent of the tubers expressed pressure bruise and discoloration under the skin.

On April 27, 2010, the bin was sent to Better Made for processing. The picture in the upper right shows a snap-shot of the chip quality from this bin. The total defects are higher than desired at 11.4 percent. These defects appear to be comprised of mostly stem end defects. The Storage and Handling Committee would like to continue further testing of MSJ126-9Y in the 2010-2011 storage season. Agronomically, the variety performed well exhibiting strong common scab tolerance. 2009 was a cold growing season and the crop experienced 200-400 fewer GDD40 heat units than on an average year. This may help to explain the stem end defects and chemical immaturity.

Bulk Bin 4, MSJ147-1



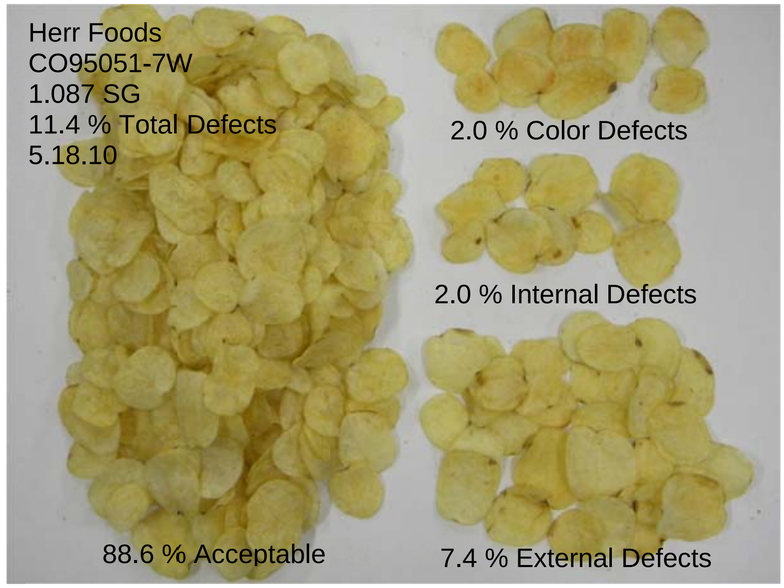
MSJ147-1 is an MSU breeding line with a medium-late maturity, slight small size profile, high specific gravity and long-term chip quality. In the 2007 to 2009 field trials, this clone exhibited an average yield of 307 cwt/A US#1 and a high specific gravity of 1.090.

MSJ147-1 was grown by Sandyland Farms and was delivered on October 20th with a pulp temperature of 51.0 ºF. The goal for this bin was to establish the long-term storage potential of this variety. MSJ147-1 arrived at the storage with a 75% bruise free rating. The variety was slated for long-term storage and scheduled to go to 50 ºF for holding. At this time, the sugar profile would be reevaluated and the variety possibly cooled further if chip quality remained. In early December, the pile temperature was 50.6 ºF and the sucrose and glucose values were 0.631 and 0.003, respectively. The pile chip quality was acceptable, so the decision was made to cool the pile further to 48.0 ºF by early January 2010. In January, we experienced a rise in tuber sucrose values indicating the induction of sugars as a result of cooling. The pile was warmed to 50.0 ºF in early February and remained there for the duration of the storage season. The sucrose and glucose values stabilized in March and the chip quality continued to improve. The chip quality of MSJ147-1 was good in early May and the committee felt they had reached their goal of storing this variety beyond that of a Snowden.

Bulk Bin 4 was shipped May 17th and processed at Utz Quality Foods on May 18th 2010. The picture to the upper right depicts the excellent chip color at the time of processing. Total tuber weight loss numbers at bin unloading were higher than desired at 6.10 percent. 7.6 percent of the tubers expressed pressure bruise and discoloration under the skin. This high level of tuber moisture loss resulted in an elevated amount of pressure bruise being observed at the time of processing.

Overall, the variety processed very well. Tuber weight loss must be managed better to reduce the appearance of this level of pressure bruising. The agronomic performance of this line remains a concern as well. It becomes hard to remain profitable with a variety that does not yield better than 307 cwt/A. We need to continue to look for varieties that chip process like this line, but have better agronomic quality.

Bulk Bin 5, CO95051-7W



CO95051-7W is a Colorado State University developed variety. In 2009, this variety yielded 331 cwt/A US#1. It has a three year US#1 yield average of 303 cwt/A from 2007-2009. This variety is small and uniform round in type. It exhibits some moderate common scab tolerance. A small amount of vine rot has been observed to occur in this variety. A fungicide application at blossom drop for White Mold prevention is recommended. In-row seed spacing should be 10.5 to 11.5 inches. The tuber set per plant is 10-18 tubers.

The potatoes in Bin 5 were grown by Sackett Ranch, Stanton, MI., and were harvested and loaded into storage on October 22nd with a pulp temperature of 54.0 ºF. Upon arrival, the tubers were held for two weeks to suberize and then were cooled at 0.2 ºF per day until the potatoes reached a pulp temperature of 52.0 ºF. At this time the status of the potatoes was reevaluated and then cooled to 50.0 ºF for holding. The tubers were determined to be 78% bruise free at bin loading. In early January 2010, the pile temperature was cooled to 50.0 ºF. On March 15th, 2010, the tubers reached their most stable sugar levels of the storage season with a 0.327 sucrose value and a 0.001 glucose value on recorded. From this point, the sucrose value rose steadily until the potatoes were shipped in mid-May. The pile temperature was 49.6 ºF on the date of shipping.

The picture at the upper right depicts the overall chip quality of this load after processing at Herr Food, Inc. on May 18, 2010. White knot and black spot bruise was evident in the internal chip defects, as well as, some pressure bruise in the external defect score. The overall weight loss in this bin was good at 2.55 percent, but 8.4 percent of the tubers had pressure bruise and discoloration under the skin. The bin processed acceptably at Herr's.

Overall, this variety has excellent chip quality and processing potential. Of concern is the varieties weak yield performance and some potential for vine rot susceptibility.

Bulk Bin 6, Classic Russet (A95109-1)

Classic Russet has looked promising in on-farm variety trials since 2007. In 2009, this variety yielded 348 cwt/A US#1 with a 1.073 specific gravity. The three year yield average for this variety is 367 cwt/A US#1. Vine maturity is medium to late. The tuber type is uniform and blocky with a Russet Norkotah type russet skin. The variety produces a nice percentage of marketable potatoes. The common scab tolerance is strong, but tuber susceptibility to Pink Eye and Pythium Leak is concerning. In row seed spacing should be kept at 9-10 inches to prevent oversized potatoes. This variety had roughly 8 percent hollow heart observed across nine trial locations in 2009.

The MPIC stored about 550 cwt. of Classic Russet in 2009. The potatoes were grown at Sandyland Farms in Howard City, MI. They stored 2500 cwt. as well in their commercial storage. In the 2009 growing season, Ariel Black Leg was noted in this variety which expressed itself as stem end rot and Black Leg in the harvested tubers. At harvest, the tubers were evaluated for black spot bruise and determined to be only 67 percent bruise free. The Classic Russet was loaded into Bin 6 on October 21st, 2009, with a 54.0 ºF pulp temperature. At bin load, a large amount of Black Leg was noted in the tubers. The potatoes were held at 54.0 ºF to suberize and then the pile was cooled to 40.0 ºF as outside air was available. Shortly after bin loading, tuber quality was declining as was evident by visible wet breakdown. As the pile was cooled, the breakdown slowed and reached a manageable level. The grower was experiencing similar quality issues and shipped their potatoes shortly after storing. We managed to hold Bin 6 until December 15th, 2009, when we chose to ship them to Fresh Solutions for packaging. At load-out, the pile was reported to have lost 7.19 percent of its initial weight to dehydration. But, over 91 percent of the tubers were bruise free and less than 1 percent of the tubers with bruise had discoloration under the skin.

In 2009, many reports of bacterial rot in this variety were made throughout the country, not only in commercial production, but in seed producing regions as well. This variety looked as though, initially, it would bring some good agronomic quality and tuber type to our russet industry in Michigan, but the tuber rot from Black Leg and Pythium Leak brought an end to the commercial potential of this line in Michigan.

Ethylene Study, Bulk Bins 8 and 9

This section is intended to provide a brief summary of the Ethylene versus CIPC study that the MPIC Storage and Handling Committee conducted over two storage seasons from 2008-2009 and 2009-2010. The general protocol was described earlier in this report. Two, 575 cwt bulk bins of Snowden potatoes were treated either with CIPC (Bin 8) or ethylene (Bin 9). The CIPC applications were described earlier. The ethylene levels and their timings were described early. Figure 1 shows the EMU and the ethylene tank configuration in the storage facility.

In comparing these two sprout inhibitor products we will discuss; storage management, chip quality and sprout suppression. In both years, 2008 and 2009, the Snowden tubers arrived at the MPIC storage with elevated glucose values. Neither in 2008 nor 2009 did the control chip quality look as good as expected. There was always some background vascular discoloration and color shading in the control chips each year at the beginning of the experiment. The reduced chip quality, in both years, warranted elevated storage pile temperatures and increased fresh air inlet to facilitate the respiration of the simple sugars present in the tubers. This was feasible in the control bin, but in the treatment bin which contained ethylene gas, it was very difficult to maintain the desired amount of fresh air inlet and maintain ethylene levels at 10.0 ppm to control sprouting. Thus, the amount of fresh air was limited. Limited fresh air inlet into Bin 9 caused reduced respiration of free sugars. Also, because the inlet had to be open periodically, this made it difficult to maintain the necessary ethylene concentration to control tuber sprouting. There is a difficult trade off imposed by the ethylene product and its protocol. The ethylene system may work better in a storage environment where the inlet door is rarely opened if ever and the pile temperature is maintained between 36.0 and 42.0 ºF. It would also be ideal if the tuber sugar quality was not a factor. Both years the reduction in fresh air inlet resulted in the treatment bins having higher glucose and sucrose values when compared to the control bins. For example, in the 2009-2010 storage season, Bulk Bin 8 had sucrose and glucose values of 0.417 and 0.003, respectively, and a 34.5 percent total chip defect score on January 18th, 2010. Bin 9 had a sucrose value of 0.477 and glucose value of 0.006 with 57.2 percent of the chips with defects on this same date. It was not clear during the two storage seasons if the ethylene level in the storage was causing the elevated sugars observed or the fact that the fresh air inlet had been reduced that was causing this reduction in chip quality. Figures 3 and 5 show the chip quality, in both Bins 8 and 9 at the time of bin unloading in 2010.

Table 1 shows sprout data from the 2008-2009 storage season. Sprouting in each pile was evaluated from 5 locations described earlier in the report. The table also shows the sprout results from tuber control samples taken from both bins prior to sprout treatment which were stored at 50.0 ºF. In both years, the mass of sprouts removed from the CIPC treated tubers, the amount of sprouting in both sprout length categories and the length of the longest sprouts were much smaller with the CIPC treatment than with the ethylene treatment (Tables 1-2). Figures 2 and 4 depict these results. Under these storage conditions and during both storage seasons, the CIPC sprout treatment provided the best sprout control for the tubers and the CIPC treatment resulted in the best quality chips being produced at the end of the storage seasons.

Table 1.

2008-2009
MPIC Demonstration Storage Bins 8 & 9
Snowden: CIPC and Ethylene Sprout Evaluation

	Mass of sprouts > 2mm in grams	# of eyes	# of eyes sprouting 2-5 mm	# of eyes sprouting > 5 mm	longest sprout length in mm
CIPC Door MEAN	2.00	6.93	0.03	0.03	0.33
Ethylene Door MEAN	5.67	6.73	1.33	0.43	3.98
CIPC 10s MEAN	5.00	7.33	0.13	0.40	6.20
Ethylene 10s MEAN	6.33	7.23	1.53	0.90	6.98
CIPC 20s MEAN	2.00	7.20	0.40	0.30	4.72
Ethylene 20s MEAN	7.00	7.30	1.97	0.20	4.90
CIPC 30s MEAN	2.67	7.57	0.07	0.23	3.23
Ethylene 30s MEAN	6.67	7.10	2.50	0.43	5.37
CIPC Top of Pile MEAN	6.33	6.80	0.33	0.40	5.03
Ethylene Top of Pile MEAN	14.00	6.87	3.30	1.70	7.73
Non-Treated Snowden Bin 8 MEAN	50.67	8.10	0.67	1.77	105.95
Non-Treated Snowden Bin 9 MEAN	44.67	7.57	0.70	1.60	104.43

Table 2.

2009-2010
MPIC Demonstration Storage Bins 8 & 9
Snowden: CIPC and Ethylene Sprout Evaluation

	Mass of sprouts > 2mm in grams	# of eyes	# of eyes sprouting 2-5 mm	# of eyes sprouting > 5 mm	longest sprout length in mm
CIPC Door MEAN	0.00	7.93	0.00	0.00	0.07
Ethylene Door MEAN	8.29	8.60	6.77	0.83	5.03
CIPC 10s MEAN	1.79	8.83	0.17	0.03	1.30
Ethylene 10s MEAN	7.07	7.30	3.37	0.37	4.03
CIPC 20s MEAN	0.20	9.10	0.03	0.00	1.03
Ethylene 20s MEAN	8.88	7.30	2.83	0.27	4.03
CIPC 30s MEAN	0.70	9.17	0.13	0.07	1.50
Ethylene 30s MEAN	6.21	8.13	6.20	0.43	4.10
CIPC Top of Pile MEAN	7.60	9.07	0.57	0.27	4.07
Ethylene Top of Pile MEAN	17.21	7.60	5.83	0.63	5.90
Non-Treated Snowden Bin 8 MEAN	NA	NA	NA	NA	NA
Non-Treated Snowden Bin 9 MEAN	NA	NA	NA	NA	NA

Figure 1. Ethylene Management Unit and Ethylene Tank

Figure 2. Snowden tubers from Bin 8 (CIPC Treated) 1.28.10

Figure 3. Chip quality picture Bin 8, 1.18.10

Figure 4. Snowden tubers from Bin 9 (Ethylene Treated) 1.28.10

Figure 5. Chip quality picture Bin 9, 1.18.10