Michigan State University
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In Cooperation With

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Michigan Potato Research Report
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MICHIGAN POTATOES
MICHIGAN POTATO INDUSTRY COMMISSION

Michigan Potato Industry Commission
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To All Michigan Potato Growers & Shippers:

The Michigan Potato Industry Commission, Michigan State University's Agricultural Experiment Station and Cooperative Extension Service are pleased to provide you with a copy of the results from the 2009 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 2010 season.

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2009 MICHIGAN POTATO RESEARCH REPORT

C. M. Long, Coordinator

INTRODUCTION AND ACKNOWLEDGMENTS

The 2009 Potato Research Report contains reports of the many potato research projects conducted by MSU potato researchers at several locations. The 2009 report is the 41st 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 and Esther Haviland at MPIC for helping with the details of this final draft.

WEATHER

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 (Table 1). 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. These 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 (Table 1). 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. (Table 2). 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. Irrigation at MRF was applied 7 times from June 24th to August 6th, averaging 0.83 inches for each application. The total amount of irrigation water applied during this time period was 5.8 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.
1995	51	31	66	45	81	57	82	60	82	65	70	45	72	51
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**
15-Year Average	57	35	67	45	78	56	81	58	79	58	73	49	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
1995	3.65	1.87	2.30	5.25	4.59	1.38	19.04
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**
15-Year Average	2.63	3.77	3.21	3.14	3.71	2.75	19.21

GROWING DEGREE DAYS

Tables 3 and 4 summarize the cumulative growing degree days (GDD) for 2009. Growing degree days base 50 for May through September, 2009 are in (Table 3) and growing degree days base 40 for May through October, 2009 are in (Table 4). The total GDD base 50 for 2009 was 1963 (Table 3), which is lower than the 10-year average. The total GDD base 40 for 2009 was 3620 (Table 4).

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

Cumulative Monthly Totals					
Year	May	June	July	August	September
2000	313	780	1301	1851	2256
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
10-Year Average	281	783	1371	1928	2290

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

Cumulative Monthly Totals						
Year	May	June	July	August	September	October
2006	532	1310	2298	3180	3707	3923
2007	639	1503	2379	3277	3966	4443
2008	447	1240	2147	2973	3596	3834
2009	**519**	**1264**	**2004**	**2800**	**3420**	**3620**
2010						
2011						
2012						
2013						
2014						
2015						
10-Year Average	534	1329	2207	3058	3672	3955

*2000-2009 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 2009 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 2008 and harvested fall 2008 with crop residue disked into the soil. In the spring of 2009, the recommended rate of potash was applied and disked into the remaining corn residue. The ground was deep chiseled, disked and direct planted to potatoes. The area was not fumigated prior to potato planting. Early potato vine senescence was an issue in 2009. It is not clear if the early vine death was the result of the potato early die complex.

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)	214 (107 ppm)	720 (360 ppm)	118 (59 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 ($N-P_20_5-K_20$)
Broadcast at plow down	0-0-60	395 lbs/A	0-0-237
At planting	19-17-0	20 gpa	42-37-0
	10-34-0	12 gpa	13-45-0
At cultivation	28-0-0	22 gpa	68-0-0
At hilling	46-0-0	135 lbs/A	62-0-0
Late side dress (late varieties)	46-0-0	100 lbs/A	46-0-0

Magnesium and Sulfur were applied July 17 in the form of Magnesium Sulfate (with an analysis of 9.8% Mg and 12.9% S) for a total application of 20 lb/A. The composite nutrient value resulted in 1 lbs actual Mg and 1.3 lbs of S being applied per acre on the potato production area.

HERBICIDES AND PEST CONTROL

Hilling was done in late May, followed by a pre-emergence application of Linex at 1.5 qts/A and Dual at 1.33 pints/A. A post-emergence application of Sencor at 1/3 lb/A and Matrix at 1 oz/A was made in mid-July.

Platinum was applied at planting at a rate of 8 fl oz/A.

Fungicides used were; Bravo, Tanos, Previcur, Revos Top, Champ, Echo, Manzate and Super Tin, over 11 applications.

Potato vines were desiccated with Reglone in mid-August at a rate of 1.5 pints/A.

2009 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 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 and the development of the grading line at the MSU campus facility.

PROCEDURE

I. Varietal Development

Each year, during the winter months, 500-1000 crosses are made using about 150 of the most promising cultivars and advanced breeding lines. The parents are chosen on the basis of yield potential, tuber shape and appearance, chip quality, specific gravity, disease and insect resistance, adaptation, maturity, lack of internal and external defects, etc. The seeds collected from these crosses are then used as the breeding base for the program. We also obtain seedling tubers or crosses from other breeding programs in the US to include other germplasm with desirable traits. The seedlings are grown annually for visual evaluation (size, shape, set, internal defects) at the Montcalm and Lake City Research Farms as part of the first year selection process of this germplasm each fall. Each selection is then evaluated post harvest for specific gravity and chip processing. These selections each represent a potential variety. This system of generating new seedlings is the initial step in an 8-12 year process to develop new varieties. This step is followed by evaluation and selection at the 8-hill, 20-hill and 30-hill stages. The best selections out of the four-year process are then advanced for testing in replicated trials (Preliminary, Adaptation, Advanced, Grower-cooperator trials, North Central Regional Trials, USPB/Snack Food Association Trials, and other out-of-state trials) over time and locations. ***The agronomic evaluation of the advanced breeding lines in the replicated trials is in the annual Potato Variety Evaluation Report.***

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 4x = 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). In general, diploid breeding utilizes haploids (half the chromosomes) from potato varieties, and diploid wild and cultivated tuber-bearing relatives of the potato. 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, and late blight resistance from *S. microdontum*. Furthermore, we are investing our efforts in developing new vector constructs that use alternative selectable markers and give us the freedom to operate from an intellectual property rights perspective. In addition, we are exploring transformation techniques that eliminate the need for a selectable marker (antibiotic resistance) from the production of transgenic plants.

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 2009 field season, progeny from over 550 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 2009 harvest, over 1,500 selections were made from the 50,000 seedlings produced. All potential chip-processing selections will be tested in January and April 2010 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 8-hill and 20-hill evaluation state, about 175 and 40 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 70% of the single hill selections have a chip-processing parent in their pedigree. Based upon the pedigrees of the parents we have identified for breeding cold-chipping potato varieties, there is a diverse genetic base. We have at least eight cultivated sources of cold-chipping. Examination of pedigrees shows up to three different cold-chipping germplasm sources have been combined in these selections. Our promising chip-processing lines are MSJ147-1, MSH228-6 (moderate scab resistance), MSJ126-9Y (scab resistant), MSL007-B (scab resistance), MSK409-1 (scab resistant), MSN191-2Y, 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), MSP459-5 (scab and moderate late blight resistant), MSP516-A (scab and late blight resistant), MSN170-A (scab resistant) MSR036-5 (scab and late blight resistant), MSR102-3 (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. 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 2009, while others were tested under replicated conditions at the Montcalm Research Farm. Promising tablestock lines include 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 MSQ432-2PP is a purple-fleshed chipper.

Early harvest breeding material screen

In 2009, we initiated an 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 92 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 176 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. 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 2010. We also identified some desirable early tablestock lines among this material tested. The shaded cells in the table indicate the higher yielding plots and lines with higher specific gravity.

Table 1 Early Observation Trial: Most promising chip-processing lines

EARLY OBSERVATIONAL TRIAL 2009

Montcalm Research Farm

May 15 to August 14, 2009 (92 days)

	Weight (lbs)		Chip	Trial	Pedigree	
	Total	SP GR	OTF	Scab	Female	Male
Beacon Chipper	**6.5**	**1.082**	**1.0!**	**2**	**-**	
FL1879	**15.9**	**1.077**	**1.0**	**4**	**-**	
Kalkaska	**7.8**	**1.080**	**1.0**	**1**	**B1254-1**	**S440**
Snowden	**12.2**	**1.083**	**1.0**	**3**	**-**	
MSH228-6	7.6	1.077	1.0	1	MSC127-3	OP
MSJ126-9Y	10.2	1.078	1.0	1	PENTA	OP
MSM037-3	15.2	1.072	1.0	1	MSE230-6	ND2676-10
MSM060-3	10.5	1.092	1.0	1	MSG007-1	ND2676-10
MSN148-A	6.2	1.092	1.0!	1	MSH095-4	MSJ143-4
MSN190-2	8.7	1.092	1.0	1	MSI234-6Y	MSG227-2
MSP515-2	12.5	1.072	1.5	1	NY112	Missaukee
MSQ070-1	9.3	1.082	1.0	1	MSK061-4	Missaukee
MSQ086-3	12.4	1.075	1.0!	1	Onaway	Missaukee
MSQ279-1	13.2	1.070	1.0	1	Boulder	Pike
MSR058-1	15.2	1.079	1.0	1	W1201	MSJ319-1
MSR061-1	7.5	1.078	1.0	1	W1201	NY121
MSR127-2	9.0	1.084	1.5	1	MSJ167-1	MSG227-2
MSR159-02	6.2	1.084	1.0	1	MSL766-1	MSJ126-9Y
MSS026-2Y	9.1	1.093	1.0	2	SJ-Y7	MSJ126-9Y
MSS165-2Y	15.3	1.082	1.0	1	MSM188-1	MSL159-AY
MSS176-1	15.2	1.077	1.5	1	ND5822C-7	MSL211-3
MSS934-4	12.3	1.082	1.0	1	ND6095-1	ND7377Cb-1
MST033-2	9.4	1.083	1.0	1	Atlantic	MSL211-3
MST094-1	10.3	1.081	1.0	1	MSG227-2	MSH228-6
MST096-2Y	8.9	1.076	1.0	1	MSG227-2	MSJ126-9Y
MST412-3	14.8	1.074	1.0	1	MSN105-1	MSM051-3
MST429-3Y	9.6	1.075	1.0	1	NY126	Missaukee
MST443-1	12.8	1.083	1.0	2	MSM070-1	OP
MST443-2Y	11.4	1.092	1.0	2	MSM070-1	OP

Single rep observational 10 ft plots.

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

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

Disease and Insect Resistance Breeding

Scab: Disease screening for scab has been an on-going process since 1988. Results from the 2009 MSU scab nursery indicate that 69 of 156 lines evaluated had a scab rating of 1.5 or less (better than or equivalent to Pike). The limitation of breeding for scab resistance is the reliance on the scab nursery. In addition to the replicated trial, we have been conducting early generation selection for scab resistance among our breeding material. In 2009, 128 of 327 early generation selections showed strong scab resistance (rating of 1.0 or better). These data were 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 hope that the nutrient film technology (NFT) hydroponic tuberization system will help us more reliably screen for scab resistance. The NFT study is supported through Project GREEEN.

In 2009 we conducted an inoculated scab trial at the scab nursery at MSU. We planted seed pieces into peat pots filled with scab infested vermiculite. Alternately, the vermiculite was spread in the furrow prior to planting rather than in the peat pot. The four varieties tested were Pike, Atlantic, Snowden and FL1879. The first planting was in mid-May and the second planting was two weeks later. At harvest the tubers were laid on the ground and plot and tuber scab ratings were taken. **Table 2** below summarizes the results from the scab ratings that were collected. We learned in this first year that the peat pot inoculation treatments led to greater levels of scab infection on the tubers and did differentiate resistant from susceptible varieties. We will continue to conduct scab inoculation experiments in 2010 to improve our ability to screen for scab resistance in the breeding program.

Table 2. *Streptomyces* Inoculated Scab Trial Main Effects Means for Scab Rating (0-5: 0 = No scab; 5 = Severe pitted scab).

Source	First Rating		Second Rating		Combined Rating	
Scab Treatment Main Effects:						
1 Non-tx control	1.81		2.07	d	1.93	c
2 In-furrow-1X	2.13		2.29	cd	2.20	bc
3 In-furrow-2X	2.13		2.79	bc	2.43	b
4 Cup-1X	2.60		3.13	ab	2.87	a
5 Cup-2X	2.47		3.67	a	2.97	a
$LSD_{0.05}$	***NA***		*0.58*		*0.41*	
Variety Main Effects:						
Atlantic	2.20	a	2.68	a	2.44	b
Private Chipper Check	2.53	a	3.11	a	2.81	ab
Snowden	2.53	a	3.10	a	2.82	a
Pike	1.65	b	1.83	b	1.72	c
$LSD_{0.05}$	*0.54*		*0.53*		*0.38*	

Late Blight: No late blight research was completed because of June flooding of the research plots. All field trials from the breeding program were lost.

Colorado potato beetle: With support from GREEEN, we conducted our Colorado potato beetle screen at the Montcalm Research Farm. In 2009, 16 of 40 breeding lines were at least moderately resistant to Colorado potato beetle at the Montcalm Research Farm Beetle Nursery. The beetle pressure was extremely high leading to complete defoliation in all susceptible check lines. Percent defoliation was visually estimated during the beetle infestation in June and July. This resistant material was selected for further advancement in the breeding program and also for use in the next round of crossing to develop beetle resistant cultivars. Some of these lines are beginning to enter the preliminary trials in the breeding program and are being used as parents for further breeding.

It is a great challenge to achieve host plant resistance to insects in a commercially acceptable line. We have some promising advanced selections with partial resistance to Colorado potato beetle. In addition, we have *Bt-cry3A* transgenic lines that could be commercialized if the processors renewed their acceptance and regulatory environment was modified to reduce costs.

Russet Table Varieties for Michigan

The dynamics of the potato industry in Michigan have been changing in the recent years. A reason for this change is Michigan's position to major markets in the central and eastern US. With rising fuel costs, Michigan growers can capture table market share with a freight advantage over western potatoes. Key to capturing this market is having russet varieties that suit Michigan's climate and soils and also serves the consumers taste and quality needs. Current russet varieties may not provide the quality and production levels to compete profitably in these markets. The three most desirable potatoes for production and type in Michigan are Russet Norkotah, GoldRush and Silverton Russet. Two of these potatoes suffer as symptomless carriers of PVY. Russet Norkotah also has a weak vine and susceptibility to potato early die. We need a PVY resistant or PVY expressing Silverton Russet potato. GoldRush has proven not to perform well in Michigan's southern tier of counties. New russet varieties with adaptability to Michigan could lead to greater market penetration and further diversify the markets for the Michigan potato industry.

The breeding strategy is to make selected crosses that have a high probability of selecting Norkotah types. We grew out large progenies to further increase the probability of finding desirable selections. We will use Silverton, Russet Norkotah, MSE192-8RUS, A95109-1RUS, etc. as parents. Single hill selections were made in 2009. These will be further evaluated and a new set of crosses will be evaluated in 2010 at Lake City.

Sugar Profile Analysis of Early Generation Selections for Extended Storage: Chip-processing Results From the MPIC Demonstration Commercial Storage (October 2008 - June 2009)

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 10 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.

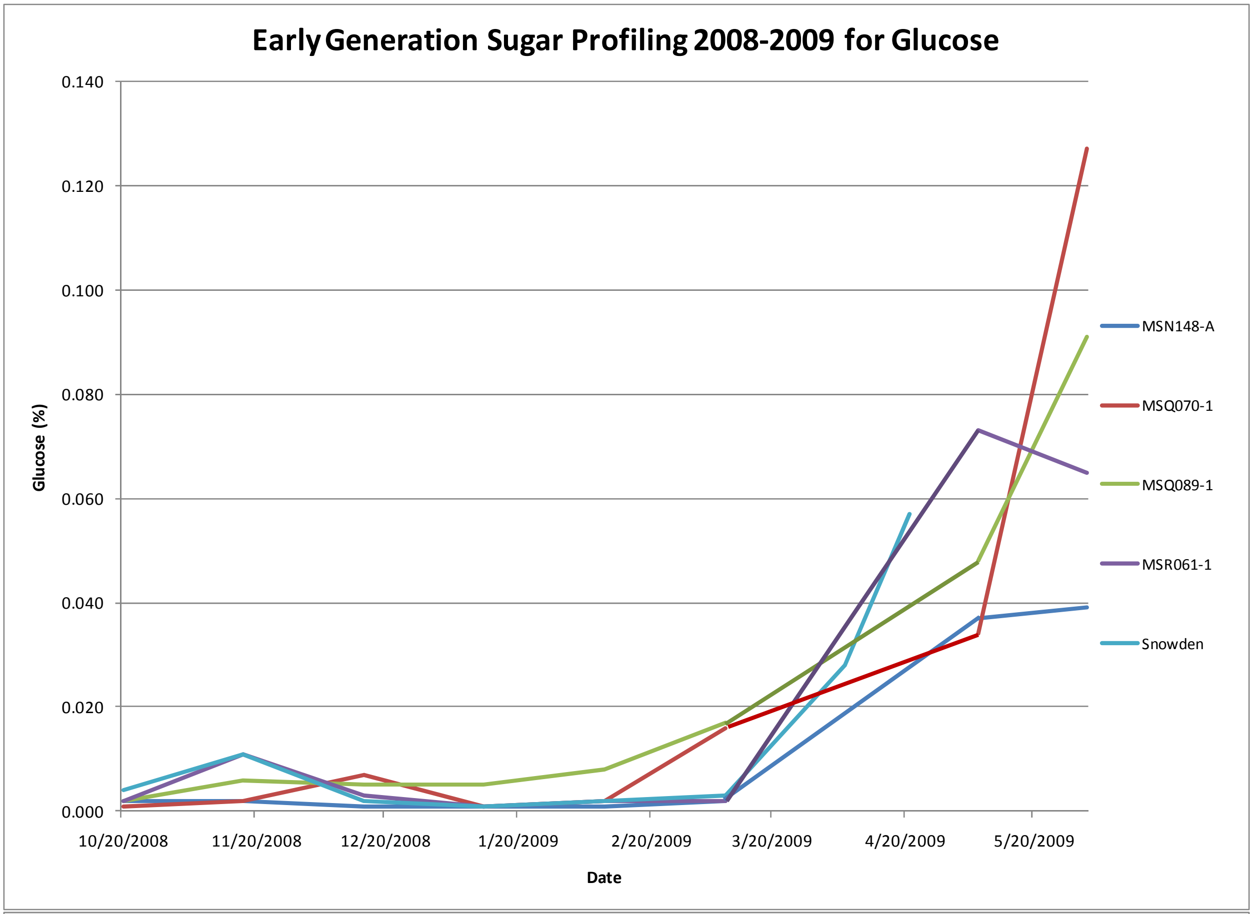
In October 2008, tuber samples from 14 MSU lines from the Montcalm Research Farm and Lake City Experiment Station trials were placed in the bins. The first samples were chip-processed in October and then 8 more times until June 2009. Samples were evaluated for chip-processing color and defects. **Table 3** summarizes the chip-processing color and scab rating of 14 lines and four check varieties (Atlantic, FL1879, Pike and Snowden) over the 7-month storage season. From November to April all lines chip-processed acceptably. The lines that chip processed exceptionally well were Beacon Chipper, MSH228-6, MSJ126-9Y, MSJ147-1, MSL292-A, MSM037-3, MSM246-B and MSQ279-1. These lines are highlighted in the table. We are continuing to advance these lines except MSM246-B and MSM037-3 because of scab susceptibility and low specific gravity issues, respectively.

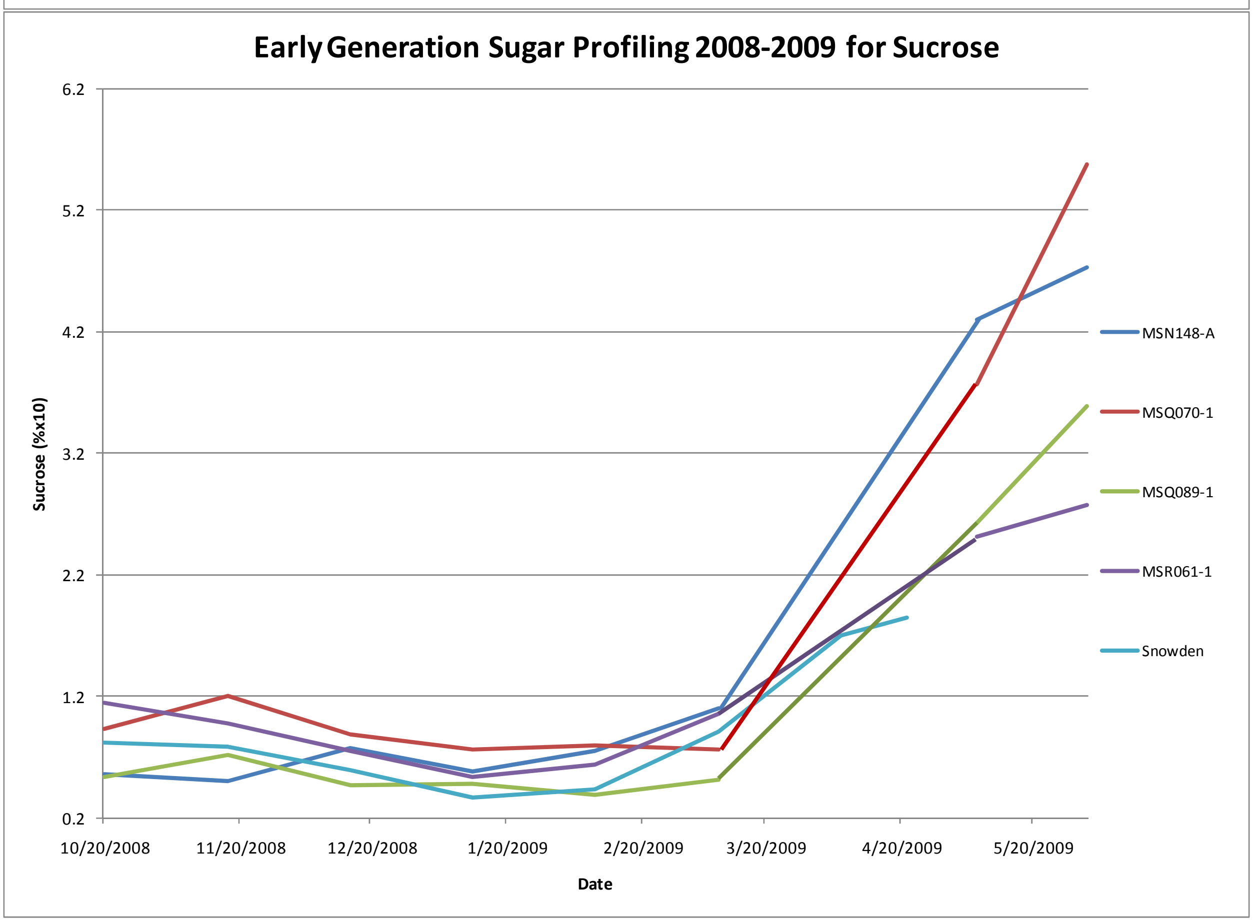
Early generation sugar profiling was also conducted on a series of MSU advanced breeding lines. These glucose and sucrose sugar profiles are presented in Figures 1-4. The results confirm the good storage potential of MSJ126-9Y, MSH228-6 and MSL292-A. MSJ147-1 has stored longer in previous years, but in the past storage seasons the MSJ147-1 tubers physiologically aged sooner than previous years. Of the newer advanced breeding lines tested MSQ070-1 and MSR061-1 showed promising sugar profiles. Both lines exhibit scab resistance. The other two lines, MSN148-A and MSQ089-1 were discontinued because of their susceptibility to scab.

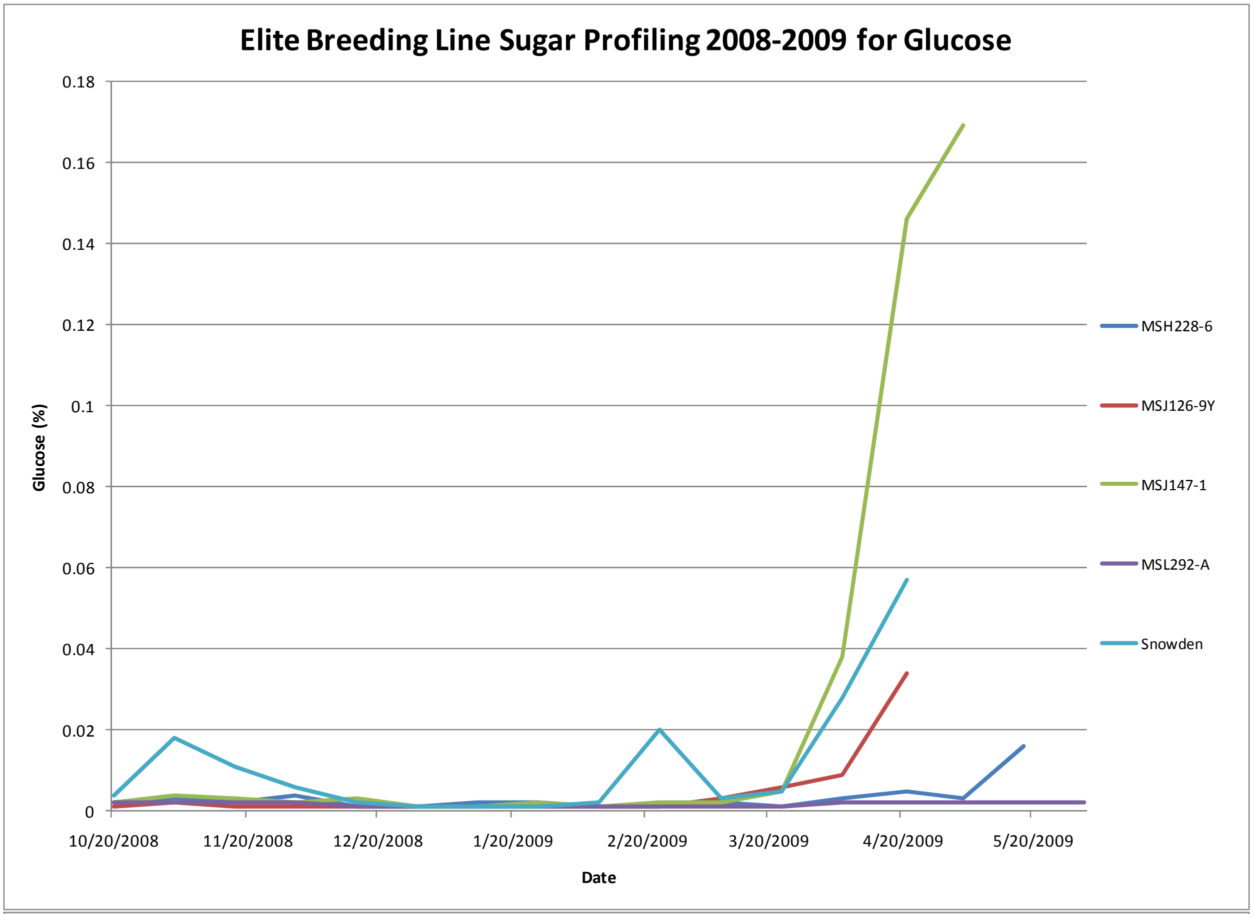
We also undertook a study to measure acrylamide levels in potato chips of nine potato lines along with Snowden. The chip samples were sent to the University of Wisconsin for analysis. The acrylamide data (ppb) was correlated with the glucose, sucrose and defect data collected by Techmark. Figures 5a, b and c summarize the results. We learned that acyrlamide levels ranged from 650 ppb to over 1700 ppb when the chip color was acceptable. There was no correlation between glucose level, sucrose level and defect levels in the tubers with acrylamide levels in the chip samples. For example the potato chip acrylamide level ranged from 650 ppb -1700 ppb for tuber glucose readings of 0.002% or less. We are conducting follow up studies in 2009-10.

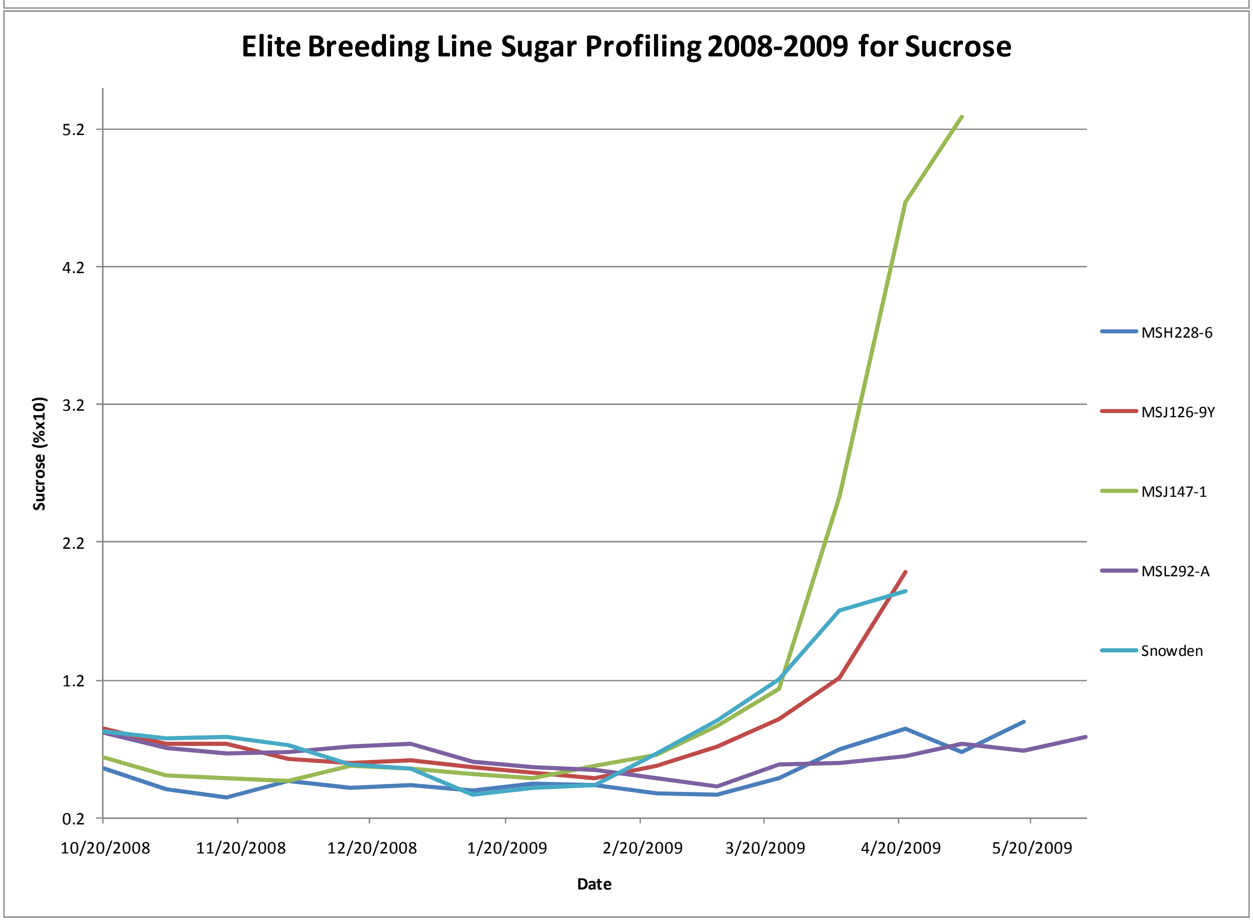
Table 3. 2008-2009 Demonstration Storage Chip Results of Elite MSU Breeding Lines

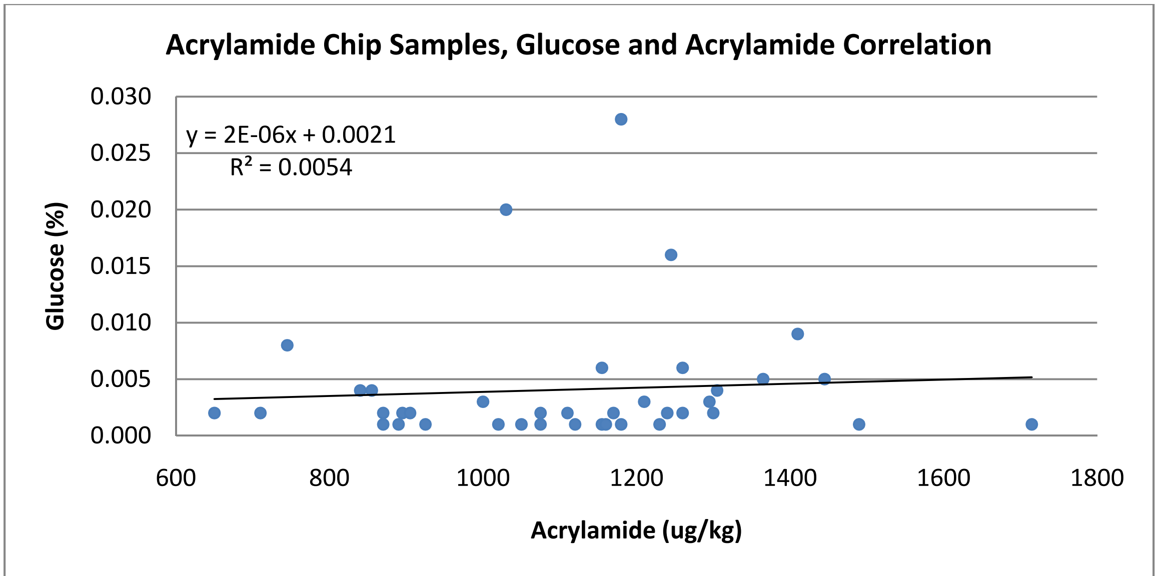
		2009	SFA Chip Score Rating Scale 1-5								
LINE		**Scab**	**10/2008**	**11/2008**	**12/2008**	**1/2009**	**2/2009**	**3/2009**	**4/2009**	**5/2009**	**6/2009**
Atlantic		**2.7**	**1.5**	**1.5**	**1.5**	1.0	**1.5**	**1.0**	**1.5**	**3.0**	**3.5**
Beacon Chipper	ScabMR	1.3	1.0	1.0	1.0!	1.0	1.0	1.0	1.0	1.5	1.5
FL1879		**2.0**	**1.0**	**1.0**	**1.0**	1.0	**1.5**	**1.0**	**1.0**	**1.5**	**2.0**
Kalkaska (MSJ036-A)	ScabR	1.3	1.0	1.0	1.5	1.5	1.5	1.5	3.0	3.5	4.0
MSH228-6	ScabR	1.3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
MSJ147-1		1.7	1.0	1.0!	1.0	1.0	1.0!	1.0	1.0	1.0	1.5
MSJ461-1	LBR	2.1	1.0	1.0	1.0	1.5	1.5	1.5	1.5	2.5	2.0
MSK061-4	ScabR	1.4	1.0	1.0	1.0	1.0	1.0	1.0!	1.0	1.0	2.5
MSL292-A		2.3	1.0	1.0	1.0!	1.0	1.0!	1.0!	1.0	1.0	1.5
MSM037-3	ScabMR	1.3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
MSM246-B		2.8	1.0	1.0	1.0	1.0	1.0!	1.0	1.0	1.0	1.0
MSN170-A	ScabR	1.0	1.0	1.0	1.0	1.0	1.0!	1.0!	3.0	3.0	3.5
MSN191-2Y		2.8	1.0	1.0	1.0!	1.0	1.0	1.0!	1.0	1.0	2.0
MSP459-5	ScabR-LBR	1.8	1.0	1.0!	1.0	1.0	1.0!	1.0!	1.0	1.5	2.0
MSQ279-1	ScabR	1.4	1.0	1.0	1.0	1.5	1.0	1.0	1.0	2.0	1.5
MSR036-5	ScabR-LBR	1.3	1.0	2.0	1.5	2.0	1.5	2.0	2.0	2.5	3.0
Pike	**ScabR**	**1.5**	**1.0**	**1.0**	**1.0**	1.0	**1.0**	**1.0**	**1.5**	**2.5**	**2.5**
Snowden		**2.3**	**1.0**	**1.5**	**1.0**	1.0	**1.0**	**1.0**	**2.0**	**3.0**	**3.0**

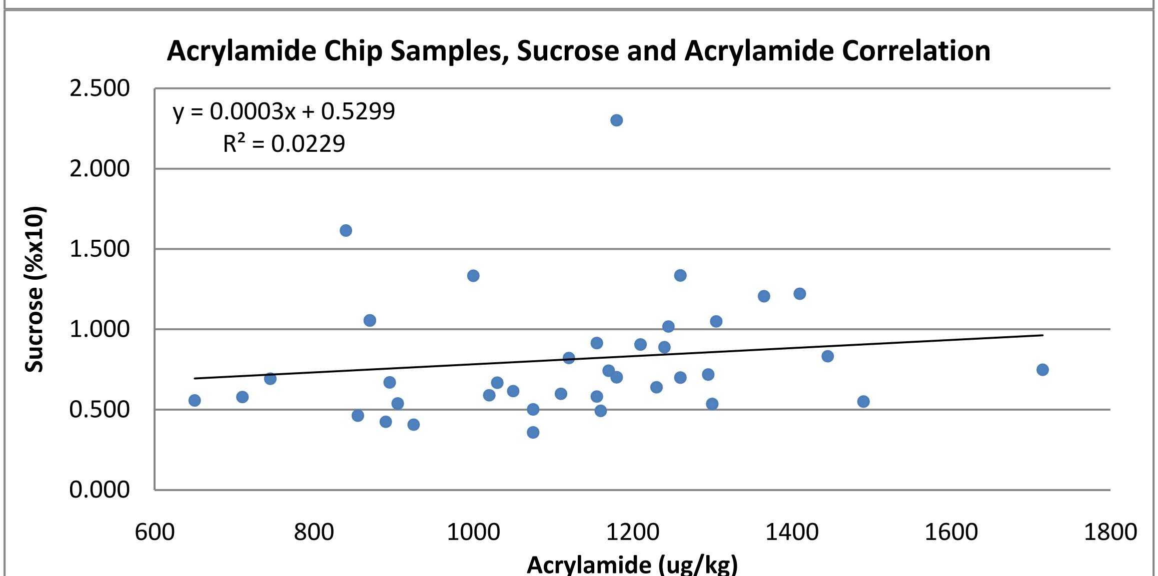

Early Generation Sugar Profiling 2008-2009 for Glucose
Glucose (%)
0.140
0.120
0.100
0.080
0.060
0.040
0.020
0.000
10/20/2008
11/20/2008
12/20/2008
1/20/2009
2/20/2009
3/20/2009
4/20/2009
5/20/2009
Date
MSN148-A
MSQ070-1
MSQ089-1
MSR061-1
Snowden

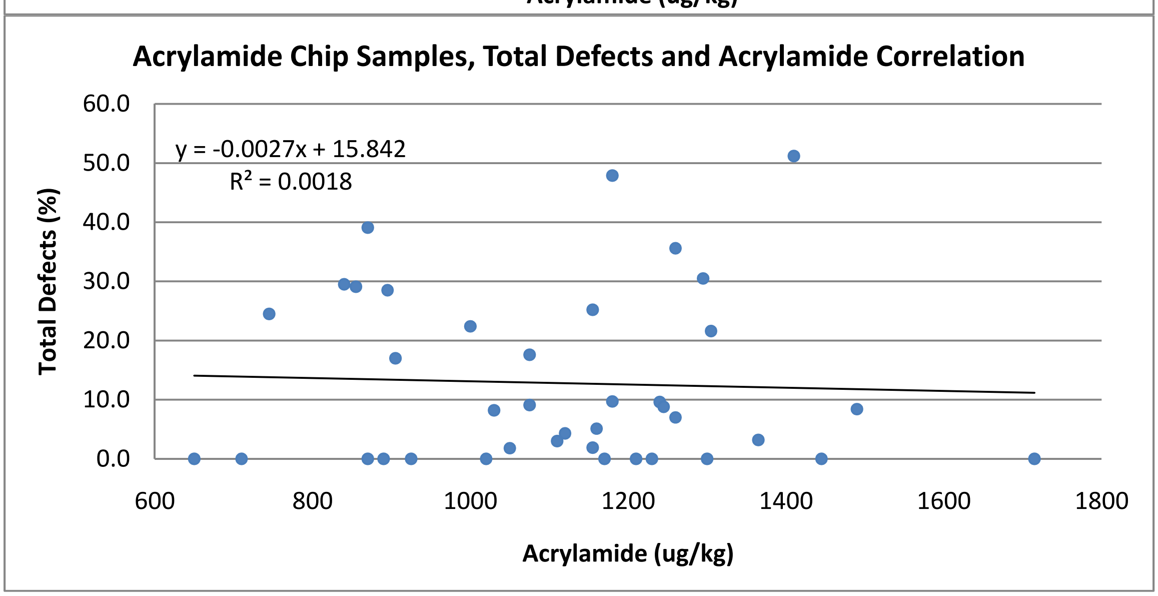

Early Generation Sugar Profiling 2008-2009 for Sucrose
Sucrose (%x10)
6.2
5.2
4.2
3.2
2.2
1.2
0.2
10/20/2008
11/20/2008
12/20/2008
1/20/2009
2/20/2009
3/20/2009
4/20/2009
5/20/2009
Date
MSN148-A
MSQ070-1
MSQ089-1
MSR061-1
Snowden


Elite Breeding Line Sugar Profiling 2008-2009 for Glucose
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
Glucose (%)
10/20/2008
11/20/2008
12/20/2008
1/20/2009
2/20/2009
3/20/2009
4/20/2009
5/20/2009
Date
MSH228-6
MSJ126-9Y
MSJ147-1
MSL292-A
Snowden


Elite Breeding Line Sugar Profiling 2008-2009 for Sucrose
5.2
4.2
3.2
2.2
1.2
0.2
Sucrose (%x10)
10/20/2008
11/20/2008
12/20/2008
1/20/2009
2/20/2009
3/20/2009
4/20/2009
5/20/2009
Date
MSH228-6
MSJ126-9Y
MSJ147-1
MSL292-A
Snowden


Acrylamide Chip Samples, Glucose and Acrylamide Correlation
y = 2E-06x + 0.0021
R² = 0.0054
Glucose (%)
0.030
0.025
0.020
0.015
0.010
0.005
0.000
600
800
1000
1200
1400
1600
1800
Acrylamide (ug/kg)


Acrylamide Chip Samples, Sucrose and Acrylamide Correlation
y = 0.0003x + 0.5299
R² = 0.0229
Sucrose (%x10)
2.500
2.000
1.500
1.000
0.500
0.000
600
800
1000
1200
1400
1600
1800
Acrylamide (ug/kg)


Acrylamide Chip Samples, Total Defects and Acrylamide Correlation
y = -0.0027x + 15.842
R² = 0.0018
Total Defects (%)
60.0
50.0
40.0
30.0
20.0
10.0
0.0
600
800
1000
1200
1400
1600
1800
Acrylamide (ug/kg)

Variety Release

We released MSJ036-A as Kalkaska (scab resistant and verticllium wilt tolerant round white) in 2008 and MSJ461-1 as Missaukee (late blight, golden nematode and verticillium wilt resistant round white) in 2009. 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. Lastly, commercial seed of MSH228-6, MSJ147-1, and MSJ126-9Y are being produced and we will continue to seek commercial testing of these lines. MSQ070-1 is also being fast-tracked for the chip-processing market. It has both scab and late blight resistance. We also have a focused ribavirin-based virus eradication system to generate virus-free tissue culture lines for the industry. We are initiating mini-tuber increase of three scab-resistant chippers: MSL007-B, MSR061-1 and MSP270-1. We are also increasing MSL292-A, a long-term storage chipper. About 30 lines are in ribaviran treatment at this time to remove PVS and PVY. This year, about 60 new MSU breeding lines are being put into tissue culture.

MSU Variety Releases:

Kalkaska (MSJ036-A)

Parentage: B1254-1 X S440
Developers: Michigan State University and the Michigan Agricultural Experiment Station.

Plant Variety Protection: submitted

Strengths: MSJ036-A is a high yielding, round white potato with an attractive round appearance with shallow eyes.MSJ036-A has a strong vine and a full season maturity. This variety has resistance to *Streptomyces scabies* (common scab) stronger than Pike. MSJ036-A also has chip-processing storage characteristics and better tolerance to blackspot bruise than Snowden.

Weaknesses: Sugar levels have to be watched at harvest during cold temperatures.

Incentives for production: High yield and good tuber type combined with scab resistance.

Missaukee (MSJ461-1)

Parentage: Tollocan X NY88
Developers: Michigan State University and the Michigan Agricultural Experiment Station, Michigan Potato Industry Commission
Plant Variety Protection: Plant Variety Protection is being considered for this variety.

Strengths: MSJ461-1 is a round white chip-processing variety with an attractive round shape and bright skin. The primary strength of this variety is its strong foliar resistance to late blight (*Phytophthora infestans*) combined with chip-processing quality. MSJ461-1 can also be marketed as tablestock because of its good culinary quality. The tubers will chip process out-of-the-field and from 10°C (50°F) storage. MSJ461-1 performed well in Michigan on-farm trials and regional testing. Under irrigated conditions, the yield is similar to Snowden. MSJ461-1 is being considered for release, although no name has yet been chosen for this line.

Weaknesses: The specific gravity of MSJ461-1 is lower than Snowden in Michigan.

Incentives for production: High yield with uniform tuber size combined with strong foliar resistance to late blight, GN resistance and tolerance to verticillium wilt. Can be used for both chip-processing and table use.

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.

MSQ176-5

Parentage: MSI152-A x Missaukee (MSJ461-1)
Developers: Michigan State University and the Michigan Agricultural Experiment Station
Plant Variety Protection: To Be Applied For.

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 2009 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 2010. 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

Commercialization of Potato Tuberworm Resistant Potatoes in South Africa

The potato tuberworm (*Phthorimaea operculella* Zeller) is a primary pest problem facing potato farmers in developing countries. Currently, the primary means to control the potato tuberworm and avoid major crop losses is the use of chemical pesticides. Michigan State University (MSU), funded by the U.S. Agency for International Development (USAID), initiated biotechnology research on the development of potato tuberworm resistant varieties in 1992. A *Bacillus thuringiensis* (Bt)-*cry1Ia1* gene, was successfully introduced into several potato varieties and shown to be highly resistant to potato tuberworm in the Spunta-G2 line (both tuber and foliage). This Bt potato will be one of the first public sector developed products to reach farmers in developing countries and will serve as a model for the public sector deployment of insect resistant transgenic crops. The commercialization project includes six components: Product Development, Regulatory File Development, Obtaining Freedom to Operate and Establishing Licensing Relationships, Marketing and Technology Delivery, Documentation of Socio-Economic Benefits, and Public Communication. This technology would also have benefits in controlling PTM in the US and reducing the need for insectcide-based protection. In 2007, we focused on collecting the regulatory data that has to be submitted to the review agency. In 2008, we submitted the regulatory file to the South African authorities. In late 2009 the South African government denied the approval on non-scientific reasons. We are appealing, but the political realities probably will not change the final outcome. Regardless of the outcome, our team at MSU is well positioned to commercialize future GM potato varieties.

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

USDA/ARS funded project:
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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 (since October 2009)

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 *L. 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 tomato *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 were done using the PVY susceptible line MSE149-5Y. Over twenty independently generated transgenic plants have been isolated and are in culture. Insertion of either the tomato sequence or the potato control sequence was confirmed in each of the transgenic plants by PCR. Because of conservation of sequence between the different eIF4E sequences, primers for this PCR were designed to span the junction between the 35S promoter and the tomato or potato eIF4E sequences thus; these primers will not amplify in non-transgenic plants. A preliminary PVY test was attempted in the greenhouse using this first generation of the transgenic lines. Inconsistent responses in the control plants were observed. These plants are now being grown in preparation for revised PVY resistance tests. Transformation experiments were also conducted with Silverton Russet and Classic Russet. The regeneration ability of these lines is much lower that MSE149-5Y and modifications in the regeneration protocol will be made.

In a second experiment to allele mine the potato eIF4E gene for sequence homology to *pot-1* and *pvr2*, DNA sequences from 27 total accessions of four species of potato (*S. chacoense, S. microdontum, S. phureja, S. tuberosum* subsp. *andigena*) exhibiting different levels of PVY resistance were examined for natural variation in amino acid sequences. Due to introns separating the key signature regions, RT-PCR was used to create and clone cDNA fragments so that DNA sequencing through all four key regions could be accomplished in a single pass. At least three to five independent cDNA clones from 2 different eIF4E genes (*i.e.* eIF4E1 and eIF4E2) were sequenced for each variety. None of the sequences contained changes identical to the tomato resistance gene. In fact, most of the sequences in the signature regions contained amino acid residues identical to those of a PVY susceptible tomato variety or were conservative changes not expected to affect resistance function.

In a follow-up experiment to help identify the mechanisms of resistance for these 27 accessions, a PCR experiment was performed to determine if resistance was associated with a known extreme resistance gene linked to markers M45 (Ry_{sto}) and SCAR-RYSC3 (Ry_{adg}). Preliminary PCR results were negative for these markers. However control samples were inconsistent and additional experiments will be needed to confirm the results.

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2009 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 2009, we tested 220 varieties and breeding lines in the replicated variety trials. The variety evaluation also includes disease testing in the scab nursery (MSU Soils Farm, E. Lansing) 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.

PROCEDURE

Nine 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 (92 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.*

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 scab nursery at the MSU Soils Farm and the late blight trial at the Muck Soils Research Farm are used for scab and foliar late blight assessment of lines in the agronomic trials. 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 included in the summary sheets this year.

RESULTS

A. Early Trial:

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

There were 18 entries that were evaluated at the early harvest trial. The results are summarized in **Table 1**. Atlantic, Onaway and FL1867 were used as check varieties. The plot yields were average to slightly below average in the early harvest (102 days), and specific gravity values were typical to an average year. Hollow heart was the most prevalent internal defect in the early harvest this year, although only to a limited degree. MSQ176-5 and MSM037-3 showed the highest incidence of hollow heart in the late harvest (30% and 28%, respectively). Interestingly, the hollow heart standard Atlantic, had less incidence of hollow heart (3%) compared to average years. In the early harvest trial, the best yielding lines were Onaway, Michigan Purple Red Sport, MSQ086-3, MSL211-3, MSM037-3, and MSQ176-5. Michigan Purple Red Sport is a red-skinned selection with splashes of purple from a sport of Michigan Purple. MSQ086-3 is a round-white breeding line which chip-processes out of the field, is showing early bulking potential, and has strong foliar late blight resistance. MSL211-3 is an attractive, smooth-skinned, round to oval tablestock line with foliar late blight resistance. MSQ176-5 is a round-white freshmarket potato with good yield, round, uniform tuber shape, strong foliar late blight resistance, and moderate scab resistance.

B. Advanced Trial (Table 2)

A summary of the 25 entries evaluated in the Advanced trial results is given in **Table 2**. Overall, the yields for the Advanced trial (135 days) were average or slightly below average. The check varieties for this trial were Snowden, Pike, FL1879, and FL2137. The highest yielding lines were tightly clustered (and not significantly different) between MSP515-2 (316 cwt/a), Kalkaska, FL1879, MSQ089-1, and Beacon Chipper (265 cwt/a). The next highest yielding group was MSQ070-1, followed by MSR036-5, MSK061-4, and MSH228-6. Hollow heart and vascular discoloration were the predominant internal defects, with Kalkaska, MSR159-02, and FL2137 having the highest levels of hollow heart (30, 30, and 23%, respectively). Specific gravity was average with five lines having specific gravities higher than Snowden (1.086): MSQ070-1 (1.097), MSN191-2Y, MSJ147-1, FL2137, and MSK409-1 (1.087). All entries in the trial had excellent chip-processing quality out of the field, with an SFA score of 1.0. Most of the MSU breeding lines have moderate to strong scab resistance. Kalkaska and Beacon Chipper continue to be consistently high yielding lines with good specific gravity, chip quality, and scab resistance. Two promising chip-processing lines are MSQ070-1 (chip quality, high specific gravity, scab and late blight resistance) and MSR061-1 (chip quality, good specific gravity, scab and PVY resistance, and moderate late blight resistance).

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.

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.

MSJ147-1 – a full season storage chipper that also has some early sizing. It has excellent chip-processing quality and a high solids content. It has performed well in on-farm trials and has demonstrated an excellent long-term storage chipping profile.

Missaukee (MSJ461-1) – an MSU chip-processing selection with strong foliar resistance to late blight and maturity similar to Snowden. It has excellent chip-processing quality, round shape and above average yield, but an intermediate specific gravity in most years. The chips show few defects. It has good tablestock quality too.

MSK061-4 – an attractive round-white chip-processing line with good scab resistance. This line produces clean chips with good specific gravity and average yield, with low blackspot bruising, but has a short dormancy.

MSK409-1 – a round-white chip-processing line with good scab resistance. This earlier maturing line has average yield and slightly lower specific gravity.

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.

MSM171-A – a round-white tablestock line with moderate scab resistance and strong foliar late blight resistance. This line also has an moderately early maturity with a 'Superior' type tuber appearance.

MSM246-B – a round-white chip-processing line with good specific gravity and excellent chip quality that has demonstrated potential for good long-term chip quality.

MSN105-1 – an attractive round-white tablestock line with moderate foliar late blight resistance, moderate scab resistance, and an early maturity.

MSN170-A – 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.

MSN191-2Y – an MSU chip-processing selection with a very uniform round type. This newer line produces excellent chips with a high specific gravity and low incidence of internal defects.

MSP459-5 – another new MSU chip-processing selection with scab resistance, average specific gravity, and a good, round type. This line has excellent chip quality with a low incidence of internal defects and storage potential.

Two varieties were released in 2009: Kalkaska and Missaukee. The breeding line MSJ036-A was released as 'Kalkaska.' We have submitted the PVP application to the USDA and the variety release description to the American Journal of Potato Research. Kalkaska is a high yielding, round white potato with an attractive round appearance with shallow eyes. Kalkaska has a strong vine and a full season maturity. This variety has resistance to *Streptomyces scabies* Thaxter (common scab of potato) similar to Pike.

Kalkaska also has industry approved chip-processing storage characteristics (light color and low incidence of defects) and it also has better tolerance to blackspot bruise than Snowden. Specific gravity in Michigan averages 1.083, ranging from 1.075 to 1.096. Kalkaska also has a higher marketable yield than Pike and does not express heat necrosis in the tubers. The name Kalkaska was chosen to acknowledge a town located in the Michigan seed growing region.

MSJ461-1 was released as 'Missaukee.' Missaukee is a round white chip processing potato variety resulting from a cross between Tollocan and NY88 and has foliar resistance to potato late blight (*Phytophthora infestans* de Bary). This variety has an attractive round shape and mildly netted, bright skin. Seven years of field testing in Michigan indicate that the yield of total marketable tubers in Missaukee is similar to that of Snowden. However, Missaukee has a lower incidence of internal defects than Snowden. Specific gravity ranged from 1.069 to 1.086 in Michigan trials and out-of-the-field chip scores were similar to those of Snowden. Missaukee showed some resistance to *Verticillium* wilt in 2-years of trials. DNA marker and greenhouse tests indicate that Missaukee is also resistant to the golden cyst nematode (*Globodera rostochiensis* Woll) pathotype Ro1.

In December 2004, 2005, 2007, and 2008, the MPIC sponsored a booth at the Great Lakes Fruit, Vegetable, and Farm Market Expo to market Liberator, Michigan Purple and Jacqueline to the farm market/roadside stand market segment. The breeding program sponsored the booth in 2009 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-one entries were tested in Michigan in 2009. The clones were from three market classes: Red (9 entries), Russet (4 entries), or Round White (8 entries). The results are presented in **Tables 3 and 4**. The MSU lines Missaukee (MSJ461-1), MSN170-A, MSM171-A, and MSL268-D were the Michigan representatives included in the 2009 North Central Trial. The two lines MSM171-A and MSL268-D were trialed in the Russet Trial due to trial size limitations. Missaukee has a good, round type and chip-processing quality combined with strong foliar late blight resistance and continues to perform well in Michigan and other out of state testing locations. MSM171-A a round-white tablestock line with moderate scab resistance, strong foliar late blight resistance, and an early maturity. MSN170-A has exceptional chip-processing quality and typical agronomic performance. 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.

D. Russet Trial (Table 4)

We continue to increase our russet breeding efforts to reflect the growing interest in russet types in Michigan. In 2009, 18 lines evaluated after 128 days. The results are summarized in **Table 4**. Russet Norkotah was the reference variety used in the trial. 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 AC99375-1Rus (50%), Classic Russet (A95109-1Rus) (40%), and MN02467RUS (15%). Classic Russet also had a significant amount of vascular discoloration (30%). Specific gravity measurements were average with Russet Norkotah at 1.074. The yield of the overall trial was average to below average for 2009. Off type and cull tubers were found in nearly all lines tested, but ranged only from a high of 7% down to 1%. The highest yielding entry was AC99375-1Rus with 367 cwt/a US#1 yield, followed by A02062-TE and A01025-4.

E. Adaptation Trial (Tables 5 and 6)

The Adaptation Trial is 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. Four reference cultivars (Atlantic, Snowden, Pike, and FL1879), and 15 advanced breeding lines are reported in the chip-processing trial. The trial was harvested after 135 days and the results are summarized in **Table 5**. All entries had good out-of-the-field chip scores (1.0 SFA scale). Specific gravity values were average for the Montcalm Research Farm (Atlantic was 1.090 and Snowden was 1.085). The highest specific gravity was MSR102-3 at 1.095. The overall plot yields for this trial were lower than average in 2009. Boulder was the highest yielding line in 2008 and 2009 (133 cwt/a greater than Atlantic). Multiple new breeding lines combine scab resistance and chip-processing: MSR102-3, MSR058-1, MSR127-2, MSR161-2, and MSR169-8Y. MSR102-3 also combines late blight resistance, scab resistance, and chip-processing with a high specific gravity. MSR058-1 and MSR157-1Y are also late blight resistant and have moderate scab resistance. MSQ461-2PP is a purple-skinned purple flesh line with good specific gravity and scab resistance that can be used to make chips for the specialty market.

In the tablestock trial, 22 advanced breeding lines were evaluated with Onaway and Yukon Gold check varieties. The trial was harvested after 128 days and the results are summarized in **Table 6**. In general, the yield was average in this trial and internal defects were low. The greatest amount of hollow heart was seen in Yukon Gold (15%), followed by Reba (13%) and MSQ176-5 (10%). There were a significant number of oversize potatoes in MSQ176-5 and MSQ279-1. The highest yielding line was MSI005-20Y (yellow flesh) at 330 cwt/a, followed by MSQ279-1, MSS176-1, and MSQ086-3.

Eight of the 20 lines have late blight resistance and eight lines have moderate to strong scab resistance. Seven of the 20 lines also had early maturity, similar to Yukon Gold. Promising lines with attractive type for the tablestock market and strong foliar late blight resistance include MSM182-1, MSS176-1, MSQ086-3, MSQ176-5, and MSS737-1Y. MSM182-1 also has PVY resistance. MSQ086-3 is a round-white breeding line which chip-processes out of the field, is showing early bulking potential, and has strong foliar late blight resistance. It is exciting to see lines with combined traits for type, scab, late blight, and PVY resistance, and earlier maturity classes in more advanced selections in the breeding program.

F. Preliminary Trial (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 had 34 advanced selections and two check varieties (Atlantic and Snowden). The chip-processing trial was harvested after 133 days and is summarized in **Table 7**. Most lines chip-processed well from the field (SFA chip score 1.0 – 1.5). Specific gravity values were average for the trial (Atlantic: 1.086). The yields were slightly below average with Atlantic at 291 cwt/a and Snowden at 250 cwt/a. Twelve of the lines (35%) were classified to be resistant or moderately resistant to scab (≤ 1.5 scab disease rating). Seven lines have demonstrated foliar late blight resistance. MSQ029-1 has good agronomic performance with yield potential, solid specific gravity, late blight and PVY resistance.

Table 8 summarizes the 32 tablestock lines evaluated in the Preliminary Trial (Onaway was the check variety). This tablestock trial was harvested and evaluated after 128 days. Ten of the 32 lines were late blight resistant, two have moderate late blight resistance, and seven were scab resistant or moderately resistant (≤ 1.5 scab disease rating). MST500-1, Stirling, MSR601-22, MSS070-B, MST384-1PP, MSS206-2 were the highest yielding lines. In general, there was a low incidence of internal defects, except for some hollow heart: Stirling (95%), MST377-2P (30%), MSS487-2 (25%). Four of the top yielding lines have late blight resistance and marketable maturities (MST500-1, MSS070-B, MSS206-2, and MSS483-1). In addition to traditional round white, red-skinned, and yellow flesh freshmarket categories, there are some unique specialty lines. A few of the lines in this trial were considered for their unique color attributes for the specialty potato market: MST377-2P (purple skin, white flesh), MST123-1RY (red skin, yellow flesh), MST235-2SPL (splash), MST384-1PP, MSS514-1PP (purple skin, purple flesh).

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. We are using a scale of a 0-5 ranking 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. **Table 9** categorizes many of the varieties and advanced selections tested in 2009 at the MSU Soils Farm Scab Nursery over a three-year period. 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 Norkotah, Yukon Gold, Onaway, Pike, Atlantic and Snowden can be used as references (bolded in **Table 9**). The table is sorted in ascending order by 2009 rating. In general, most russet lines were scab resistant. 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 69 lines, of the 157 tested, had a scab rating of 1.5 (better than or equivalent to Pike) or lower in 2009. Most notable scab resistant MSU lines are MSH228-6, Kalkaska (MSJ036-A), MSJ126-9Y, MSK061-4, MSL007-B, MSN230-1RY, MSQ070-1, MSQ289-5, MSQ440-2, MSR036-5, MSR061-1, MSR102-3; as well as some earlier generation lines MSS176-1, MSS544-1R, S737-1Y, and MST306-01. 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 327 early generation selections that were evaluated, 128 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

In 2009, a late blight trial was planted at the Muck Soils Research Farm. As in previous years, 256 entries were planted in replication for evaluation in replicated plots. These include lines tested in the agronomic variety trial and entries in the National Late Blight Variety Trial. Block planting full rows of advanced selections provide a better assessment of the late blight resistance of these lines. We also planted 171 early generation breeding lines that have a late blight resistant pedigree. The field was planted on June 4. Two weeks following planting, almost six inches of rain fell at the farm over 12 days. The flooding from these and subsequent rains damaged the plots beyond recovery. Unfortunately, all plots were destroyed and no data were taken. We were able to do a late planting for a trial to test 90 *Solanum microdontum* accessions. The late blight trials will be conducted at a new location next year at the MSU Clarksville Horticultural Experiment Station. We will try again for a successful late blight disease field test in 2010.

I. Blackspot Bruise Susceptibility (Table 10)

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 10**. 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 2009, the bruise levels were comparable to previous years. The most bruise resistant MSU breeding lines this year from the Advanced trial were MSQ289-5, MSP459-5, MSQ131-A, MSQ130-4, MSL292-A, Pike, MSQ089-1, MSR061-1, MSJ126-9Y, and MSK061-4. The most susceptible lines from the Advanced trial were Kalkaska, FL2137, MSN191-2Y, MSL007-B, MSK409-1, and FL1879. Of the earlier generation breeding lines (Preliminary Trial), the most bruise resistant were MSS927-1, MST096-2Y, MST169-07, MSS199-A, MSS514-1PP, and MST065-2. The most bruise resistant russet entries were A02062-1TE, AOTX95265-4Rus, CO99053-4Rus, and CO99100-1Rus; the most susceptible were PA03NM5-1, Canela Russet, and AC99375-1Rus. The most bruise resistant entries in the US Potato Board/Snack Food Association Trial were NY138, CO96141-4W, and Kalkaska. Snowden, AF2291-10, CO97043-14W, and Atlantic were the most bruise susceptible in this trial.

Table 1

MICHIGAN STATE UNIVERSITY
POTATO BREEDING and GENETICS

EARLY HARVEST TRIAL
MONTCALM RESEARCH FARM
May 5 to August 14, 2009 (102 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]
Onaway	**315**	**349**	**90**	**9**	**86**	**5**	**1**	**1.073**	**3.0**	**0**	**3**	**0**	**0**	**1.6**
MI Purple Red Sport	282	307	92	6	79	12	2	1.072	1.5	20	3	0	0	2.8
MSQ086-3[LBR]	278	322	86	13	86	0	1	1.079	1.0	0	8	0	3	2.5
MSL211-3[LBR]	252	305	83	16	72	11	1	1.074	1.5	0	0	0	0	2.4
MSM037-3	225	241	93	6	86	7	1	1.071	1.0	28	0	0	0	1.3
MSQ176-5[LBR]	217	237	92	8	83	9	0	1.067	1.5	30	0	0	0	1.8
Atlantic	**213**	**256**	**83**	**16**	**83**	**0**	**0**	**1.095**	**1.0**	**3**	**0**	**0**	**3**	**2.7**
MSQ131-A[LBR]	212	226	94	6	90	3	1	1.070	1.0	0	0	0	0	2.0
MSN170-A	203	243	84	16	83	1	1	1.084	1.0	0	0	0	3	-
FL1867	**200**	**252**	**79**	**20**	**78**	**1**	**0**	**1.097**	**1.0**	**0**	**0**	**0**	**0**	**-**
MSL292-A	198	251	79	21	79	0	0	1.089	1.0	0	0	0	0	2.3
MSQ279-1	192	205	93	6	81	12	0	1.073	1.0	0	0	0	0	1.4
MSS582-1SPL	180	193	93	5	71	22	2	1.072	-	3	0	0	0	1.6
MSL228-1SPL	179	207	86	12	83	4	2	1.083	1.5	3	0	0	0	2.5
MSP368-1	170	204	83	17	81	3	0	1.084	1.0	0	0	0	0	-
MSN105-1	159	227	70	30	70	0	1	1.081	1.0	0	0	0	0	2.0
MSQ130-4[LBR]	158	197	80	19	80	0	1	1.078	1.0	3	0	5	0	1.8
MSR036-5[LBR]	101	130	78	21	75	2	2	1.077	1.0	0	0	3	0	1.3
MEAN	207	242						1.079						* Two-Year Average
$LSD_{0.05}$	61	65						0.004						

[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.

Table 2

ADVANCED TRIAL
MONTCALM RESEARCH FARM
May 5 to September 17, 2009 (135 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	SCAB[4]	MAT[5]	BRUISE[6]	CWT/A
MSP515-2	316	381	83	16	75	8	1	1.079	1.0	3	5	3	0	1.8	2.1	0.8	-
Kalkaska (J036-A)	280	316	89	11	81	7	1	1.085	1.0	30	0	0	5	1.3	1.7	1.6	356*
FL1879	278	300	93	7	84	9	0	1.080	1.0	10	5	0	0	2.0	1.3	1.0	366
MSQ089-1	274	321	85	14	83	2	1	1.075	1.0	8	5	3	0	1.9	1.8	0.4	-
Beacon Chipper	265	282	94	6	88	6	0	1.077	1.0	0	20	0	0	1.3	1.6	0.8	335
MSQ070-1[LBR]	229	318	72	27	72	0	0	1.097	1.0	3	0	0	0	1.3	2.3	0.9	387*
MSR036-5[LBR]	216	246	88	11	76	12	1	1.080	1.0	0	8	3	0	1.3	2.9	0.6	-
MSK061-4	215	267	81	19	80	1	0	1.085	1.0	0	25	0	0	1.4	1.8	0.5	283
MSH228-6	212	245	87	13	82	4	1	1.081	1.0	3	0	0	0	1.3	2.0	0.7	263
MSQ035-3[LBMR]	207	260	79	19	79	0	1	1.080	1.0	0	0	0	0	2.0	1.3	1.0	-
MSR159-02[LBR]	206	239	86	10	72	14	4	1.083	1.5	30	3	0	0	1.5	2.5	0.5	-
MSQ131-A[LBR]	204	216	94	5	83	11	1	1.067	1.0	0	0	0	0	2.0	1.9	0.2	-
FL2137	204	220	93	6	81	12	1	1.088	1.0	23	3	0	0	-	1.5	1.1	-
MSJ126-9Y	183	236	77	21	77	1	2	1.082	1.0	0	3	0	0	1.3	1.6	0.5	248
MSR061-1[LBRS]	176	222	79	21	75	4	0	1.080	1.0	5	5	0	0	1.1	1.9	0.4	237*
Snowden	**169**	**249**	**68**	**31**	**67**	**0**	**1**	**1.086**	**1.0**	**3**	**23**	**0**	**0**	**2.3**	**2.0**	**0.8**	**264***
Pike	**163**	**214**	**76**	**23**	**76**	**0**	**0**	**1.086**	**1.0**	**0**	**3**	**0**	**0**	**1.5**	**2.0**	**0.4**	**209***
MSJ147-1	162	274	59	40	58	1	1	1.091	1.0	0	0	0	0	1.7	2.1	0.9	196
MSP459-5[LBRS]	152	218	70	29	70	0	1	1.078	1.0	3	3	0	0	1.8	1.0	0.2	204*
MSQ130-4[LBR]	151	198	77	23	73	3	0	1.073	1.0	5	0	8	0	1.8	1.0	0.3	-
MSL292-A	150	222	67	33	67	0	0	1.084	1.0	0	5	0	0	2.3	1.1	0.4	-
MSK409-1	146	205	71	25	71	0	3	1.087	1.0	0	10	0	0	1.6	1.3	1.0	208
MSN191-2Y	137	242	56	43	56	0	0	1.095	1.0	3	0	0	0	2.8	1.0	1.0	214
MSQ289-5	135	202	67	32	66	1	2	1.086	1.0	3	0	0	0	1.3	1.0	0.1	-
MSL007-B	118	206	58	42	58	0	0	1.083	1.0	0	3	0	0	1.0	1.6	1.0	-
MEAN	198	252						1.083								* Two-Year Average	
$LSD_{0.05}$	52	53						0.004						1.1	0.4		

[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, 2009; 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 13 to September 8, 2009 (118 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	SCAB[4]	MAT[5]	BRUISE[6]	CWT/A
MN96013-1RY	315	361	87	10	85	2	3	1.068	1.5	0	0	3	0	-	1.8	0.4	-
W5767-1R	315	345	91	7	84	7	1	1.067	2.0	3	0	8	5	-	2.0	0.8	-
Snowden	**312**	**377**	**83**	**17**	**82**	**1**	**1**	**1.083**	**1.0**	**0**	**11**	**0**	**0**	2.3	**2.0**	**0.8**	**326**
ATND98459-1RY	308	398	77	22	77	0	0	1.070	2.5	0	0	0	0	-	1.6	0.1	-
Atlantic	**296**	**319**	**93**	**6**	**88**	**4**	**1**	**1.087**	**1.0**	**8**	**0**	**5**	**3**	**2.7**	**2.3**	**1.7**	**298**
ND8305-1	292	332	88	11	85	3	1	1.085	1.0	0	0	0	0	-	1.1	1.1	-
Missaukee (MSJ461-1)[LBR]	287	335	85	14	82	4	0	1.074	1.0	0	3	0	0	-	2.6	0.2	-
ND028842-1RY	285	362	79	19	79	0	2	1.065	2.0	0	10	8	0	-	1.3	0.3	-
Red Norland	**270**	**303**	**89**	**10**	**86**	**3**	**1**	**1.061**	**2.5**	**0**	**0**	**0**	**0**	-	**1.0**	**0.1**	**-**
MSN170-A	264	297	89	9	84	5	2	1.078	1.0!	8	0	0	11	-	1.6	0.4	294*
W5015-12	260	311	84	15	79	5	1	1.078	1.5	0	5	0	5	-	3.4	0.7	-
MN02616RY	253	314	81	17	77	3	2	1.067	1.5	0	0	0	0	-	1.0	0.8	-
WV4992-1RUS	242	316	77	20	72	4	3	1.075	1.5	0	0	0	0	-	1.5	0.8	-
W2978-3	240	277	87	11	85	1	3	1.071	1.0	0	0	0	0	-	1.4	0.1	-
CV01238-3RUS	217	309	70	20	64	6	10	1.067	1.5	0	0	8	0	-	1.3	0.1	-
CV99073-1R	182	227	80	19	76	4	1	1.063	3.5	0	15	0	0	-	1.5	0.2	-
ND8304-2	157	220	71	24	71	0	4	1.075	1.0	0	5	5	0	-	1.0	0.2	139*
MN19298RY	140	209	67	31	67	0	2	1.061	1.0	0	0	0	0	-	1.3	0.1	-
WV5843-6R	138	209	66	25	61	6	9	1.054	3.0	0	0	3	3	-	1.0	0.5	-
MEAN	251	306						1.071								* Two-Year Average	
$LSD_{0.05}$	69	71						0.003						1.1	0.4		

[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, 2009; 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

MICHIGAN STATE UNIVERSITY
POTATO BREEDING and GENETICS

RUSSET TRIAL 2009
MONTCALM RESEARCH FARM
May 5 to September 10, 2009 (128 days)

	CWT/A		PERCENT OF TOTAL[1]						PERCENT (%) TUBER QUALITY[2]							3-YR AVG
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	HH	VD	IBS	BC	SCAB[3]	MAT[4]	BRUISE[5]	US#1 CWT/A
AC99375-1Rus	367	473	78	10	66	11	7	1.080	50	5	3	0	1.3	3.1	0.6	368*
A02062-1TE	319	357	90	7	69	20	5	1.070	0	18	0	0	1.5	1.8	0.0	-
A01025-4	314	390	80	8	68	12	5	1.074	3	13	0	0	1.0	2.1	0.3	-
PA03NM5-1	294	355	83	14	73	10	4	1.085	8	30	0	0	1.0	3.4	3.6	-
MN02467RUS	292	396	74	13	63	11	4	1.080	15	0	0	0	0.4	3.4	0.5	-
Classic Russet (A95109-1Rus)	287	335	86	7	63	23	4	1.074	28	30	0	0	1.3	1.6	0.4	337
CO99053-3Rus	273	336	81	11	71	10	7	1.076	8	10	0	0	1.5	2.5	0.4	312*
**MSM171-A[LBR]	269	293	92	6	80	11	2	1.066	5	0	3	0	2.3	1.3	0.4	307
Goldrush Russet	256	343	75	5	73	1	4	1.075	0	0	0	0	1.0	1.1	0.3	-
Silverton Russet	246	299	82	7	76	7	4	1.068	3	3	3	0	1.3	1.4	0.3	314*
W7098-2Rus	240	295	81	11	66	15	6	1.067	0	10	0	0	1.3	2.1	0.2	-
**MSL268-D[LBR]	231	321	72	8	72	0	2	1.080	3	18	0	0	2.5	1.8	0.8	289*
CO99053-4Rus	229	319	72	5	69	3	4	1.078	0	5	0	0	1.5	1.0	0.2	227*
CORN #8	217	303	72	7	67	5	5	1.071	13	10	0	0	1.0	1.4	0.2	207
Canela Russet	202	263	77	8	75	2	1	1.083	0	5	0	0	0.7	1.5	1.0	241
AOTX95265-4Rus	162	262	62	7	58	4	4	1.072	0	0	0	0	1.3	1.3	0.1	-
CO99100-1Rus	149	230	65	6	65	0	3	1.075	0	8	0	0	1.3	1.0	0.2	201*
Russet Norkotah	**143**	**270**	**53**	**6**	**52**	**1**	**2**	**1.074**	**5**	**3**	**0**	**0**	**2.0**	**1.1**	**0.2**	**155**
MEAN	249	324						1.075								* Two-Year Average
$LSD_{0.05}$	70	72						0.003					1.1	0.6		

**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.

NCR North Central Regional Entry

[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, 2009; 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

ADAPTATION TRIAL, CHIP-PROCESSING LINES
MONTCALM RESEARCH FARM
May 5 to September 17, 2009 (135 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]
Boulder	309	320	97	3	64	32	1	1.075	1.0	8	3	0	3	2.3	2.1	0.8
AO1143-3C	299	355	84	14	83	2	2	1.080	-	8	0	0	0	1.3	2.5	-
MSR102-3[LBR]	254	295	86	11	72	14	3	1.095	1.0	18	0	0	0	0.8	3.0	1.6
MSP270-1	253	295	86	14	84	2	0	1.078	1.0	0	0	0	0	1.5	2.5	0.6
MSR058-1[LBR]	201	256	79	21	77	2	0	1.083	1.0	0	3	0	0	1.3	2.3	1.7
MSQ461-2PP	196	225	87	13	84	3	0	1.078	1.0	0	0	0	0	0.8	1.5	-
MSR127-2	194	250	78	13	69	8	9	1.087	1.0	0	0	0	0	1.0	2.5	1.1
MSN148-A	192	239	80	18	74	6	1	1.087	1.0	3	10	0	0	2.0	1.5	2.1
MSR128-4Y	184	279	66	32	66	0	2	1.090	1.0	0	0	0	0	2.0	2.5	0.6
AO0188-3C	179	234	77	22	77	0	1	1.083	1.0	0	10	0	0	1.3	2.3	0.2
Atlantic	**176**	**221**	**80**	**19**	**78**	**1**	**2**	**1.090**	**1.0**	**5**	**3**	**3**	**0**	**2.7**	**1.8**	**1.1**
FL1879	**172**	**203**	**85**	**14**	**84**	**1**	**1**	**1.079**	**1.0**	**3**	**18**	**0**	**0**	**2.0**	**1.1**	**0.3**
Snowden	**172**	**275**	**63**	**37**	**63**	**0**	**0**	**1.085**	**1.0**	**0**	**10**	**0**	**0**	**2.3**	**1.9**	**0.7**
MSQ440-2 [Table]	168	202	83	15	80	3	2	1.064	-	0	48	0	0	1.0	1.3	0.4
Pike	**158**	**192**	**82**	**18**	**82**	**1**	**0**	**1.085**	**1.0**	**5**	**10**	**0**	**0**	**1.5**	**1.8**	**0.9**
MSR161-2	157	220	71	25	71	0	4	1.087	1.0	0	3	0	0	1.0	2.0	1.1
MSR157-1Y[LBR]	148	195	76	24	76	0	0	1.080	1.0	0	8	0	0	1.5	2.0	0.4
MSN190-2	119	207	57	42	57	0	1	1.094	1.0	0	0	0	0	1.6	1.0	1.1
MSR169-8Y	78	136	57	43	57	0	0	1.084	1.0	0	3	0	0	1.0	2.0	0.4
MEAN	190	242						1.083								
$LSD_{0.05}$	55	57						0.005						1.1	0.5	

[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, 2009; 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 5 to September 10, 2009 (128 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]
MSI005-20Y	330	393	84	14	81	3	2	1.074	0	0	0	0	2.8	1.6	0.2
MSQ279-1	306	334	92	6	78	14	3	1.080	0	0	0	0	1.4	2.9	0.6
MSS176-1[LBR]	292	335	87	10	80	7	3	1.074	0	0	0	0	1.3	2.0	0.4
MSQ086-3[LBR]	291	380	77	23	75	1	0	1.080	3	10	0	0	2.5	1.8	0.5
MI Purple Red Sport	273	305	89	7	80	9	3	1.074	3	5	0	0	2.8	1.0	0.6
MSQ176-5[LBR]	271	296	92	7	79	13	1	1.067	10	0	0	0	1.8	1.8	0.4
MSN230-1RY[LBR]	235	304	77	21	73	4	2	1.080	0	10	0	0	0.3	2.0	0.3
MSS737-1Y[LBR]	235	278	84	13	74	10	3	1.071	0	5	0	0	1.3	2.1	0.1
MSM037-3	233	265	88	11	87	1	1	1.070	8	3	0	0	1.3	1.8	0.0
MI Purple	230	251	92	7	83	8	1	1.071	5	5	0	3	2.3	1.3	0.2
Onaway	**230**	**265**	**87**	**11**	**84**	**3**	**3**	**1.071**	**0**	**0**	**0**	**0**	**1.6**	**1.4**	**0.3**
Reba	228	265	86	13	82	4	1	1.074	13	0	0	0	2.0	1.9	0.9
MSM182-1[LBR PVYR]	194	286	68	31	67	1	1	1.075	3	0	0	0	2.9	1.6	0.8
MSL228-1SPL	189	240	79	18	77	2	4	1.081	0	3	0	0	2.5	1.1	0.4
MSQ134-5[LBR]	186	226	83	17	80	3	0	1.073	0	0	0	0	1.9	1.8	0.6
MSL211-3[LBR]	181	242	75	25	71	4	1	1.073	0	3	0	0	2.4	1.0	0.0
MSQ425-4PYSPL	157	230	68	32	68	0	0	1.076	0	0	0	0	2.3	1.5	0.5
MSS576-05SPL	156	196	80	20	78	2	0	1.072	0	0	0	0	2.0	1.4	0.2
MSS108-1	156	246	63	36	63	0	1	1.075	0	3	10	0	-	1.6	0.2
Yukon Gold	**152**	**180**	**85**	**10**	**76**	**8**	**6**	**1.077**	**15**	**8**	**3**	**0**	**2.3**	**1.0**	**0.0**
MSN105-1	150	240	63	36	63	0	1	1.079	0	0	0	0	2.0	1.3	0.2
MSR217-1R	137	173	80	20	80	0	0	1.065	0	3	0	0	1.8	1.0	0.3
MSN215-2P	131	202	65	31	65	0	4	1.073	0	0	0	0	0.8	1.0	0.2
MSQ432-2PP	112	124	90	5	90	0	5	1.068	0	0	0	0	1.8	1.8	-
MEAN	211	261						1.074							
$LSD_{0.05}$	66	68						0.003					1.1	0.3	

[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, 2009; 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 5 to September 14, 2009 (133 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]
MST222-5	386	405	95	2	67	29	3	1.062	1.5	5	20	0	0	2.2	2.8	0.6
MST220-08[LBR]	365	419	87	11	76	11	2	1.078	1.5	25	5	5	0	2.1	4.0	1.1
MST193-4Y	339	408	83	15	82	1	2	1.077	1.5	0	0	0	0	2.0	3.3	1.0
MST412-3	332	367	90	7	64	26	2	1.074	1.0	20	5	0	0	2.0	2.8	0.2
MSQ029-1[LBR PVYR]	315	376	84	8	67	17	8	1.084	1.5	20	0	0	0	2.0	4.3	0.5
CO00197-3W	312	407	77	22	75	2	1	1.079	1.0	5	10	0	0	3.1	1.3	0.6
MST611-1Y	306	352	87	8	67	21	5	1.075	1.5	0	0	0	0	-	3.0	0.2
MSM246-B	302	340	89	9	78	10	2	1.081	1.0	20	0	0	0	2.8	2.0	0.6
MSS934-4	301	347	87	6	65	21	7	1.079	1.0	0	0	0	0	2.8	2.3	1.0
MST443-1	295	334	88	11	79	9	1	1.083	1.0	0	0	0	0	-	2.0	0.7
Atlantic	**291**	**328**	**89**	**11**	**88**	**1**	**0**	**1.086**	**1.0**	**0**	**0**	**0**	**0**	**2.7**	**2.0**	**1.3**
MST169-07	278	330	84	16	81	3	0	1.073	1.0	0	0	0	0	1.5	1.0	0.1
MST424-3	266	298	89	8	85	4	3	1.076	1.0	0	0	0	0	1.3	2.5	1.3
Snowden	**250**	**327**	**76**	**23**	**76**	**0**	**0**	**1.081**	**1.0**	**0**	**0**	**0**	**0**	**2.3**	**2.8**	**1.4**
MSN111-4PP	244	324	75	24	75	1	1	1.069	1.5	0	0	0	0	1.0	1.3	0.9
MST458-04[LBR]	240	254	94	2	58	37	4	1.075	1.0	0	0	0	0	1.5	1.0	0.9
MST429-3Y[LBR]	237	304	78	9	61	17	13	1.073	1.5	25	5	0	0	1.8	3.3	0.4
MST008-01[LBR]	231	306	76	23	60	15	2	1.060	1.0	10	0	0	0	2.8	1.0	0.2
MST443-2Y	230	317	73	27	73	0	0	1.087	1.0	0	5	0	0	1.5	1.3	0.9
MST184-3	228	264	86	7	70	16	7	1.080	1.0	15	0	0	0	1.6	3.0	0.8
MSS165-2Y	219	294	75	17	74	1	8	1.082	1.5	15	0	5	0	1.5	2.8	0.7
MST202-5	201	274	73	16	73	0	10	1.080	1.0	5	15	0	0	1.8	1.3	0.2
MSS258-1	187	216	87	12	83	4	1	1.068	1.0	5	0	0	0	2.0	1.0	0.9
MSS026-2Y	184	232	79	18	78	1	2	1.092	1.5	0	0	0	0	2.5	2.5	1.2
MST611-2	179	246	73	12	67	6	15	1.073	1.0	0	0	0	0	1.8	1.8	0.4
MSS428-2	172	228	76	24	76	0	0	1.080	1.0	5	0	0	0	2.3	1.0	1.0
MST096-2Y	162	197	82	18	82	0	0	1.073	1.5	0	0	0	0	1.5	1.5	0.0

Table 7

MICHIGAN STATE UNIVERSITY
POTATO BREEDING and GENETICS

PRELIMINARY TRIAL, CHIP-PROCESSING LINES
MONTCALM RESEARCH FARM
May 5 to September 14, 2009 (133 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]
MST007-2	157	212	74	23	74	0	3	1.080	1.0	30	0	5	0	1.8	1.5	0.5
MSS297-3	157	247	63	36	63	0	1	1.077	1.0	0	5	0	0	1.0	1.3	0.6
MST190-15Y[LBR]	155	233	67	32	67	0	1	1.080	1.0	0	0	0	0	2.3	2.3	0.3
MST229-1	155	184	84	11	83	1	4	1.080	1.0	10	5	0	0	1.3	4.3	0.8
MSS927-1	149	176	84	16	77	7	0	1.070	1.0	0	5	0	0	1.5	1.3	0.0
MST094-1	148	176	84	15	61	23	0	1.071	1.0	0	10	0	0	1.5	1.5	2.2
MST458-06	144	211	68	32	68	0	0	1.070	1.0	0	0	0	0	2.5	1.0	-
CO00188-4W	121	223	54	46	54	0	0	1.081	1.0	0	0	0	0	2.0	1.0	0.2
MST306-01[LBR]	90	199	45	54	45	0	1	1.074	1.0	0	0	0	0	1.0	1.5	0.7
MEAN	231	288						1.077								
$LSD_{0.05}$	78	85						0.007						1.1	0.6	

[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, 2009; 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 5 to September 9, 2009 (128 days)

	CWT/A		PERCENT OF TOTAL[1]						PERCENT (%) TUBER QUALITY[3]						
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	HH	VD	IBS	BC	SCAB[4]	MAT[5]	BRUISE[6]
MST500-1[LBR]	424	469	90	9	76	15	1	1.073	5	0	0	0	2.7	3.5	0.5
Stirling[LBR]	413	454	91	6	59	32	3	1.065	95	0	0	0	2.8	3.5	1.6
MSR601-22	384	420	91	9	89	2	0	1.064	0	0	0	0	2.5	2.0	0.2
MSS070-B[LBMR]	373	416	90	8	79	10	2	1.076	0	0	0	0	2.0	2.3	0.3
MST384-1PP	339	367	92	5	74	19	3	1.071	0	0	0	0	1.5	3.3	0.4
MSS206-2[LBR]	336	358	94	2	50	44	4	1.066	20	0	0	0	2.1	2.3	0.3
MST065-1	317	361	88	11	78	10	1	1.076	0	5	5	0	2.1	3.5	0.7
MSS483-1[LBR]	299	387	77	22	75	2	1	1.071	15	0	0	0	2.3	1.0	0.4
Onaway	**298**	**344**	**87**	**8**	**81**	**6**	**5**	**1.071**	**0**	**0**	**0**	**0**	**1.6**	**1.0**	**1.1**
MST377-2P	292	352	83	14	76	7	3	1.062	30	0	0	0	1.5	1.3	0.6
MST285-2[LBR]	280	325	86	6	67	19	8	1.073	15	0	0	0	1.5	3.0	0.3
ATTX961014-1RY	274	373	73	26	68	6	0	1.073	0	0	0	0	3.5	1.0	0.3
MSS199-A[LBR]	267	310	86	12	78	8	2	1.073	0	0	0	0	2.3	2.3	0.1
MSS487-2[LBR]	262	286	92	8	65	27	0	1.072	25	0	0	0	2.0	3.5	1.3
MST065-2	250	289	87	9	74	13	4	1.059	0	0	0	0	1.8	1.0	0.1
CO99256-2R	248	334	74	25	74	0	1	1.065	0	0	0	0	1.8	1.8	0.9
Reba	244	275	89	11	84	5	0	1.071	5	0	0	5	2.0	2.0	0.1
MSR601-19	242	345	70	30	70	0	0	1.076	0	0	0	0	2.0	2.5	0.5
MST235-2SPL	234	256	91	9	88	4	0	1.073	0	0	0	0	2.5	1.0	0.6
MSR601-21	231	296	78	19	75	3	3	1.071	0	0	0	0	3.3	1.0	0.3
MST145-1[LBR]	222	294	75	23	73	2	1	1.069	0	0	0	0	2.0	2.0	0.4
MSS514-1PP	205	261	78	17	75	3	4	1.061	0	0	0	0	1.5	1.3	0.1
CO00270-7W	204	246	83	16	81	2	0	1.076	0	5	0	0	2.8	1.3	0.4
MST123-1RY	198	272	73	16	67	6	11	1.063	0	0	0	0	1.4	2.8	0.4
CO99076-6R	197	234	84	12	75	9	4	1.067	10	0	0	0	2.5	1.0	0.6
MST359-3[LBR]	194	224	87	11	83	4	3	1.074	0	0	0	0	1.8	2.8	0.2
MST075-1R	194	264	73	27	73	0	0	1.067	0	0	0	0	1.8	1.0	0.2
Midnight	178	310	57	41	54	4	2	1.053	0	0	0	0	2.3	1.0	0.4

Table 8

PRELIMINARY TRIAL, TABLESTOCK LINES
MONTCALM RESEARCH FARM
May 5 to September 9, 2009 (128 days)

	CWT/A		PERCENT OF TOTAL[1]						PERCENT (%) TUBER QUALITY[3]						
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	HH	VD	IBS	BC	SCAB[4]	MAT[5]	BRUISE[6]
MSR297-A[LBRS]	162	180	90	10	86	5	0	1.066	0	0	0	0	1.7	1.5	0.2
MSS544-1R	157	281	56	44	56	0	0	1.069	0	0	0	0	0.8	1.0	0.4
MST033-2[LBR]	136	200	68	30	65	3	2	1.075	0	0	0	0	1.5	1.0	0.4
CO98012-5R	132	234	56	44	56	0	0	1.068	0	0	0	0	1.8	1.3	1.0
MEAN	256	313						1.069							
$LSD_{0.05}$	105	108						0.005					1.1	0.7	

[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, 2009; 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

2007-2009 SCAB DISEASE TRIAL SUMMARY
SCAB NURSERY, EAST LANSING, MI

LINE	*3-YR* AVG.*	2009 RATING	2009 WORST	2009 N	2008 RATING	2008 WORST	2008 N	2007 RATING	2007 WORST	2007 N
Sorted by ascending 2009 Rating;										
MSN230-1RY	-	0.3	1	4	-	-	-	-	-	-
MN02467RUS	-	0.4	1	5	-	-	-	-	-	-
Canela Russet	***0.8***	0.7	1	3	1.4	2	4	0.3	1	4
MSR176-4P	***1.0****	0.7	1	3	1.3	2	4	-	-	-
MSR102-3[LBR]	***0.8***	0.8	1	4	1.1	2	4	0.5	1	2
MSQ461-2PP	***1.2***	0.8	1	4	1.5	2	4	1.3	2	4
MSN215-2P	***0.9****	0.8	1	4	1.0	1	4	-	-	-
MSS544-1R	***0.9****	0.8	1	4	1.0	1	4	-	-	-
MSQ405-1PP	-	0.8	1	4	-	-	-	-	-	-
MSR161-2	***1.0***	1.0	1	4	1.0	1	4	1.0	1	3
MSQ440-2	***1.1***	1.0	2	4	1.3	2	4	1.0	1	4
MSR127-2	***1.1***	1.0	1	4	1.3	2	4	1.0	1	3
CORN#8	***1.8***	1.0	1	4	2.1	3	4	2.3	3	4
MSR169-8Y	***1.0****	1.0	1	4	1.0	1	2	-	-	-
MSR226-ARR	***1.0****	1.0	1	4	1.0	1	2	-	-	-
MSS297-3	***1.3****	1.0	1	4	1.5	2	1	-	-	-
MSR226-1RR	***1.5****	1.0	2	4	2.0	2	3	-	-	-
MSN111-4PP	***1.9****	1.0	3	4	2.9	4	4	-	-	-
A01025-4	-	1.0	1	1	-	-	-	-	-	-
Goldrush Russet	-	1.0	1	4	-	-	-	-	-	-
MSL007-B	-	1.0	1	3	-	-	-	-	-	-
MST306-01	-	1.0	2	4	-	-	-	-	-	-
PA03NM5-1	-	1.0	1	4	-	-	-	-	-	-
MSR061-1[LBMR,PVYR]	***1.1***	1.1	2	4	1.3	2	4	1.0	1	4
Classic Russet (A95109-1Rus)	***1.0***	1.3	2	4	1.0	2	4	0.7	1	3
Kalkaska (MSJ036-A)	***1.0***	1.3	2	4	1.1	2	4	0.8	1	4
MSQ289-5	***1.1***	1.3	2	4	1.0	2	4	1.0	1	4
MSR036-5[LBR]	***1.3***	1.3	2	4	1.5	2	3	1.0	1	3
MSJ126-9Y	***1.2***	1.3	2	4	1.1	2	4	1.3	2	4
MSH228-6	***1.3***	1.3	2	4	1.0	1	3	1.5	2	4
Beacon Chipper	***1.3***	1.3	2	4	1.0	1	1	1.8	2	4
MSQ558-2RR	***1.6***	1.3	2	4	1.6	2	4	2.0	3	4
Silverton Russet	***1.0****	1.3	2	4	0.8	1	4	-	-	-
AC99375-1RUS	***1.1****	1.3	2	4	1.0	1	1	-	-	-
CO99100-1RUS	***1.3****	1.3	2	4	1.3	3	4	-	-	-
MSR058-1	***1.3****	1.3	2	4	1.3	2	4	-	-	-
MSS737-1Y[LBR]	***1.5****	1.3	2	4	1.7	2	3	-	-	-
MSM037-3	***1.5****	1.3	2	4	1.8	2	4	-	-	-
A01143-3C	-	1.3	2	4	-	-	-	-	-	-
MST229-1	-	1.3	2	4	-	-	-	-	-	-
MST424-3	-	1.3	2	4	-	-	-	-	-	-
MST491-2RUS	-	1.3	3	4	-	-	-	-	-	-
W7098-2Rus	-	1.3	2	4	-	-	-	-	-	-

Table 9

MICHIGAN STATE UNIVERSITY

POTATO BREEDING and GENETICS

2007-2009 SCAB DISEASE TRIAL SUMMARY
SCAB NURSERY, EAST LANSING, MI

LINE	*3-YR* AVG.*	2009 RATING	2009 WORST	2009 N	2008 RATING	2008 WORST	2008 N	2007 RATING	2007 WORST	2007 N
Sorted by ascending 2009 Rating;										
MSQ070-1[LBR]	***1.0***	1.3	2	3	1.0	1	4	0.8	1	4
MSS176-1[LBR]	***1.2****	1.3	2	3	1.0	1	1	-	-	-
AOTX95265-4Rus	***1.8****	1.3	2	3	2.3	3	4	-	-	-
A00188-3C	-	1.3	2	3	-	-	-	-	-	-
MSK061-4	***1.1***	1.4	2	4	1.0	1	4	1.0	1	4
MSQ279-1	***1.5***	1.4	2	4	1.5	2	4	1.8	3	4
MSS165-2Y[LBR]	***1.3****	1.4	2	4	1.3	2	4	-	-	-
MST123-1RY	-	1.4	3	4	-	-	-	-	-	-
MSR157-1Y	***1.4***	1.5	2	4	1.5	2	4	1.3	2	4
Pike	***1.4***	**1.5**	**2**	**8**	**1.4**	**2**	**15**	**1.4**	**2**	**8**
MSS514-1PP	***1.1****	1.5	3	4	0.8	1	4	-	-	-
CO99053-4RUS	***1.4****	1.5	2	4	1.4	2	4	-	-	-
CO99053-3RUS	***1.5****	1.5	3	4	1.5	3	4	-	-	-
MSR159-02[LBR]	***1.5****	1.5	2	4	1.5	2	3	-	-	-
MSS927-1	***1.8****	1.5	2	4	2.0	2	4	-	-	-
A02062-1TE	-	1.5	2	4	-	-	-	-	-	-
MSP270-1	-	1.5	2	4	-	-	-	-	-	-
MST033-2	-	1.5	2	4	-	-	-	-	-	-
MST094-1	-	1.5	3	4	-	-	-	-	-	-
MST096-2Y	-	1.5	3	4	-	-	-	-	-	-
MST169-07	-	1.5	3	4	-	-	-	-	-	-
MST285-2	-	1.5	2	4	-	-	-	-	-	-
MST377-2P	-	1.5	2	4	-	-	-	-	-	-
MST384-1PP	-	1.5	2	4	-	-	-	-	-	-
MST443-2Y	-	1.5	3	4	-	-	-	-	-	-
MST458-04	-	1.5	2	2	-	-	-	-	-	-
MSK409-1	***1.5***	1.6	2	4	2.0	4	3	0.8	1	4
MSN190-2	***1.6***	1.6	3	4	2.0	2	4	1.3	2	4
MSS582-1SPL	***2.0***	1.6	3	4	2.4	3	4	2.0	3	5
Onaway	***1.7****	**1.6**	**2**	**8**	**1.8**	**2**	**7**	-	-	-
MST184-3	-	1.6	2	4	-	-	-	-	-	-
MSJ147-1	***1.3***	1.7	2	3	1.4	2	4	1.0	1	4
MSR297-A	***1.7****	1.7	2	3	1.8	2	3	-	-	-
MSP459-5[LBMR]	***1.4***	1.8	3	4	1.5	2	4	1.0	1	4
MSQ432-2PP	***1.5***	1.8	3	4	1.5	2	2	1.3	2	3
MSQ130-4[LBR]	***1.6***	1.8	3	4	1.5	2	4	1.5	2	4
MSR217-1R	***1.6****	1.8	3	4	-	-	-	1.5	2	2
MSQ176-5[LBR]	***1.9***	1.8	3	4	2.0	2	3	2.0	2	4
MSR218-AR	***1.4****	1.8	3	4	1.0	1	1	-	-	-
CO98012-5R	***1.9****	1.8	4	4	2.1	3	4	-	-	-
MSR241-4RY	***2.0****	1.8	3	4	2.3	3	4	-	-	-
CO99256-2R	-	1.8	3	4	-	-	-	-	-	-
MSP515-2	-	1.8	2	4	-	-	-	-	-	-

Table 9

MICHIGAN STATE UNIVERSITY

POTATO BREEDING and GENETICS

2007-2009 SCAB DISEASE TRIAL SUMMARY
SCAB NURSERY, EAST LANSING, MI

LINE	*3-YR* AVG.*	2009 RATING	2009 WORST	2009 N	2008 RATING	2008 WORST	2008 N	2007 RATING	2007 WORST	2007 N
Sorted by ascending 2009 Rating;										
MST007-2	-	1.8	3	4	-	-	-	-	-	-
MST065-2	-	1.8	3	3	-	-	-	-	-	-
MST075-1R	-	1.8	3	4	-	-	-	-	-	-
MST202-5	-	1.8	3	4	-	-	-	-	-	-
MST359-3	-	1.8	2	4	-	-	-	-	-	-
MST429-3Y	-	1.8	2	4	-	-	-	-	-	-
MST611-2	-	1.8	2	4	-	-	-	-	-	-
MSQ089-1	***1.6***	1.9	3	4	1.9	2	7	1.0	1	3
MSQ134-5[LBR]	***1.8***	1.9	2	4	1.9	3	4	1.5	2	4
MSR128-4Y	***1.7***	2.0	3	4	2.0	3	4	1.0	1	3
MSQ029-1[LBR]	***1.8***	2.0	2	4	2.0	2	4	1.3	2	3
MSQ035-3[LBR]	***1.7***	2.0	2	4	1.5	2	3	1.5	2	2
Reba	***1.9***	2.0	3	8	2.0	3	8	1.8	2	4
MSN313-A	***1.9****	2.0	3	4	-	-	-	1.8	2	4
MSN105-1[LBMR]	***2.0***	2.0	2	4	1.9	3	4	2.0	3	4
FL1879	***2.2***	2.0	3	7	2.5	3	11	2.0	2	4
Russet Norkotah	***2.0****	**2.0**	**3**	**4**	**-**	**-**	**-**	**2.0**	**3**	**4**
MSN148-A	***1.7****	2.0	3	4	1.4	2	4	-	-	-
MSQ131-A[LBR]	***2.0****	2.0	3	4	2.0	2	4	-	-	-
MSS258-1	***2.0****	2.0	3	4	2.0	2	1	-	-	-
MSS487-2	***2.0****	2.0	3	4	2.0	2	1	-	-	-
CO00188-4W	-	2.0	2	4	-	-	-	-	-	-
MSR601-19	-	2.0	3	3	-	-	-	-	-	-
MSS070-B	-	2.0	3	4	-	-	-	-	-	-
MSS576-05SPL	-	2.0	3	4	-	-	-	-	-	-
MST145-1	-	2.0	4	4	-	-	-	-	-	-
MST193-4Y	-	2.0	3	4	-	-	-	-	-	-
MST412-3	-	2.0	2	3	-	-	-	-	-	-
MSM060-3	***1.8***	2.1	3	4	1.5	2	4	1.8	2	4
MSS206-2[LBR]	***1.9****	2.1	3	4	1.8	2	4	-	-	-
MST065-1	-	2.1	3	4	-	-	-	-	-	-
MST220-08	-	2.1	3	4	-	-	-	-	-	-
MST222-5	-	2.2	3	3	-	-	-	-	-	-
MSM171-A[LBR]	***1.7***	2.3	3	4	1.7	3	8	1.3	2	4
Boulder	***1.9***	2.3	3	4	1.6	2	4	1.8	2	4
MSL292-A	***2.4***	2.3	3	4	2.8	3	4	2.3	3	4
Snowden	***2.5***	**2.3**	**3**	**12**	**2.6**	**3**	**16**	**2.6**	**3**	**18**
Yukon Gold	***2.7***	**2.3**	**3**	**4**	**3.0**	**3**	**1**	**2.8**	**3**	**4**
MSQ425-4Y SPL	***2.4***	2.3	4	4	1.9	2	4	3.0	3	1
MSS428-2	***2.0****	2.3	3	4	1.7	2	3	-	-	-
MSS097-3[LBR]	***2.3****	2.3	3	4	2.3	3	3	-	-	-
MSS438-1	-	2.3	3	4	-	-	-	-	-	-
MST190-15Y	-	2.3	3	4	-	-	-	-	-	-

Table 9

MICHIGAN STATE UNIVERSITY
POTATO BREEDING and GENETICS

2007-2009 SCAB DISEASE TRIAL SUMMARY
SCAB NURSERY, EAST LANSING, MI

LINE	*3-YR* AVG.*	2009 RATING	2009 WORST	2009 N	2008 RATING	2008 WORST	2008 N	2007 RATING	2007 WORST	2007 N
Sorted by ascending 2009 Rating;										
Michigan Purple	***2.1***	2.3	3	8	1.8	3	4	2.3	3	4
MSS199-A	***1.8****	2.3	3	3	1.3	2	4	-	-	-
Midnight	-	2.3	4	3	-	-	-	-	-	-
MSL211-3	-	2.4	3	4	-	-	-	-	-	-
MSL268-D[LBR,PVYR]	***1.7***	2.5	4	4	1.1	2	4	1.5	2	4
MSQ086-3[LBR]	***2.0***	2.5	4	4	1.5	2	4	2.0	2	4
Jacqueline Lee[LBR]	***2.7***	2.5	3	4	3.3	4	4	2.3	3	4
MSL228-1SPL	***2.1****	2.5	4	3	1.6	2	4	-	-	-
MSS026-2Y	***2.3****	2.5	3	4	2.2	3	3	-	-	-
MSR219-2R	***2.4****	2.5	3	2	2.3	3	4	-	-	-
CO99076-6R	-	2.5	3	4	-	-	-	-	-	-
MSR601-22	-	2.5	3	2	-	-	-	-	-	-
MST235-2SPL	-	2.5	3	4	-	-	-	-	-	-
MST458-06	-	2.5	4	4	-	-	-	-	-	-
MST500-1	-	2.7	3	3	-	-	-	-	-	-
Atlantic	***2.5***	**2.7**	**3**	**8**	**2.4**	**3**	**12**	**2.4**	**3**	**16**
MSN191-2Y	***2.3***	2.8	3	4	2.5	3	4	1.5	2	4
MSI005-20Y	***2.3***	2.8	3	4	2.2	3	9	2.0	2	4
MSM246-B	***2.5***	2.8	4	4	2.5	3	3	2.3	3	4
MSS934-4	***2.8****	2.8	3	4	2.8	3	2	-	-	-
CO00270-7W	-	2.8	3	4	-	-	-	-	-	-
MI Purple Red Sport	-	2.8	4	3	-	-	-	-	-	-
MST008-01	-	2.8	3	4	-	-	-	-	-	-
Stirling	-	2.8	4	4	-	-	-	-	-	-
MSM182-1[LBR,PVYR]	***2.3***	2.9	4	4	2.1	3	4	2.0	3	4
CO00197-3W	-	3.1	4	4	-	-	-	-	-	-
MSR601-21	-	3.3	4	3	-	-	-	-	-	-
ATTX961014-1RY	-	3.5	4	4	-	-	-	-	-	-
$LSD_{0.05}$ =		**1.1**			**0.9**			**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.

N = Number of replications.

Table 10

MICHIGAN STATE UNIVERSITY
POTATO BREEDING and GENETICS

2009 BLACKSPOT BRUISE SUSCEPTIBILITY TEST
SIMULATED BRUISE SAMPLES*

	NUMBER OF SPOTS PER TUBER						PERCENT (%) BRUISE	AVERAGE
ENTRY	0	1	2	3	4	5+	FREE	SPOTS/TUBER
ADVANCED TRIAL								
MSQ289-5	22	3					88	0.1
MSP459-5	21	4					84	0.2
MSQ131-A	24					1	96	0.2
MSQ130-4	19	5	1				76	0.3
MSL292-A	18	6		1			72	0.4
Pike	**17**	**7**	**1**				**68**	**0.4**
MSQ089-1	18	5	1	1			72	0.4
MSR061-1	18	5	1	1			72	0.4
MSJ126-9Y	15	8	2				60	0.5
MSK061-4	16	6	3				64	0.5
MSR159-02	16	5	4				64	0.5
MSR036-5	15	7	2	1			60	0.6
MSH228-6	12	9	3	1			48	0.7
MSP515-2	15	2	6	2			60	0.8
Beacon Chipper	11	10	1	3			44	0.8
Snowden	**10**	**9**	**6**				**40**	**0.8**
MSJ147-1	12	8	2	2	1		48	0.9
MSQ070-1	16	3	1	4		1	64	0.9
FL1879	13	4	3	5			52	1.0
MSK409-1	12	4	6	3			48	1.0
MSL007-B	10	8	4	3			40	1.0
MSN191-2Y	8	11	4	2			32	1.0
MSQ035-3	12	8	2		2	1	48	1.0
FL2137	11	5	6	2		1	44	1.1
Kalkaska (J036-A)	7	5	7	5		1	28	1.6
RUSSET TRIAL								
A02062-1TE	24	1					96	0.0
AOTX95265-4Rus	23	2					92	0.1
CO99053-4Rus	21	4					84	0.2
CO99100-1Rus	20	5					80	0.2
Russet Norkotah	20	5					80	0.2
CORN #8	19	6					76	0.2
W7098-2Rus	19	6					76	0.2
Silverton Russet	19	5	1				76	0.3
A01025-4	17	8					68	0.3
Goldrush Russet	17	8					68	0.3

2009 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
CO99053-3Rus	17	7	1				68	0.4
Classic Russet (A95109-1Rus)	18	5	1	1			72	0.4
MSM171-A[NCR]	17	6	2				68	0.4
MN02467RUS[NCR]	14	9	2				56	0.5
AC99375-1Rus	16	5	2	2			64	0.6
MSL268-D[NCR]	10	11	4				40	0.8
Canela Russet	12	7	2	3	1		48	1.0
PA03NM5-1	1	3	4	2	3	12	4	3.6
NORTH CENTRAL REGIONAL TRIAL								
MN19298RY	23	2					92	0.1
Red Norland	23	2					92	0.1
W2978-3	23	2					92	0.1
ATND98459-1RY	22	3					88	0.1
CV01238-3RUS	22	3					88	0.1
CV99073-1R	21	4					84	0.2
Missaukee (MSJ461-1)	20	5					80	0.2
ND8304-2	21	3	1				84	0.2
ND028842-1RY	19	5	1				76	0.3
MSN170-A	17	7	1				68	0.4
MN96013-1RY	18	3	4				72	0.4
WV5843-6R	16	6	3				64	0.5
W5015-12	13	8	2	2			52	0.7
WV4992-1RUS	11	9	5				44	0.8
Snowden	**10**	**10**	**5**				**40**	**0.8**
MN02616RY	11	8	5	1			44	0.8
W5767-1R	12	8	2	3			48	0.8
ND8305-1	8	9	5	3			32	1.1
Atlantic	**3**	**8**	**9**	**3**	**2**		**12**	**1.7**
ADAPTATION TRIAL, CHIP-PROCESSING LINES								
AO0188-3C	21	4					84	0.2
FL1879	18	7					72	0.3
MSR157-1Y	19	3	3				76	0.4
MSQ440-2	17	6	2				68	0.4
MSR169-8Y	16	8	1				64	0.4
MSP270-1	14	8	2	1			56	0.6
MSR128-4Y	13	10		2			52	0.6
Snowden	**15**	**5**	**3**	**2**			**60**	**0.7**
Boulder	9	11	5				36	0.8

2009 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+		
Pike	**13**	**5**	**4**	**3**			**52**	**0.9**
Atlantic	**8**	**10**	**4**	**3**			**32**	**1.1**
MSN190-2	10	7	5	2	1		40	1.1
MSR127-2	12	3	7	2		1	48	1.1
MSR161-2	12	5	3	4		1	48	1.1
MSR102-3	7	7	5	2	2	2	28	1.6
MSR058-1	7	3	7	6	2		28	1.7
MSN148-A	4	5	5	8	1	2	16	2.1
ADAPTATION TRIAL, TABLESTOCK LINES								
MSL211-3	24	1					96	0.0
MSM037-3	24	1					96	0.0
Yukon Gold	**24**	**1**					**96**	**0.0**
MSS737-1Y	23	1	1				92	0.1
MI Purple	21	4					84	0.2
MSN215-2P	21	4					84	0.2
MSI005-20Y	21	3	1				84	0.2
MSS576-05SPL	22	1	2				88	0.2
MSN105-1	22		3				88	0.2
MSS108-1	21	3		1			84	0.2
MSN230-1RY	20	4		1			80	0.3
MSR217-1R	19	5	1				76	0.3
Jacqueline Lee	18	6	1				72	0.3
Onaway	**19**	**5**		**1**			**76**	**0.3**
MSS176-1	19	4	1	1			76	0.4
MSL228-1SPL	16	8	1				64	0.4
MSQ176-5	15	10					60	0.4
MSQ086-3	16	6	3				64	0.5
MSQ425-4PY	16	7	1	1			64	0.5
MI Purple Red Sport	16	5	3	1			64	0.6
MSQ279-1	16	5	3	1			64	0.6
MSR219-2R	13	9	3				52	0.6
MSQ134-5	13	8	4				52	0.6
MSM182-1	10	10	4	1			40	0.8
Reba	10	12	1		2		40	0.9
PRELIMINARY TRIAL, CHIP-PROCESSING LINES								
MSS927-1	24	1					96	0.0
MST096-2Y	24	1					96	0.0
MST169-07	23	2					92	0.1
MST202-5	22	2	1				88	0.2

2009 BLACKSPOT BRUISE SUSCEPTIBILITY TEST
SIMULATED BRUISE SAMPLES*

	NUMBER OF SPOTS PER TUBER						PERCENT (%) BRUISE	AVERAGE
ENTRY	0	1	2	3	4	5+	FREE	SPOTS/TUBER
MST611-1Y	21	4					84	0.2
MST412-3	21	3	1				84	0.2
CO00188-4W	20	4	1				80	0.2
MST008-01	20	4	1				80	0.2
MST190-15Y	19	5	1				76	0.3
MST429-3Y	17	6	2				68	0.4
MST611-2	17	6	2				68	0.4
MSQ029-1	15	8	2				60	0.5
MST007-2	14	10	1				56	0.5
CO00197-3W	17	4	3		1		68	0.6
MSM246-B	15	7	2	1			60	0.6
MST222-5	14	9	1	1			56	0.6
MSS297-3	16	5	3		1		64	0.6
MSS165-2Y	13	9	1	2			52	0.7
MST306-01	12	9	4				48	0.7
MST443-1	13	10		1	1		52	0.7
MST184-3	15	5	2	2	1		60	0.8
MST229-1	6	4	2	1			46	0.8
MSN111-4PP	9	11	4	1			36	0.9
MSS258-1	10	10	3	2			40	0.9
MST458-04	13	6	4	1		1	52	0.9
MST443-2Y	12	6	4	3			48	0.9
MSS428-2	11	7	4	3			44	1.0
MST193-4Y	11	7	4	3			44	1.0
MSS934-4	13	4	3	5			52	1.0
MST220-08	8	10	4	3			32	1.1
MSS026-2Y	6	12	4	3			24	1.2
MST424-3	9	7	4	3	2		36	1.3
Atlantic	**8**	**8**	**4**	**4**		**1**	**32**	**1.3**
Snowden	**6**	**11**	**3**	**3**	**1**	**1**	**24**	**1.4**
MST094-1	7	4	1	7	3	3	28	2.2
PRELIMINARY TRIAL, TABLESTOCK LINES								
MSS199-A	23	2					92	0.1
MSS514-1PP	23	2					92	0.1
MST065-2	23	2					92	0.1
Reba	22	3					88	0.1
MSR601-22	22	2	1				88	0.2
MST075-1R	21	4					84	0.2
MSR297-A	20	5					80	0.2

2009 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
MST359-3	20	5					80	0.2
MSS206-2	20	4		1			80	0.3
ATTX961014-1RY	19	4	2				76	0.3
MSR601-21	18	6	1				72	0.3
MSS070-B	18	6	1				72	0.3
MST285-2	18	6	1				72	0.3
MSS544-1R	19	4	1	1			76	0.4
MST123-1RY	17	7	1				68	0.4
Midnight	15	10					60	0.4
MSS483-1	19	3	2	1			76	0.4
MST033-2	17	6	2				68	0.4
MST145-1	19	2	4				76	0.4
CO00270-7W	15	9	1				60	0.4
MST384-1PP	15	9	1				60	0.4
MSR601-19	16	6	3				64	0.5
MST500-1	19	1	4		1		76	0.5
CO99076-6R	13	10	2				52	0.6
MST235-2SPL	13	10	2				52	0.6
MST377-2P	16	5	3	1			64	0.6
MST065-1	13	8	3	1			52	0.7
CO99256-2R	9	10	5	1			36	0.9
CO98012-5R	8	11	5	1			32	1.0
Onaway	**13**	**6**	**1**	**3**		**2**	**52**	**1.1**
MSR218-AR	6	11	5	3			24	1.2
MSS487-2	9	5	7	3		1	36	1.3
Stirling	9	5	4	4		3	36	1.6

2009 BLACKSPOT BRUISE SUSCEPTIBILITY TEST
SIMULATED BRUISE SAMPLES*

	NUMBER OF SPOTS PER TUBER						PERCENT (%) BRUISE	AVERAGE
ENTRY	0	1	2	3	4	5+	FREE	SPOTS/TUBER
USPB/SFA TRIAL CHECK SAMPLES (Not bruised)								
CO96141-4W	16	9					64	0.4
NY138	15	8	2				60	0.5
NY139	16	7	1	1			64	0.5
ND7519-1	12	10	2			1	48	0.8
Kalkaska (MSJ036-A)	10	10	4	1			40	0.8
CO97065-7W	8	13	3	1			32	0.9
AF2291-10	8	11	4	1		1	32	1.1
W2717-5	12	6	3	2		2	48	1.1
Atlantic	**8**	**8**	**6**	**3**			**32**	**1.2**
MSJ126-9Y	9	7	4	3	1	1	36	1.3
Snowden	**9**	**7**	**5**	**1**	**2**	**1**	**36**	**1.3**
CO97043-14W	7	7	6	4	1		28	1.4
USPB/SFA TRIAL BRUISE SAMPLES								
NY138	17	5	1	1		1	68	0.6
CO96141-4W	11	11	2	1			44	0.7
Kalkaska (MSJ036-A)	9	9	4	2	1		36	1.1
CO97065-7W	13	3	4	4		1	52	1.1
W2717-5	9	8	4	4			36	1.1
MSJ126-9Y	10	8	1	4	1	1	40	1.2
ND7519-1	6	5	8	5	1		24	1.6
NY139	1	13	4	5	2		4	1.8
Atlantic	**5**	**6**	**4**	**5**	**3**	**2**	**20**	**2.0**
CO97043-14W	4	6	7	3	2	3	16	2.1
AF2291-10	2	7	6	6	1	3	8	2.2
Snowden	**0**	**3**	**5**	**8**	**3**	**6**	**0**	**3.2**

* 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 11/2/2009.
The table is presented in ascending order of average number of spots per tuber.

Funding: Federal Grant, MPIC and USPB/SFA

2009 On-Farm Potato Variety Trials

Chris Long, Dr. Dave Douches, Greg Steere, John Pullis (Presque Isle), Dr. Doo-Hong Min and Chris Kapp (Upper Peninsula)

Introduction

On-farm potato variety trials were conducted with 16 growers in 2009 at a total of 24 locations. Fourteen of the locations evaluated processing entries and ten evaluated fresh market entries. The processing cooperators were Crooks Farms, Inc. (Montcalm), Walther Farms, Inc. (St. Joseph), Lennard Ag. Co. (Monroe), County Line Potato Farms, Inc. (Allegan), Main Farms (Montcalm), Michigan State University (MSU), Montcalm Research Farm (Montcalm), Sackett Potatoes (Mecosta), Sackett Ranch (Montcalm) and Thorlund Brothers (Montcalm). The United States Potato Board/Snack Food Association (USPB / SFA) chip trial was at Sandyland Farms, LLC (Montcalm). Fresh market trial cooperators were Crawford Farms, Inc. (Montcalm), DuRussel's Potato Farms, Inc. (Washtenaw), Elmaple Farms (Kalkaska), R & E Farms (Presque Isle), Horkey Bros. (Monroe), T.J.J. VanDamme Farms (Delta), Lennard Ag. Co. (St. Joseph), Sandyland Farms, LLC. (Montcalm) and Walther Farms, Inc. (Branch).

Procedure

There were seven 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 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 seven 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 processing trial format was conducted at Sackett Potatoes in Mecosta County. Two varieties were commercially planted in eight row plots 300 feet long. One 23' yield dig was performed in each block at harvest. These varieties were planted at a 10" spacing. The fourth type was a four replication processing variety trial conducted at Walther Farms, Inc. (St. Joseph) in which 19 test varieties were compared to the check varieties Snowden, Pike, FL1867 and FL1833. The plots were 15' by 34" and the seed was planted at 10" in-row spacing. The fifth type was the Box Bin trial at the Montcalm Research Farm in Montcalm County, MI. This trial contained 16 varieties compared against the check variety Snowden. All 17 varieties were planted in 34" wide rows, 600' long with 10" in-row seed spacing. A single 23' yield check was taken to evaluate each clone. The sixth type of chip trial contained large multiple acreage blocks of nine 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 variety and growers were: Crawford Farms, Inc. (Montcalm), Classic Russet; Horkey Bros. (Monroe), MSQ176-5 and MSM182-1;

Sandyland Farms LLC (Montcalm), Classic Russet and MSJ147-1; Sackett Potatoes (Mecosta), Kalkaska, MSJ147-1 and MSQ070-1; Sackett Ranch (Montcalm), CO95051-7W; Thorlund Brothers (Montcalm), MSJ126-9Y; Elmaple Farms (Kalkaska), MSQ176-5; R & E Farms (Presque Isle), Classic Russet; T.J.J. VanDamme Farms (Delta), Classic Russet and Lennard Ag. Co. (Monroe), MSH228-6.

The USPB / SFA trial was the 7th chip processing trial type. For procedural details on this trial, reference the 2009 annual report published by the United States Potato Board.

Within the fresh market trials, there were 38 entries evaluated. There were 8 to 28 lines planted at each of the following locations: Branch, Delta, Kalkaska, Monroe, Montcalm, Presque Isle, St. Joseph and Washtenaw 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), replicated trials were evaluated. The plots were 15' long by 34" wide and seed spacing was 12". Four replications were evaluated per trial. The last 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 row 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.

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, Mecosta, Monroe, Montcalm and St. Joseph counties are shown in Table 2.

Processing Variety Highlights

CO00197-3W; is a Colorado State University selection with good long term chip quality. In 2009, CO00197-3W yielded 449 cwt/A US#1 with 14% undersize (Table 2). Seed spacing should be widened for this clone to 11-12" in row spacing. Specific gravity was average to below average at 1.077. Internal quality was good and vine maturity was comparable to Snowden. This variety has susceptibility to common scab.

MSL292-A; is a Michigan State University developed variety. In 2009, MSL292-A had an average yield at 429 cwt/A US#1 (Table 2). This variety had 91% marketable yield and a slightly below average specific gravity at 1.077. Raw internal tuber quality was good. A trace of pitted scab was noted. MSL292-A exhibited excellent chip quality out of the field and from storage in 2009 and early 2010.

MSQ070-1; is a MSU clone with common scab and late blight resistance. In 2009 on-farm trials, this variety yielded 429 cwt/A US#1 with a 1.090 specific gravity. There was 19% hollow heart reported across eight 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.

MSQ279-1; is a MSU chipping clone with good long term chip quality. In 2009, this variety yielded 453 cwt/A US#1 with 91% of the total yield being marketable. The specific gravity was average (Table 2). The raw tuber quality was good with some late vine maturity reported. The in-row seed spacing could be reduced to 9 inches for this clone based on the large percent of oversize noted.

NY139; this is a Cornell, New York developed clone. This variety continues to exhibit a strong yield and good size profile. In the 2009 processing potato variety trials, NY139 yielded 440 cwt/A US#1 over seven locations with a 95% marketable yield average (Table 2). The specific gravity of this clone was at the trial average of 1.080. No hollow heart was noted in 90 cut tubers. NY139 also performed very well in the 2009 USPB/SFA trial (Table 3). This clone yielded 455 cwt/A US#1 with a 99% marketable yield. The specific gravity was six points above the trial average at 1.087. Raw tuber internal quality was good. Vine maturity for this variety appeared to be medium-late to late.

W2133-1; this clone was developed at the University of Wisconsin and has excellent mid to late storage 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 2009, W2133-1, when averaged across two southern Michigan locations, yielded 567 cwt/A US#1 with no hollow heart being observed (Table 2). The size profile and the specific gravity was at or slightly above average. This variety was susceptible to common scab. The long term storability and yield potential of this clone makes it attractive.

B. <u>USPB / SFA Chip Trial Results</u>

The Michigan location of the USPB / SFA chip trial was on Sandyland Farms, LLC in Montcalm County in 2009. 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. Table 7 provides a pre-harvest panel for each of the 12 varieties in the trial. This table compares tuber specific gravity, percent glucose and sucrose ratings taken on August 24th, 2009 for each variety.

USPB / SFA Chip Trial Highlights

Atlantic and Snowden topped the yield chart in 2009 followed by a group of lines that yielded very similarly (Table 3). These lines are: AF2291-10, NY139, CO97043-14W, Kalkaska and NY138. NY139 had a large percentage of recorded oversize tubers (Table 3). The CO97043-14W, NY138, CO96141-4W and MSJ126-9Y had very low specific gravities. The variety in the 2009 trial that displayed the greatest potential for commercialization was NY139. Yield potential and specific gravity were excellent for NY139 (Table 3). This clone has a full season maturity and good chip quality. NY139 appeared to have some susceptible 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 highest yield performance, but had great chip quality, such as ND7519-1 and NY138.

C. Fresh Market and Variety Trial Results

A description of the freshpack varieties, their pedigree and scab ratings are listed in Table 8. Table 9 shows the overall average of ten locations: Branch, Delta, Kalkaska, Monroe, Montcalm (2), Presque Isle, St. Joseph (2) and Washtenaw counties.

Fresh Market Variety Highlights

Three round whites, one red skin and three russet lines are worthy of mention from the 2009 variety trials. They are MSL268-D, MSM182-1, MSQ176-5 (the round whites), CO99256-2R (the red variety) and the russets, A02062-1TERus, CO99053-3Rus and Classic Russet (A95109-1).

MSL268-D; this Michigan State University variety has nice tuber type with foliar late blight resistance. In 2009, MSL268-D yielded 425 cwt/A US#1 with a medium vine maturity (Table 9). The total yield of this variety was reported as 633 cwt/A. The percentage of “B” sized tubers and the specific gravity was higher than desired. This variety was also common scab susceptible.

MSM182-1; this variety has strong PVY and foliar late blight resistance. In the 2009 freshpack variety trials, this clone had a 425cwt/A US#1 yield with a 1.073 specific gravity (Table 9). There were four hollow heart in 50 cut tubers and a trace of vascular discoloration observed. The skin type of this variety was bright and the tubers were very uniform in shape.

MSQ176-5; this MSU clone has foliar late blight resistance and some common scab tolerance. The 2009 yield trial data showed this variety having a 427 cwt/A US#1 yield which represents 90% of the total yield reported (Table 9). This variety averaged a 1.071 specific gravity, a medium-late maturity and two hollow heart in fifty tubers cut. The tubers were generally bright skinned and uniformly round in appearance.

CO99256-2R; this is a red skinned selection from Colorado State University. In 2009, CO99256-2R yielded 445 cwt/A US#1 with an average specific gravity of 1.077 (Table 9). Vine maturity was medium-late with good internal quality. Tuber appearance was smooth with a very nice red color. Tuber type was round to more oval in the larger tubers.

A02062-1TE; this University of Idaho selection had a 444 cwt/A US#1 yield, an average specific gravity of 1.076 and good 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 2009.

CO99053-3Rus; this Colorado State selection has good yield potential. In 2009, it yielded 409 cwt/A US#1 with 21 percent oversize. The average specific gravity for this variety was 1.077 (Table 9). The clone had 3 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. This russet may be a dual purpose selection.

Classic Russet (A95109-1); this clone is a USDA Aberdeen, ID release. It was named in early 2009 as Classic Russet. Over the 9 trial locations where it was tested, A95109-1 yielded 348 cwt/A US#1 with 19 percent oversize (Table 9). In-row seed spacing for this variety should be approximately 9 inches. The average specific gravity for Classic Russet was 1.073 with 10 of 120 cut tubers exhibiting hollow heart. Vine maturity was medium-late with a nice, uniform blocky tuber type. This variety exhibited strong common scab resistance.

Table 1

2009 MSU Processing Potato Variety Trials

Entry	Pedigree	2009 Scab Rating*	Characteristics
Atlantic	Wauseon X B5141-6 (Lenape)	2.7	High yield, early maturing, high incidence of internal defects, check variety, high specific gravity
Kalkaska (MSJ036-A)	A7961-1 X Zarevo	1.3	Medium – high yield, mid-season maturity, nice round uniform tuber type, warm harvest recommended, medium high specific gravity
Monticello	Steuben X Kanona	-	Average yield, mid – late season maturity, good long term storability, low internal defects, vine rot susceptible, medium specific gravity
Pike (NYE55-35)	Allegany X Atlantic	1.5	Average yield, early to mid-season maturity, small size tuber profile, early storage check variety, some internal defects, medium specific gravity
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
AF2291-10	SA8211-6 X EB8109-1	-	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	2.0	Medium-high yield potential. small tuber size, minimal grade defects, medium-early maturity, high specific gravity, some ability to recondition out of 40F
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 40F
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 40F
CO95051-7W	AC88456-6W X BC0894-2W	1.3	Low – average yield, medium to late maturity, high percent of US#1 tubers, low internal defects, medium specific gravity
CO96141-4W	BC0894-2 X AC87340-2	2.3	Average yield, early – mid maturity, oval tuber type, white skin, medium specific gravity
CO97043-14W	AC91817-5 X AC87340-2	3.0	Average to high yield, medium maturity, white skin, oblong tuber type, medium specific gravity
CO97065-7W	AC92513-3 X Chipeta	2.0	Average to high yield, early maturity, white skin, round tuber type, medium specific gravity

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

Table 1 continued

Entry	Pedigree	2009 Scab Rating*	Characteristics
FL1867	FL162 X Atlantic	-	High yield, early maturity, medium-high specific gravity
FL1879	Snowden X FL1207	2.0	High yield, late maturity, large tuber type, late season storage, medium specific gravity, check variety
FL1922	FL1533 X FL1207	-	Average yield, mid-season maturity, oval to oblong tubers, common scab and black spot bruise resistant, good chip quality out of late storage, medium to low specific gravity
FL2053	FL1922 X FL1831	1.8	Average yield, mid-season maturity, round to oblong tuber type, good bruise tolerance, fresh or early season storage, highly susceptible to growth crack, medium-high specific gravity
FL2137	FL2006 X FL1291	-	Above average yield, medium-late maturity, some scab resistance
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
MSJ147-1	Norvalley X S440	1.7	Average yield, mid to late season maturity, good internal quality, very good chip quality late in storage, specific gravity similar to Snowden
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
MSM037-3	MSE230-6 X ND2676-10	1.3	Large uniform blocky tubers, high yield, low specific gravity, some hollow heart
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 tubers type with netted skin, low sugars, PVY resistant, moderate late blight resistance
ND7519-1	-	-	Below average yield, high specific gravity, small uniform tuber type, medium maturity

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

Table 1 continued

Entry	Pedigree	2009 Scab Rating*	Characteristics
NY138 (Y18-16)	Marcy X NY115	-	High yield, large uniform round tuber type, below average specific gravity, great chip quality
NY 139 (Y28-9)	NY120 X NY115	1.5	High yield, mid-late season maturity, medium specific gravity
W2133-1	Snowden X RHL 167	1.8	Medium to high yield, mid to late maturity, good internal quality, nice tuber type, 42-45º F cold chipper, medium specific gravity
W2324-1	Snowden X S438	2.5	Very high yield, late maturity, uniform tuber type, strong vine vigor, medium to high specific gravity
W2717-5	S440 X ND2828-15	-	Round tuber type, medium yield, medium maturity, medium specific gravity, moderate scab susceptibility
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 Processing Potato Variety Trial
Overall Average - Eight Locations
Allegan, Mecosta, Monroe, Montcalm, St. Joseph Counties

NUMBER OF		CWT/A		PERCENT OF TOTAL[1]						CHIP	TUBER QUALITY[2]				TOTAL	VINE	VINE		3-YR AVG US#1
LOCATIONS	LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	SCORE[3]	HH	VD	IBS	BC	CUT	VIGOR[4]	MATURITY[5]	COMMENTS	CWT/A
1	FL2053	679	722	94	4	91	3	2	1.088	1.0	0	0	0	0	30	2.5	3.7	tr pitted scab, oblong	445
1	FL1867	600	635	94	5	93	1	1	1.079	1.0	0	0	0	0	30	2.5	2.7	tr pitted scab, sheepnose in pickouts	514**
4	MSM037-3	580	614	95	3	78	17	2	1.070	1.3	4	1	0	1	60	3.6	3.8	large uniform blocky tubers, misshapen pickouts, gc & misshapen pickouts,	580*
2	W2133-1	567	648	89	9	79	10	2	1.081	1.0	0	2	1	0	30	3.6	4.2	gc & misshapen pickouts, sl pitted scab	488**
2	W2324-1	552	589	93	6	83	10	1	1.089	1.0	4	2	0	2	20	3.8	3.3	large size, tr pitted scab, misshapen pickouts	575
3	**FL1879**	**548**	**566**	**97**	**2**	**79**	**18**	**1**	**1.074**	**1.2**	**1**	**1**	**6**	**1**	**50**	**3.2**	**3.1**	**tr surface & pitted scab, large tuber size, misshapen in pickouts**	**471**
1	FL1922	519	549	94	5	94	0	1	1.072	1.0	0	2	1	0	30	1.8	3.8	oblong tuber type, gc in pickouts, pear shape	519*
7	W5015-12	487	558	85	14	75	10	1	1.085	1.0	8	6	3	0	90	3.3	4.0	heavy russet skin, gc & misshapen pickouts, tr pitted & surface scab	487*
5	**Snowden**	**475**	**513**	**91**	**9**	**86**	**4**	**1**	**1.082**	**1.1**	**4**	**11**	**0**	**0**	**70**	**3.3**	**3.5**	**sl pitted & surface scab, misshapen pickouts**	**416**
5	MSQ279-1	453	490	91	6	72	19	3	1.077	1.4	2	3	0	0	70	3.4	4.6	gc & sheepnose in pickouts, tr surface scab	453*
2	CO00197-3W	449	529	82	14	82	0	4	1.077	1.0	0	4	0	0	40	2.3	3.5	gc & misshapen in pickouts, sl pitted scab, 1 pythium leak	**449***
7	NY139	440	462	95	5	89	6	0	1.080	1.0	0	8	0	0	90	3.5	3.1	tr surface scab, some pear shape, gc in pickouts	429**
8	MSQ070-1	429	495	86	13	83	3	1	1.090	1.1	19	4	4	2	100	2.9	4.2	round uniform tuber type, tr surface & pitted scab, misshapen pickouts	429*
7	MSL292-A	429	465	91	9	85	6	0	1.077	1.1	1	6	5	2	90	3.7	3.0	round uniform type, some netting, sl pitted scab	433**
5	MSL007-B	410	461	87	13	85	2	0	1.080	1.1	0	3	0	0	70	2.6	3.6	nice uniform type, misshapen pickouts, some netting & russeting	**330****

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	3-YR AVG US#1 CWT/A
4	**Pike**	**409**	**440**	**93**	**4**	**82**	**11**	**3**	**1.082**	**1.0**	**4**	**2**	**2**	**0**	**60**	**3.2**	**3.3**	**gc & misshapen pickouts, 3 with heat necrosis**	**370**
1	Monticello	409	433	94	6	88	6	0	1.073	1.0	3	1	0	0	10	1.5	2.0	tr surface and pitted scab	384**
5	MSH228-6	407	431	94	5	85	9	1	1.079	1.0	1	6	1	0	70	3.5	4.4	flat, oval tuber type, tr surface scab,	348
2	FL2137	393	410	95	5	84	11	0	1.083	1.0	0	2	0	0	20	2.0	2.5	nice uniform type, tr surface scab	456**
5	MSN170-A	388	426	91	4	78	13	5	1.077	1.1	1	0	0	0	70	3.0	2.7	gc, misshapen, knobs & points in pickouts, oval to oblong type	388*
2	CO00188-4W	354	434	70	30	70	0	0	1.081	1.0	0	0	2	0	40	2.8	2.2	small bright appearance, tr black leg, tr surface scab	**354***
4	MSJ147-1	346	432	79	16	78	1	2	1.090	1.1	12	0	0	0	60	2.3	4.3	small, round uniform type, tr surface scab	307
5	MSJ126-9Y	333	372	88	9	86	2	3	1.076	1.2	0	6	1	0	70	2.6	2.4	nice round uniform type, gc & misshapen pickouts	350
4	CO95051-7W	331	370	90	9	90	0	1	1.081	1.0	0	1	3	1	60	3.2	4.1	sl surface & pitted scab, small round size	303
2	CO00270-7W	325	375	86	12	85	1	2	1.074	1.0	0	2	0	0	40	2.1	2.6	tr pitted scab, misshapen pickouts, small size	325*
5	MSP459-5	311	379	80	19	77	3	1	1.075	1.1	6	2	0	0	70	3.6	2.0	misshapen & deep apical eyes in pickouts, 3 pythium	311*
3	MSR061-1	279	334	82	18	81	1	0	1.079	1.0	2	3	0	0	30	3.2	2.5	nice small round uniform type, some netting	279*
1	AO0188-3C	228	302	76	24	74	2	0	1.082	1.0	2	1	0	5	10	2.5	3.5		228*
1	AO1143-3C	225	297	76	21	74	2	3	1.078	1.0	0	0	0	0	10	2.0	4.5	misshapen in pickouts	225*
	MEAN	**426**	**473**	**88**					**1.080**									tr = trace, sl = slight, N/A = not applicable	
																		SED = stem end defect, gc = growth crack	

[1]SIZE
Bs: < 1 7/8"
As: 1 7/8" - 3.25"
OV: > 3.25"
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]CHIP COLOR SCORE - Snack Food Association Scale
(Out of the field)
Ratings: 1 - 5
1: Excellent
5: Poor

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

[5]VINE 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

Table 3. Yield ,Size Distribution*, Specific Gravity								
	Yield (cwt/A)		**Percent Size Distribution**					
Entry	**US#1**	**TOTAL**	**US#1**	**Small**	**Mid-Size**	**Large**	**Culls**	**Specific Gravity**
Atlantic	**498**	**523**	**96**	**2**	**80**	**16**	**2**	**1.087**
Snowden	**488**	**512**	**95**	**5**	**89**	**6**	**0**	**1.088**
AF2291-10	466	480	97	3	86	11	0	1.089
NY139	455	462	99	1	73	26	0	1.087
CO97043-14W	455	472	96	3	85	11	1	1.073
Kalkaska	454	486	93	6	89	4	1	1.082
NY138	444	458	97	3	78	19	0	1.073
CO96141-4W	423	444	96	3	83	13	1	1.070
CO97065-7W	404	420	96	3	81	15	1	1.078
ND7519-1	387	414	93	5	90	3	2	1.092
W2717-5	361	395	91	4	82	9	5	1.085
MSJ126-9Y	342	370	92	3	81	11	5	1.071
MEAN	**432**	**453**	**95**	**3**	**83**	**12**	**1.5**	**1.081**

*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.					
	Internal Defects[1]				
Entry	**HH**	**VD**	**IBS**	**BC**	**Total Cut**
Atlantic	**11**	**0**	**0**	**1**	**30**
Snowden	**1**	**7**	**0**	**0**	**30**
AF2291-10	0	7	0	0	30
NY139	0	4	3	0	30
CO97043-14W	0	5	0	0	30
Kalkaska	0	5	0	2	30
NY138	0	0	0	0	30
CO96141-4W	1	3	0	0	30
CO97065-7W	1	0	0	6	30
ND7519-1	1	2	0	0	30
W2717-5	7	3	0	9	30
MSJ126-9Y	2	11	0	0	30

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

Table 5. 2009 Post-Harvest Chip Quality[1].

Entry	Agtron Color	SFA[2] Color	Specific Gravity	Percent Chip Defects[3] Internal	External	Total
Atlantic	**58.6**	**3**	**1.077**	**23.6**	**2.7**	**26.3**
Snowden	**61.5**	**2**	**1.081**	**7.3**	**6.7**	**14.0**
AF2291-10	58.5	2	1.085	13.0	2.0	15.0
NY139	61.5	1	1.079	3.3	9.1	12.4
CO97043-14W	62.7	2	1.079	15.4	4.4	19.8
Kalkaska	58.1	4	1.076	26.2	1.0	27.2
NY138	63.1	1	1.068	8.5	3.5	12.0
CO96141-4W	63.5	2	1.073	10.0	4.9	14.9
CO97065-7W	58.5	2	1.078	12.7	6.1	18.8
ND7519-1	61.5	1	1.079	1.4	8.3	9.7
W2717-5	60.6	3	1.081	8.1	7.5	15.6
MSJ126-9Y	60.1	4	1.068	8.7	2.9	11.6

[1] Samples collected at harvest September 29th and processed by Herr Foods, Inc., Nottingham, PA on October 1, 2009 (2 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

	A. Check Samples[1]									B. Simulated Bruise Samples[2]								
	# of Bruises Per Tuber							Percent Bruise	Average Bruises Per	# of Bruises Per Tuber							Percent Bruise	Average Bruises Per
Entry	0	1	2	3	4	5	Total Tubers	Free	Tuber	0	1	2	3	4	5	Total Tubers	Free	Tuber
Atlantic	**8**	**8**	**6**	**3**			**25**	**32**	**1.16**	**5**	**6**	**4**	**5**	**3**	**2**	**25**	**20**	**2.0**
Snowden	**9**	**7**	**5**	**1**	**2**	**1**	**25**	**36**	**1.32**	**0**	**3**	**5**	**8**	**3**	**6**	**25**	**0**	**3.2**
AF2291-10	8	11	4	1		1	25	32	1.08	2	7	6	6	1	3	25	8	2.2
NY139	16	7	1	1			25	64	0.48	1	13	4	5	2		25	4	1.8
CO97043-14W	7	7	6	4	1		25	28	1.40	4	6	7	3	2	3	25	16	2.1
Kalkaska	10	10	4	1			25	40	0.84	9	9	4	2	1		25	36	1.1
NY138	15	8	2				25	60	0.48	17	5	1	1		1	25	68	0.6
CO96141-4W	16	9					25	64	0.36	11	11	2	1			25	44	0.7
CO97065-7W	8	13	3	1			25	32	0.88	13	3	4	4		1	25	52	1.1
ND7519-1	12	10	2			1	25	48	0.76	6	5	8	5	1		25	24	1.6
W2717-5	12	6	3	2		2	25	48	1.12	9	8	4	4			25	36	1.1
MSJ126-9Y	9	7	4	3	1	1	25	36	1.32	10	8	1	4	1	1	25	40	1.2

[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 7. Pre-Harvest Panels, 08/24/09								
								Average[5]
	Specific	**Glucose[1]**	**Sucrose[2]**	**Canopy**		**Number of**		**Tuber**
Entry	**Gravity**	**%**	**Rating**	**Rating[3]**	**Uniform.[4]**	**Hills**	**Stems**	**Weight**
Atlantic	**1.080**	**0.001**	**0.381**	**85**	**90**	**3**	**17**	**5.50**
Snowden	**1.084**	**0.002**	**0.391**	**90**	**95**	**5**	**21**	**4.56**
AF2291-10	1.086	0.005	0.748	90	95	5	16	5.92
NY139	1.079	0.003	0.613	90	90	4	11	6.01
CO97043-14W	1.076	0.005	0.559	80	90	4	15	5.62
Kalkaska	1.077	0.015	1.892	60	80	4	7	4.41
NY138	1.068	0.003	0.598	90	90	5	10	7.60
CO96141-4W	1.071	0.001	0.202	80	90	5	14	5.23
CO97065-7W	1.078	0.002	0.454	65	80	5	23	4.61
ND7519-1	1.091	0.002	0.686	75	50	3	15	4.26
W2717-5	1.082	0.004	0.735	70	90	4	10	4.31
MSJ126-9Y	1.067	0.002	0.716	60	90	6	15	5.42

[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

2009 MSU Tablestock Potato Variety Trials

Entry	Pedigree	2009 Scab Rating	Characteristics
Canela Russet	A83043-12 X A8784-3	0.7	Average yield, oblong blocky russet, medium to late maturity, good tuber dormancy, above average specific gravity, tolerant to pythium leak and pink rot
CORN 8	Russet Norkotah Line Selection	1.0	Above average yield, early to mid-season maturity, tubers are white flesh, long to slightly oblong, medium to heavy russetted skin, eyes are shallow, numerous and well distributed tuber set, medium specific gravity
Classic Russet	Blazer Russet X Summit Russet	1.3	Below average yield, medium maturity, attractive appearance, fresh market use, low-medium specific gravity, storability concerns regarding soft rot susceptibility
Elfe	L 176/89/233 X Filea	-	High yield, early maturity, yellow flesh
Eva (NY103)	Stuben X OP	3.0	Mid-season maturity, above average yield, round to oval appearance, resistant to PVX and PVY
Goldrush (ND1538-1Rus)	ND450-3Rus X Lemhi Russet	1.0	Long to oval tubers, heavy russet, check variety
Katahdin (USDA 42667)	USDA 40568 X USDA 24642	1.0	Mid-season maturity, high yielding check variety
Milva	Beltsville 606-37 X McIntosh	-	Very high yield, medium to late maturity, oblong tuber type, , scab resistant, late dormancy
Onaway	USDA X96-56 X Katahdin	1.6	High yield, early maturity, round tuber type, low specific gravity, smooth skin, white flesh, eyes medium – deep, few internal defects, check variety
Reba (NY 87)	Monona X Allegany	2.0	High yield, bright tubers, low incidence of internal defects, mid to late season maturity, medium – low specific gravity
Red Norland	ND626 X Redkote	-	Smooth to round medium oblong, deep red almost burgundy skin, white flesh. Early to very early maturity for tablestock, medium yield, low to very low specific gravity, resistant to: leaf roll, net necrosis, growth cracks, hollow heart, early blight, scab, PVA, PVY, rhizoctonia. Susceptible to greening, water damage, silver scurf and late blight, stores well – short dormancy, color tends to fade in storage.
Russet Norkotah (ND534-4Rus)	ND9526-4Rus X ND9687-5Rus	2.0	Average yield, mid-season maturity, long to oval tubers, heavy russet skin, check variety, low specific gravity
Satina	Puntila X 99 73	-	High yield, medium maturity, short oval tubers, smooth yellow skin, yellow flesh color, long storage capabilities and when cooked or peeled has a high resistance to discoloration, scab resistant

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

Table 8 continued

Entry	Pedigree	2009 Scab Rating	Characteristics
Silverton Russet (AC83064-6)	A76147-2 X A 7875-5	1.3	High yield, oblong to long blocky tuber type, medium russet skin, masks PVY, medium specific gravity, possible Sencor & linuron susceptibility
A02062-1TERus	A97201-4 X A97299-1	1.5	Long tuber type, medium-heavy russeting, higher U.S. No. 1 yields and larger tuber size than Russet Norkotah
AC99375-1Rus	AWN86514-2 X A89384-10	1.3	High yield, medium maturity, high specific gravity, oblong, dual purpose russet, large vine, blackspot resistant, late blight resistance
A01025-4Rus	A96095-3 X Premier Russet	1.0	High total & U.S. No. 1 yield, large tuber size, light – medium russeting scab & blackspot susceptibility, cold sweetening resistant
AOTX95265-4Rus	A89216-9 X A86102-6	1.3	High yield, mid-late maturity, oblong to long russetted tubers, generally nice appearance
CO95086-8Rus	CO87009-4Rus X Silverton Russet	-	Good market yield, medium maturity, resistant to black spot bruise, little internal defects, good size profile, medium yield potential, dual purpose russet, medium specific gravity, good processing from storage, possible Sencor & Linuron susceptibility
CO98012-5R	A79543—4R X AC91844-2	1.8	Good appearance, small size, low specific gravity, possible Sencor & Linuron susceptibility
CO99053-3Rus	AC91014-2 X Silverton Russet	1.5	High yield, medium late maturity, large vine, medium specific gravity, long russet, dual purpose, blackspot resistant
CO99053-4Rus	AC91014-2 X Silverton Russet	1.5	Medium yield, early maturity, medium sized vine, medium specific gravity, long russet, dual purpose, blackspot resistant
CO99076-6R	AC91848-1 X Rio Colorado	2.5	Average yield, early maturing, nice round red type
CO99100-1Rus	AC93047-1 X Silverton Russet	1.3	Medium high yield, very early-early maturity, small-medium sized vine, medium specific gravity, oblong russet, dual purpose, blackspot resistant
CO99256-2R	Rio Colorado X Colorado Rose	1.8	Medium maturity, round red
MSL268-D	NY103 X Jacqueline Lee	2.5	Medium yield, late blight resistance, round to oval tuber type
MSM171-A	Stirling X MSE221-1	2.3	High yield, late maturity, smooth shape, large round tuber type, superior skin type, late blight resistant, low specific gravity
MSM182-1	Stirling X NY121	2.9	PVY & late blight resistance, low specific gravity
MSN105-1	MSG141-3 X Jacqueline Lee	2.0	Average yield, early maturity, large heavy set tuber type, bright skin, medium specific gravity, moderate late blight resistance

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

Table 8 continued

Entry	Pedigree	2009 Scab Rating	Characteristics
MSQ086-3	Onaway X Missaukee (MSJ461-1)	2.5	Good yield potential, nice round white, medium maturity, late blight resistance, good internal quality
MSQ176-5	MSI152-A X Missaukee (MSJ461-1)	1.8	High yield potential, round, bright white skin, late blight resistance, good bulking, nice round type
ND5002-3R	ND3504-3R X NorDonna	0.3	Medium yield, medium late maturity, bright red skin, very white flesh, round to oblong, block tuber, low internal defects, low specific gravity, scab tolerant, susceptible to PVY and silver scurf, sensitivity to metribuzin applications
PA03NM5-1Rus	Blazer Russet X PA98NM21-14	1.0	Oblong-long tuber type, medium russeting, some growth cracks, possible corky ringspot / Columbia root-knot nematode resistance
TX112	Russet Norkotah Line Selection	1.0	Similar to CORN 8
TX278	Russet Norkotah Line Selection	1.0	Similar to CORN 8
TX296	Russet Norkotah Line Selection	1.0	Similar to CORN 8
W5767-1R	MN96101-1 X MN86105	-	Dark red skin, white flesh, large tuber size, good yield potential, relatively deep eyes, very large canopy, medium-late vine maturity
W7098-2Rus	A7961-1 X Goldrush	1.3	Medium yield, blocky tuber type, tendency to produce off-shape tubers, golden russeting, very scab resistant, very large canopy, late vine maturity, low specific gravity

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

Table 9

2009 Freshpack Potato Variety Trial
Overall Averages - Ten Locations
Branch, Delta, Kalkaska, Monroe, Montcalm, Presque Isle, St. Joseph & Washtenaw Counties

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	3-YR AVG US#1 CWT/A
1	TX296	632	757	83	12	49	34	5	1.058	11	4	0	1	40	4.0	3.0	alligator hide, misshapen and knobs in pickouts, sl pitted scab	514**
2	TX278	598	713	83	10	47	36	7	1.069	25	6	0	0	50	3.9	3.6	gc and misshapen in pickouts, tr pitted and surface scab, some alligator hide	598*
1	TX112	582	707	82	11	49	33	7	1.060	14	3	1	0	40	4.4	3.0	sl pitted scab, knobs in pickouts	473**
1	CO95086-8Rus	556	654	85	11	61	24	4	N/A	8	2	0	0	40	4.6	3.0	dark heavy russeting, nice type, gc and knobs in pickouts	417
6	**CORN 8**	**480**	**568**	**80**	**12**	**64**	**16**	**8**	**1.072**	**20**	**7**	**0**	**0**	**90**	**4.2**	**2.6**	**nice tuber type, misshapen & knobs in pickouts,**	**388**
1	Elfe	478	304	82	2	60	22	16	1.058	0	0	0	0	10	4.0	3.5		478*
6	Silverton Russet	459	541	84	11	59	26	5	1.072	6	7	0	0	90	4.1	3.5	gc, misshapen & knobs in pickouts, uniform oval tuber type	382
5	MSM171-A	452	484	94	3	76	18	3	1.058	8	6	3	0	50	3.5	1.8	some netting, gc & misshapen in pickouts, sl pitted scab	420
5	**Reba**	**450**	**477**	**94**	**5**	**71**	**23**	**1**	**1.070**	**3**	**3**	**2**	**2**	**50**	**4.0**	**2.9**	**tr pitted & surface scab, misshapen pickouts**	**422**
3	CO99256-2R	445	525	84	15	84	0	1	1.077	0	4	1	0	30	3.7	3.8	nice oval tuber type, bright smooth skin, tr surface scab, gc & knobs in pickouts	445*
2	AO2062-1TERus	444	559	79	15	62	17	6	1.076	0	3	0	0	20	3.3	3.3	nice size and type, heavy russet skinknobs in pickouts, no scab	444*
2	**Katahdin**	**432**	**457**	**95**	**4**	**73**	**22**	**1**	**1.063**	**0**	**2**	**3**	**0**	**20**	**3.3**	**3.5**	**moderate scab, large tuber type**	**420**
5	MSQ176-5	427	474	90	8	72	18	2	1.071	2	3	0	1	50	2.6	3.3	sl to moderate surface scab, bright skin, some netting, knobs in pickouts	427*
5	MSL268-D	425	633	74	23	70	4	3	1.079	2	4	1	0	50	3.8	2.7	nice tuber type, misshapen, knobs & gc in pickouts	**382**
5	MSM182-1	425	498	84	12	82	2	4	1.073	4	1	6	0	50	3.7	3.0	smooth skin, uniform round type, some moderate pitted & surface scab, knobs in pickouts	428**
3	W5767-1R	418	465	90	6	68	22	4	1.079	3	0	0	2	30	4.2	3.0	gc, misshapen & knobs in pickouts, tr surface scab	418*
2	CO99053-3Rus	409	557	72	21	51	21	7	1.077	3	7	0	0	50	3.9	4.2	good size profile, dark heavy russeting, gc, misshapen & knobs in pickouts	466**
1	Satina	387	463	83	4	73	10	13	1.065	0	0	0	1	10	5.0	3.5	significant tuber rot	387*
2	AO1025-4Rus	376	565	66	26	58	8	8	1.071	0	1	0	0	20	3.8	2.8	light russeting, moderate surface scab, not uniform type	376*

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	3-YR AVG US#1 CWT/A
9	**Russet Norkotah**	**367**	**486**	**76**	**18**	**61**	**15**	**6**	**1.071**	**15**	**7**	**3**	**0**	**120**	**4.1**	**2.0**	**uniform type, gc, knobs & misshapen in pickouts,some moderate pitted & surface scab**	**344**
2	**GoldRush**	**367**	**568**	**65**	**21**	**48**	**17**	**14**	**1.069**	**1**	**1**	**0**	**0**	**20**	**4.0**	**2.8**	**round tuber type, small size, gc & misshapen pickouts**	**407****
2	Red Norland	361	428	83	14	83	0	3	1.057	0	3	0	0	20	4.5	2.0	gc, knobs & misshapen in pickouts, light red skin color	361*
3	CO98012-5R	357	458	78	20	76	2	2	1.077	0	3	0	0	30	3.8	2.8	small tuber type, bright red smooth skin, thin skinned	318**
9	Classic Russet	348	448	78	11	59	19	11	1.073	10	17	6	1	120	3.6	3.3	nice flesh, misshapen & knobs in pickouts, nice size & tuber type	367
1	Milva	347	494	70	4	60	10	26	1.062	0	0	0	0	10	5.0	4.5	severe points	347*
2	CO99100-1Rus	346	464	73	20	60	13	7	1.073	8	4	0	0	50	4.8	1.8	sl pitted & surface scab, gc & misshapen pickouts	354**
5	MSN105-1	339	427	79	18	77	2	3	1.081	0	5	0	1	50	4.4	2.5	not uniform tuber type, small, misshapen & gc in pickouts	324
2	W7098-2Rus	327	489	66	27	43	23	8	1.065	0	0	0	0	20	3.5	2.8	gc & knobs in pickouts, not enough russeting	327*
2	CO99053-4Rus	316	456	69	26	60	9	5	1.074	10	0	2	5	50	4.4	2.1	dark heavy russeting, gc, misshapen points and knobs in pickouts, sl pitted scab	387**
2	ND5002-3R	313	355	88	10	81	7	2	1.078	0	9	0	0	20	3.3	3.8	gc, knobs and misshapen pickouts, bright red skin color, oval tuber type	217**
2	PA03NM5-1Rus	312	436	70	28	63	7	2	1.075	1	1	0	0	20	3.8	3.8	sl surface and pitted scab, misshapen pickouts	312*
8	Canela Russet	311	400	79	13	54	25	8	1.086	14	7	1	0	110	3.0	3.8	nice type, misshapen & knobs in pickouts, some alligator hide	330
5	MSQ086-3	306	379	80	19	78	2	1	1.076	0	3	1	2	50	3.6	3.7	tr surface scab	306*
1	**Onaway**	**304**	**340**	**89**	**10**	**88**	**1**	**1**	**1.064**	**0**	**4**	**0**	**0**	**10**	**5.0**	**1.0**	**tr surface scab, misshapen pickouts**	**359**
2	AC99375-1Rus	294	481	59	35	50	9	6	1.083	18	4	2	1	50	4.5	4.4	small size, misshapen pickouts	347**
1	AOTX95265-4Rus	248	355	70	26	70	0	4	1.074	0	0	0	0	10	4.5	2.0	misshapen pickouts, one glassy end	406
1	Eva	240	285	84	2	45	39	14	1.067	0	0	0	1	10	3.0	3.5	misshapen	255**
3	CO99076-6R	223	294	78	17	70	8	5	1.077	1	2	0	2	30	3.2	3.0	nice flesh and skin color, gc & knobs in pickouts	223*
	MEAN	**392**	**485**						**1.071**								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

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Tolerance of Potato Mini-tubers to PRE and POST Herbicide Applications.

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Demand for disease free potato seed in Michigan is high due to a large economic return upon planting disease and virus free seed potatoes. Using aseptically grown plants produced from issue culture, potato mini-tubers can be planted as a clean seed source. However, many generally accepted cultural practices for managing mini-tubers are adopted from cut seed piece, including weed management programs. Field trials were conducted at the Montcalm Research Farm in 2009 to evaluate the effect of labeled herbicide programs on three cultivars of potato mini-tubers. Potato cultivars Atlantic, Frito Lay (FL) 1867 and FL 1922 were planted in 34-inch rows, 2.5 inches deep at 8 inch spacing and hilled at planting. Fifteen herbicide treatments were arranged in a strip plot design with four replications. Treatments included, *S*-metolachlor at 1.27 lb ai/A, pendimethalin at 0.71 lb ai/A, metribuzin at 0.5 lb ai/A, linuron at 0.5 lb ai/A, rimsulfuron at .023 lb ai/A, dimethenamid at 0.66 lb ai/A, imazosulfuron at 0.4 lb ai/A, linuron at 0.5 lb ai/A plus *S*-metolachlor at 1.27 lb ai/A, linuron at 0.5 lb ai/A plus *S*-metolachlor at 1.27 lb ai/A plus metribuzin at 0.09 lb ai/A, metribuzin at 0.09 lb ai/A plus *S*-metolachlor at 1.27 lb ai/A plus pendimethalin at 0.24 lb ai/A, metribuzin at 0.09 lb ai/A plus *S*-metolachlor at 1.27 lb ai/A plus pendimethalin at 0.24 lb ai/A plus glyphosate at 0.77 lb ai/A plus ammonium sulfate at 3.4 lb/A, linuron at 0.5 lb ai/A plus *S*-metolachlor at 1.27 lb ai/A followed by rimsulfuron at 0.016 lb ai/A plus non-ionic surfactant at 0.05 gal/A, linuron at 0.5 lb ai/A plus *S*-metolachlor at 1.27 lb ai/A followed by rimsulfuron at 0.016 lb ai/A plus metribuzin at 0.25 lb ai/A plus non-ionic surfactant at 0.05 gal/A, KIH-485 at 1.26 lb ai/A and a non-treated control. Production practices were similar to those used in commercial seed production in Michigan, with plots maintained weed free by hand. Visual injury was rated throughout the season on a 0-100% scale and yield data was collected at the end of the season for tuber count and tuber defects. Treatments displaying visual injury in both cultivars contained *S*-metolachlor, pendimethalin, and dimethenamid. Treatments that caused yield reductions in all cultivars were V-10142. Several herbicide treatments appear to have sufficient crop safety to be used in mini-tuber production including metribuzin, and rimsulfuron. Treatments of imazosulfuron and KIH-485 can reduce seed potato yields. Treatment combinations with *S*-metolachlor showed early season injury and yield reductions.

Funded by AgChem Industry

Weed Control in Potato with Reflex.

Wesley J. Everman and Andrew J. Chomas. Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824.

Interest in alternative herbicides for weed control has led several companies to investigate potato tolerance to herbicides labeled in other row crops. A study was conducted at Montcalm Research Farm to investigate the tolerance of potatoes to fomesafen (Reflex). The studies consisted of 12 treatments arranged in a randomized complete block design with four replications at MRF and three at Stockbridge. The treatments consisted of PRE applications of Reflex at 1 pt/A, Reflex at 2 pt/A, Dual Magnum at 1 pt/A, Reflex at 1 pt plus Dual Magnum at 1 pt, Boundary at 1.5 pt/A, Boundary at 1.5 pt plus Reflex at 1 pt, Boundary at 1.5 pt plus Reflex at 0.5 pt, Dual Magnum at 1 pt plus Sencor at 4 oz/A, Dual Magnum at 1 pt plus Matrix at 1 oz/A and at cracking applications of Reflex at 2 pt and Boundary at 1.5 pt plus Reflex at 1 pt. A non-treated control plot was included for comparison. Timing of application was not a major factor in weed control in 2009. Reflex has postemergence activity on many weed species; however, common lambsquarters control is often reduced when Reflex was applied as a delayed preemergence application (at cracking). Overall weed control in 2009 was excellent. Control of common lambsquarters control was enhanced when Boundary was added in combination with Reflex. It will be important to include a herbicide that provides postemergence control of common lambsquarters if Reflex is used as a delayed preemergence application in most years. Potato tolerance was excellent, with minimal injury observed most likely due to the cool wet weather we experienced.

WEED CONTROL IN POTATO WITH REFLEX, 2009

Trial ID: PO209 Study Dir.: Andy Chomas
Conducted: MONTCALM RSH FARM Investigator: Christy Sprague

Date Planted:	5/11/09	**Row Spacing:**	34 IN
Variety:	SNOWDEN	**No. of Reps:**	4
Population:	1/FT	**% OM:**	2.7
Soil Type:	Loamy Sand	**pH:**	5.6
Plot Size:	10 **X** 20 **FT**	**Design:**	RANDOMIZED COMPLETE BLOCK

Tillage: Spring Disc 3X. Spring Chisel. Field Cultivated.
Fertilizer: 20 gal/A of 19-17-0, 12 gal/A of 10-34-0 in Row. 23 gal/A of 28% N at Cultivation. 23 gal/A of 28%N at Hilling. 100 lbs/A of 46-0-0 Broadcast.

Application Description

	A	**B**
Application Timing:	PRE	CRACK
Date Treated:	5/11/09	5/29/09
Time Treated:	5:00 PM	10:30 AM
% Cloud Cover:	80	40
Air Temp., Unit:	61 F	65 F
% Relative Humidity:	30	73
Wind Speed/Unit/Dir:	6 mph SW	2 mph W
Soil Temp., Unit:	68 F	
Soil/Leaf Surface M:		5
Soil Moist (1=w 5=d):	5	2

Crop Stage at Each Application

	A	**B**
Crop Name:	SOLTU	SOLTU
Stage (L):		CRACK

Weed Stage at Each Application

	A	**B**
Weed 1 Name:	ANGR	ANGR
Height (In.):		.25
Stage (L):		1
Weed 2 Name:	CHEAL	CHEAL
Height (In.):		.25-1(.5)
Stage (L):		Cot-2(1)
Weed 3 Name:	AMARE	AMARE
Height (In.):		.25-5(.3)
Stage (L):		Cot-2(1)
Weed 4 Name:	ABUTH	ABUTH
Height (In.):		.25
Stage (L):		Cot
Weed 5 Name:	ECHCG	ECHCG
Weed 6 Name:	MELAL	MELAL

Weed Density (plants/sq. ft.)

	1
Date:	5/29/09
Weed Name:	ANGR
Density:	2
Date:	5/29/09
Weed Name:	CHEAL
Density:	6
Date:	5/29/09
Weed Name:	AMARE
Density:	<1
Date:	5/29/09
Weed Name:	ABUTH
Density:	<1

Application Equipment

Appl	**Sprayer Type**	**Speed MPH**	**Nozzle Type**	**Nozzle Size**	**Nozzle Height**	**Nozzle Spacing**	**Boom Width**	**GPA**	**Carrier**	**PSI**
A	BKPK	3.5	FF	8003	18"	20"	120"	20	H2O	30
B	BKPK	3.5	FF	8003	18"	20"	120"	20	H2O	30

WEED CONTROL IN POTATO WITH REFLEX, 2009

Trial ID: PO209 Study Dir.: Andy Chomas
Conducted: MONTCALM RSH FARM Investigator: Christy Sprague

Weed Code							ANGR	CHEAL	AMARE	ABUTH	ECHCG				CHEAL
Crop Code						SOLTU						SOLTU	SOLTU	SOLTU	
Rating Data Type						injury	control	control	control	control	control	stunt	discolor	injury	control
Rating Unit						percent	percent	percent	percent	percent	percent	percent	percent	percent	percent
Rating Date						6/3/09	6/3/09	6/3/09	6/3/09	6/3/09	6/3/09	6/10/09	6/10/09	6/10/09	6/10/09
Trt-Eval Interval						7 DACRK	7 DACRK	7 DACRK	7 DACRK	7 DACRK	7 DACRK	14 DACRK	14 DACRK	14 DACRK	14 DACRK
Trt No.	Treatment Name	Form Conc	Form Type	Rate	Rate Unit Grow Stg	1	2	3	4	5	6	7	8	9	10
1	Non-Treated					0	0	0	0	0	0	1	0	1	0
2	Reflex	2	L	1	pt/a PRE	0	100	86	100	83	100	3	0	3	71
3	Reflex	2	L	2	pt/a PRE	0	100	95	100	96	100	0	0	0	84
4	Dual Magnum	7.62	L	1	pt/a PRE	0	100	74	95	75	100	3	0	3	71
5 5	Reflex Dual Magnum	2 7.62	L L	1 1	pt/a PRE pt/a PRE	0	99	96	100	91	100	5	0	5	96
6	Boundary	6.5	EC	1.5	pt/a PRE	0	100	68	99	76	100	5	0	5	72
7 7	Boundary Reflex	6.5 2	EC L	1.5 1	pt/a PRE pt/a PRE	3	96	95	100	98	100	3	0	3	90
8 8	Boundary Reflex	6.5 2	EC L	1.5 0.5	pt/a PRE pt/a PRE	0	94	92	100	91	94	13	0	13	86
9 9	Dual Magnum Sencor	7.62 75	L DF	1 4	pt/a PRE oz/a PRE	0	100	89	100	98	100	0	0	0	96
10 10	Dual Magnum Matrix	7.62 25	L WG	1 1	pt/a PRE oz/a PRE	1	100	95	100	99	100	4	0	4	95
11	Reflex	2	L	2	pt/a CRACK	6	86	93	100	98	88	11	0	11	100
12 12	Boundary Reflex	6.5 2	EC L	1.5 1	pt/a CRACK pt/a CRACK	4	100	100	100	100	100	3	0	3	100
LSD (P=.05)						4.9	11.8	18.8	4.3	26.1	11.8	7.6	0.0	7.6	22.2
Standard Deviation						3.4	8.2	13.0	3.0	18.0	8.2	5.3	0.0	5.3	15.4
CV						297.65	9.11	15.94	3.29	21.58	9.06	130.36	0.0	130.36	19.27

WEED CONTROL IN POTATO WITH REFLEX, 2009

Trial ID: PO209 Study Dir.: Andy Chomas
Conducted: MONTCALM RSH FARM Investigator: Christy Sprague

Trt No.	Treatment Name	Form Conc	Form Type	Rate	Rate Unit	Grow Stg	11	12	13	14	15	16	17	18	19	20
	Weed Code						AMARE	ABUTH	ECHCG	MELAL	CHEAL	AMARE	ABUTH	ANGR		ANGR
	Crop Code														SOLTU	
	Rating Data Type						control	control	control	control	control	control	control	control	injury	control
	Rating Unit						percent	percent	percent	percent	percent	percent	percent	percent	percent	percent
	Rating Date						6/10/09	6/10/09	6/10/09	6/10/09	6/23/09	6/23/09	6/23/09	6/23/09	7/20/09	7/20/09
	Trt-Eval Interval						14 DACRK	14 DACRK	14 DACRK	14 DACRK	27 DACRK	27 DACRK	27 DACRK	27 DACRK	54 DACRK	54 DACRK
1	Non-Treated						0	0	0	0	0	0	2	0	0	0
2	Reflex	2	L	1	pt/a	PRE	100	65	80	10	79	100	85	98	0	69
3	Reflex	2	L	2	pt/a	PRE	100	93	96	78	83	100	100	99	0	65
4	Dual Magnum	7.62	L	1	pt/a	PRE	98	90	98	68	53	75	70	98	0	88
5	Reflex	2	L	1	pt/a	PRE	100	73	99	83	93	100	100	100	0	91
5	Dual Magnum	7.62	L	1	pt/a	PRE										
6	Boundary	6.5	EC	1.5	pt/a	PRE	78	76	93	100	70	90	83	100	0	88
7	Boundary	6.5	EC	1.5	pt/a	PRE	100	90	91	96	78	100	100	95	0	80
7	Reflex	2	L	1	pt/a	PRE										
8	Boundary	6.5	EC	1.5	pt/a	PRE	100	94	95	100	80	100	100	100	0	89
8	Reflex	2	L	0.5	pt/a	PRE										
9	Dual Magnum	7.62	L	1	pt/a	PRE	100	80	98	88	86	100	100	100	0	84
9	Sencor	75	DF	4	oz/a	PRE										
10	Dual Magnum	7.62	L	1	pt/a	PRE	100	95	99	100	89	100	100	99	0	76
10	Matrix	25	WG	1	oz/a	PRE										
11	Reflex	2	L	2	pt/a	CRACK	100	95	71	100	93	98	98	95	0	59
12	Boundary	6.5	EC	1.5	pt/a	CRACK	100	100	90	100	96	100	100	98	0	75
12	Reflex	2	L	1	pt/a	CRACK										
	LSD (P=.05)						18.9	26.5	19.1	22.2	24.4	15.6	27.9	4.8	0.0	21.3
	Standard Deviation						13.1	18.4	13.2	15.4	16.9	10.8	19.3	3.3	0.0	14.8
	CV						14.64	23.21	15.75	20.01	22.61	12.23	22.33	3.68	0.0	20.52

WEED CONTROL IN POTATO WITH REFLEX, 2009

Trial ID: PO209 Study Dir.: Andy Chomas
Conducted: MONTCALM RSH FARM Investigator: Christy Sprague

Weed Code							CHEAL	AMARE	ABUTH							
Crop Code										SOLTU	SOLTU	SOLTU	SOLTU	SOLTU	SOLTU	SOLTU
Rating Data Type							control	control	control	<1 7/8"	<1 7/8"	PickOut	PickOut	Grade A	Grade A	dry
Rating Unit							percent	percent	percent	kilogram	count	kilogram	count	kilogram	count	
Rating Date							7/20/09	7/20/09	7/20/09	9/1/09	9/1/09	9/1/09	9/1/09	9/1/09	9/1/09	9/1/09
Trt-Eval Interval							54 DACRK	54 DACRK	54 DACRK	HARVEST	HARVEST	HARVEST	HARVEST	HARVEST	HARVEST	HARVEST
Trt No.	Treatment Name	Form Conc	Form Type	Rate	Rate Unit	Grow Stg	21	22	23	24	25	26	27	28	29	30
1	Non-Treated						0	0	0	1.7413	45	0	1	4.0713	44	4.0713
2	Reflex	2	L	1	pt/a	PRE	54	96	46	2.1925	45	0	0	5.1850	58	5.1850
3	Reflex	2	L	2	pt/a	PRE	72	100	75	2.0738	48	0	1	6.1263	63	6.1263
4	Dual Magnum	7.62	L	1	pt/a	PRE	35	65	58	2.4213	58	0	0	3.8825	40	3.8825
5	Reflex	2	L	1	pt/a	PRE	74	100	72	2.1138	50	0	0	6.2213	62	6.2213
5	Dual Magnum	7.62	L	1	pt/a	PRE										
6	Boundary	6.5	EC	1.5	pt/a	PRE	50	90	83	1.8750	51	0	0	4.5825	48	4.5825
7	Boundary	6.5	EC	1.5	pt/a	PRE	64	99	97	1.5413	35	0	1	4.7613	52	4.7613
7	Reflex	2	L	1	pt/a	PRE										
8	Boundary	6.5	EC	1.5	pt/a	PRE	68	94	70	1.8450	44	0	0	8.4088	80	5.7450
8	Reflex	2	L	0.5	pt/a	PRE										
9	Dual Magnum	7.62	L	1	pt/a	PRE	63	100	96	1.7388	43	0	0	6.5838	63	6.5838
9	Sencor	75	DF	4	oz/a	PRE										
10	Dual Magnum	7.62	L	1	pt/a	PRE	59	100	97	1.9613	50	0	0	5.0900	57	5.0900
10	Matrix	25	WG	1	oz/a	PRE										
11	Reflex	2	L	2	pt/a	CRACK	86	100	99	1.5025	33	0	0	8.0825	72	8.0825
12	Boundary	6.5	EC	1.5	pt/a	CRACK	87	100	100	2.3888	48	0	0	7.5338	79	7.5338
12	Reflex	2	L	1	pt/a	CRACK										
LSD (P=.05)							26.8	22.1	38.4	1.00975	23.4	0.1	0.9	3.36617	27.6	3.64321
Standard Deviation							18.6	15.3	26.6	0.69932	16.2	0.1	0.6	2.33129	19.1	2.52316
CV							31.36	17.61	35.78	35.87	35.44	305.05	259.69	39.67	32.07	44.61

WEED CONTROL IN POTATO WITH REFLEX, 2009

Trial ID: PO209 Study Dir.: Andy Chomas
Conducted: MONTCALM RSH FARM Investigator: Christy Sprague

Trt No.	Treatment Name	Form Conc	Form Type	Rate	Rate Unit	Grow Stg	31	32	33	34	35
Weed Code											
Crop Code							SOLTU	SOLTU	SOLTU	SOLTU	SOLTU
Rating Data Type							wet	SPEC. GRAV.	HH	VD	IBS
Rating Unit									0-10	0-10	0-10
Rating Date							9/1/09	9/1/09	9/1/09	9/1/09	9/1/09
Trt-Eval Interval							HARVEST	HARVEST	HARVEST	HARVEST	HARVEST
1	Non-Treated						0.32050	1.0865670	0	1	0
2	Reflex	2	L	1	pt/a	PRE	0.41713	1.0877796	0	0	0
3	Reflex	2	L	2	pt/a	PRE	0.49750	1.0884031	0	0	0
4	Dual Magnum	7.62	L	1	pt/a	PRE	0.30600	1.0867735	0	2	0
5	Reflex	2	L	1	pt/a	PRE	0.49625	1.0860866	0	0	0
5	Dual Magnum	7.62	L	1	pt/a	PRE					
6	Boundary	6.5	EC	1.5	pt/a	PRE	0.35125	1.0804309	0	1	0
7	Boundary	6.5	EC	1.5	pt/a	PRE	0.37438	1.0858561	0	1	0
7	Reflex	2	L	1	pt/a	PRE					
8	Boundary	6.5	EC	1.5	pt/a	PRE	0.45313	1.0820409	0	1	0
8	Reflex	2	L	0.5	pt/a	PRE					
9	Dual Magnum	7.62	L	1	pt/a	PRE	0.50975	1.0839401	0	1	0
9	Sencor	75	DF	4	oz/a	PRE					
10	Dual Magnum	7.62	L	1	pt/a	PRE	0.40325	1.0864125	0	1	0
10	Matrix	25	WG	1	oz/a	PRE					
11	Reflex	2	L	2	pt/a	CRACK	0.64888	1.0883949	0	0	0
12	Boundary	6.5	EC	1.5	pt/a	CRACK	0.58213	1.0839484	0	1	0
12	Reflex	2	L	1	pt/a	CRACK					
LSD (P=.05)							0.291159	0.00775012	0.3	1.4	0.4
Standard Deviation							0.201646	0.00536744	0.2	1.0	0.3
CV							45.14	0.49	497.27	119.97	411.94

ARM Action Codes
T1 = ([30])/([30]-[31])

Funded by AgChem Industry

Weed Control in Potato with Rimsulfuron Formulations.

Wesley J. Everman and Andrew J. Chomas. Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824.

A study investigating the tolerance of potato to applications of rimsulfuron formulations was conducted in 2009 at the Montcalm Research Farm. This study compared 1 oz and 1.5 oz of two formulations of rimsulfuron applied PRE, at cracking, or POST. The results indicate there were no differences in weed control observed between the two formulations for any application timing.

WEED CONTROL IN POTATO WITH RIMSULFURON FORMULATIONS, 2009

Trial ID: P0309 Study Dir.:
Conducted: MONTCALM RSCH FARM Investigator: Christy Sprague

Date Planted:	5/11/09	**Row Spacing:**	34 IN
Variety:	SNOWDEN	**No. of Reps:**	4
Population:	1/FT	**% OM:**	2.7
Soil Type:	Loamy Sand	**pH:**	5.6
Plot Size:	10 **X** 20 **FT**	**Design:**	RANDOMIZED COMPLETE BLOCK

Tillage: Spring Disc 3X. Spring Chisel. Field Cultivated.
Fertilizer: 20 gal/A of 19-17-0, 12 gal/A of 10-34-0 in Row. 23 gal/A of 28% N at Cultivation. 23 gal/A of 28%N at Hilling. 100 lbs/A of 46-0-0 Broadcast.

Application Description

	A	**B**	**C**
Application Timing:	PRE	CRACK	POST
Date Treated:	5/26/09	6/10/09	7/14/09
Time Treated:	3:37 PM	2:10 PM	9:30 AM
% Cloud Cover:	100	40	5
Air Temp., Unit:	75 F	83 F	66 F
% Relative Humidity:	44.6	52	42
Wind Speed/Unit/Dir:	3 mph E	0 mph	0 mph
Soil Temp., Unit:	61 F	70 F	66 F
Soil/Leaf Surface M:			3
Soil Moist (1=w 5=d):	2	3	4

Crop Stage at Each Application

	A	**B**	**C**
Crop Name:	SOLTU	SOLTU	SOLTU

Weed Stage at Each Application

	A	**B**	**C**
Weed 1 Name:	ANGR	ANGR	ANGR
Weed 2 Name:	CHEAL	CHEAL	CHEAL
Weed 3 Name:	AMARE	AMARE	AMARE
Weed 4 Name:	ABUTH	ABUTH	ABUTH

Application Equipment

Appl	**Sprayer Type**	**Speed MPH**	**Nozzle Type**	**Nozzle Size**	**Nozzle Height**	**Nozzle Spacing**	**Boom Width**	**GPA**	**Carrier**	**PSI**
A	BKPK	3.5	FF	8003	18"	20"	120"	20	H2O	30
B	BKPK	3.5	FF	8003	18"	20"	120"	20	H2O	30
C	BKPK	3.5	FF	8003	18"	20"	120"	20	H2O	30

WEED CONTROL IN POTATO WITH RIMSULFURON FORMULATIONS, 2009

Trial ID: P0309 Study Dir.:
Conducted: MONTCALM RSCH FARM Investigator: Christy Sprague

Weed Code								ANGR	CHEAL	AMARE	ABUTH		ANGR	CHEAL	AMARE
Crop Code							SOLTU					SOLTU			
Rating Data Type							injury	control	control	control	control	injury	control	control	control
Rating Unit							percent	percent	percent	percent	percent	percent	percent	percent	percent
Rating Date							6/16/09	6/16/09	6/16/09	6/16/09	6/16/09	7/8/09	7/8/09	7/8/09	7/8/09
Trt-Eval Interval							21 DAPRE	21 DAPRE	21 DAPRE	21 DAPRE	21 DAPRE	44 DAPRE	44 DAPRE	44 DAPRE	44 DAPRE
Trt No.	Treatment Name	Form Conc	Form Type	Rate	Rate Unit	Grow Stg	1	2	3	4	5	6	7	8	9
1	MANA Rimsulfuron	25	DF	1	oz/a	PRE	0	100	90	98	89	0	100	63	88
2	Matrix	25	WG	1	oz/a	PRE	0	99	80	100	81	0	96	51	93
3	MANA Rimsulfuron	25	DF	1.5	oz/a	PRE	1	100	100	100	81	0	100	59	98
4	Matrix	25	WG	1.5	oz/a	PRE	1	100	96	100	91	0	100	55	96
5	MANA Rimsulfuron	25	DF	1	oz/a	POST	0	90	20	30	100	0	0	0	0
5	Activator 90		L	0.2	% v/v	POST									
6	Matrix	25	WG	1	oz/a	POST						0	0	0	0
6	Activator 90		L	0.2	% v/v	POST									
7	MANA Rimsulfuron	25	DF	1.5	oz/a	POST						0	0	0	0
7	Activator 90		L	0.2	% v/v	POST									
8	Matrix	25	WG	1.5	oz/a	POST						0	0	0	0
8	Activator 90		L	0.2	% v/v	POST									
9	Non-Treated						0	0	0	0	0	0	0	0	0
10	MANA Rimsulfuron	25	DF	1	oz/a	CRACK	1	100	46	100	80	0	100	24	98
11	Matrix	25	WG	1	oz/a	CRACK	0	100	65	100	88	0	100	24	98
12	MANA Rimsulfuron	25	DF	1.5	oz/a	CRACK	0	100	55	100	76	0	100	33	98
13	Matrix	25	WG	1.5	oz/a	CRACK	1	100	70	100	94	0	100	39	98
LSD (P=.05)							1.7	1.2	23.5	2.4	19.7	0.0	1.7	9.9	4.3
Standard Deviation							1.1	0.8	16.1	1.7	13.5	0.0	1.2	6.9	3.0
CV							324.19	0.94	25.92	2.03	17.35	0.0	2.0	26.06	5.14

WEED CONTROL IN POTATO WITH RIMSULFURON FORMULATIONS, 2009

Trial ID: P0309 Study Dir.:
Conducted: MONTCALM RSCH FARM Investigator: Christy Sprague

Weed Code							ABUTH	ANGR	CHEAL	AMARE	ABUTH		CHEAL
Crop Code												SOLTU	
Rating Data Type							control	control	control	control	control	injury	control
Rating Unit							percent	percent	percent	percent	percent	percent	percent
Rating Date							7/8/09	8/12/09	8/12/09	8/12/09	8/12/09	8/27/09	8/27/09
Trt-Eval Interval							44 DAPRE	29 DAPO	29 DAPO	29 DAPO	29 DAPO	44 DAPO	44 DAPO
Trt No.	Treatment Name	Form Conc	Form Type	Rate	Rate Unit	Grow Stg	10	11	12	13	14	15	16
1	MANA Rimsulfuron	25	DF	1	oz/a	PRE	74	88	73	100	85	0	69
2	Matrix	25	WG	1	oz/a	PRE	73	84	62	100	86	0	60
3	MANA Rimsulfuron	25	DF	1.5	oz/a	PRE	84	86	78	100	86	0	78
4	Matrix	25	WG	1.5	oz/a	PRE	79	88	77	100	76	0	79
5	MANA Rimsulfuron	25	DF	1	oz/a	POST	0	76	28	100	80	0	8
5	Activator 90		L	0.2	% v/v	POST							
6	Matrix	25	WG	1	oz/a	POST	0	70	38	100	69	0	18
6	Activator 90		L	0.2	% v/v	POST							
7	MANA Rimsulfuron	25	DF	1.5	oz/a	POST	0	77	40	100	88	0	25
7	Activator 90		L	0.2	% v/v	POST							
8	Matrix	25	WG	1.5	oz/a	POST	0	63	25	100	68	0	13
8	Activator 90		L	0.2	% v/v	POST							
9	Non-Treated						0	0	0	0	0	0	3
10	MANA Rimsulfuron	25	DF	1	oz/a	CRACK	65	86	35	100	65	0	15
11	Matrix	25	WG	1	oz/a	CRACK	60	83	35	100	86	0	13
12	MANA Rimsulfuron	25	DF	1.5	oz/a	CRACK	75	83	53	100	81	0	43
13	Matrix	25	WG	1.5	oz/a	CRACK	65	89	41	100	95	0	31
LSD (P=.05)							22.4	10.1	20.8	0.0	28.0	0.0	21.8
Standard Deviation							15.7	7.1	14.5	0.0	19.6	0.0	15.3
CV							35.58	9.45	32.39	0.0	26.43	0.0	43.94

Funded by Industry

Herbicide Effect on Growth Cracks in FL2053 Potato.

Wesley J. Everman, Chris Long, and Andrew J. Chomas. Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824.

Herbicide growth cracks are a concern for potato producers, especially those growing the chipping variety FL2053. Due to concerns that herbicides may be contributing to the occurrence and severity of growth cracks in FL2053, a study was conducted near Three Rivers, MI and at the Montcalm Research Farm in 2009 to investigate several herbicides applied to FL2053 both preemergence and postemergence. Preemergence herbicide treatments consisted of Dual Magnum at 1.33 pt/A plus Sencor at 0.33 lb/A plus Prowl H2O at 0.5 pt/A and Dual Magnum at 1.33 pt/A plus Sencor at 0.33 lb/A plus Lorox at 1 pt/A. Postemergence herbicide options included Sencor at 0.33 lb/A plus NIS at 0.25%, Matrix at 1 oz/A plus NIS, Sencor at 0.33 lb plus Matrix at 1 oz plus NIS, or no POST herbicide. Treatments were applied in a factorial arrangement of PRE followed by POST herbicide options. Preemergence treatments were made after planting, and postemergence applications were made at canopy closure. Growth crack occurrence and severity were evaluated at harvest, after which tubers were graded. Results from both locations indicate there was no correlation between growth crack occurrence or severity and herbicide application. While the primary cause of growth cracks is yet to be determined, multiple stress factors and time of stress induction may play a role in growth crack occurrence.

Herbicide Effect on Growth Cracks in Production Potato, 2009

Trial ID: P0409 Study Dir.: Andy Chomas
Conducted: MONTCALM RSCH FAM Investigator: Christy Sprague

Date Planted:	5/11/09	**Row Spacing:**	34 IN
Variety:	FL 2053	**No. of Reps:**	4
Population:	1/FT	**% OM:**	1.5
Soil Type:	Loamy Sand	**pH:**	5.6
Plot Size:	10 **X** 25 **FT**	**Design:**	FACTORIAL

Tillage: Spring Disc 3X. Spring Chisel. Field Cultivated.
Fertilizer: 20 gal/A of 19-17-0, 12 gal/A of 10-34-0 in Row. 23 gal/A of 28% N at Cultivation. 23 gal/A of 28%N at Hilling. 100 lbs/A of 46-0-0 Broadcast.

Application Description

	A	**B**
Application Timing:	PRE	POST
Date Treated:	5/11/09	7/8/09
Time Treated:	2:30 PM	9:20 AM
% Cloud Cover:	60	40
Air Temp., Unit:	59 F	79 F
% Relative Humidity:	37	53
Wind Speed/Unit/Dir:	7 mph W	2 mph S
Soil Temp., Unit:	68 F	64 F
Soil/Leaf Surface M:	4	4
Soil Moist (1=w 5=d):	4	4

Crop Stage at Each Application

	A	**B**
Crop Name:	SOLTU	SOLTU
Height (In.):		22

Weed Stage at Each Application

	A	**B**
Weed 1 Name:	ANGR	ANGR
Height (In.):		.25-1(1)
Stage (L):		1-3(1)
Weed 2 Name:	CHEAL	CHEAL
Height (In.):		.25-2(1)
Stage (L):		Cot-2(2)
Weed 3 Name:	AMARE	AMARE
Height (In.):		.25-2(1)
Stage (L):		Cot-2(2)
Weed 4 Name:	AMBEL	AMBEL
Weed 5 Name:	ABUTH	ABUTH

Weed Density (plants/sq. ft.)

	1
Date:	7/8/09
Weed Name:	ANGR
Density:	16
Date:	7/8/09
Weed Name:	CHEAL
Density:	20
Date:	7/8/09
Weed Name:	AMARE
Density:	8
Date:	7/8/09
Weed Name:	AMBEL
Density:	0
Date:	7/8/09
Weed Name:	ABUTH
Density:	0

Application Equipment

Appl	**Sprayer Type**	**Speed MPH**	**Nozzle Type**	**Nozzle Size**	**Nozzle Height**	**Nozzle Spacing**	**Boom Width**	**GPA**	**Carrier**	**PSI**
A	BKPK	3.5	FF	8003	18"	20"	120"	20	H2O	30
B	BKPK	3.5	FF	8003	24"	20"	100"	20	H2O	30

Herbicide Effect on Growth Cracks in Production Potato, 2009

Trial ID: P0409 Study Dir.: Andy Chomas
Conducted: MONTCALM RSCH FAM Investigator: Christy Sprague

Weed Code															
Crop Code							SOLTU	SOLTU	SOLTU	SOLTU	SOLTU	SOLTU	SOLTU	SOLTU	SOLTU	SOLTU
Rating Data Type							<1 7/8"	<1 7/8"	PO crack	PO crack	severity*	PickOut	PickOut	oversize	oversize	Grade A
Rating Unit							kilogram	count	kilogram	count	0-3	kilogram	count	kilogram	count	kilogram
Rating Date							8/27/09	8/27/09	8/27/09	8/27/09	8/27/09	8/27/09	8/27/09	8/27/09	8/27/09	8/27/09
Trt-Eval Interval							HARVEST	HARVEST	HARVEST	HARVEST	HARVEST	HARVEST	HARVEST	HARVEST	HARVEST	HARVEST
Trt No.	Treatment Name	Form Conc	Form Type	Rate	Rate Unit	Grow Stg	1	2	3	4	5	6	7	8	9	10
1	Dual Magnum	7.62	EC	1.33	pt/a	PRE	2.4075	50	0.5800	5	2	0.0000	0	0	0	14.2175
1	Sencor	75	DF	0.33	lb/a	PRE										
1	Prowl H2O	3.8	L	0.5	pt/a	PRE										
1	Sencor	75	DF	0.33	lb/a	POST										
1	Activator 90		L	0.25	% v/v	POST										
2	Dual Magnum	7.62	EC	1.33	pt/a	PRE	2.3900	50	1.0988	9	2	0.1750	0	0	0	16.3825
2	Sencor	75	DF	0.33	lb/a	PRE										
2	Prowl H2O	3.8	L	0.5	pt/a	PRE										
2	Matrix	25	WG	1	oz/a	POST										
2	Activator 90		L	0.25	% v/v	POST										
3	Dual Magnum	7.62	EC	1.33	pt/a	PRE	2.5613	53	0.8113	6	2	0.0000	0	0	0	15.2188
3	Sencor	75	DF	0.33	lb/a	PRE										
3	Prowl H2O	3.8	L	0.5	pt/a	PRE										
3	Sencor	75	DF	0.33	lb/a	POST										
3	Matrix	25	WG	1	oz/a	POST										
3	Activator 90		L	0.25	% v/v	POST										
4	Dual Magnum	7.62	EC	1.33	pt/a	PRE	2.1275	43	0.7363	5	2	0.0388	0	0	0	18.3188
4	Sencor	75	DF	0.33	lb/a	PRE										
4	Prowl H2O	3.8	L	0.5	pt/a	PRE										
4	Non-Treated					POST										
5	Dual Magnum	7.62	EC	1.33	pt/a	PRE	1.8475	38	0.5813	4	2	0.0000	0	0	0	15.8075
5	Sencor	75	DF	0.33	lb/a	PRE										
5	Lorox	50	DF	1	lb/a	PRE										
5	Sencor	75	DF	0.33	lb/a	POST										
5	Activator 90		L	0.25	% v/v	POST										
6	Dual Magnum	7.62	EC	1.33	pt/a	PRE	2.3838	53	0.9338	6	2	0.0550	0	0	0	19.2375
6	Sencor	75	DF	0.33	lb/a	PRE										
6	Lorox	50	DF	1	lb/a	PRE										
6	Matrix	25	WG	1	oz/a	POST										
6	Activator 90		L	0.25	% v/v	POST										
7	Dual Magnum	7.62	EC	1.33	pt/a	PRE	1.9100	38	0.4838	4	2	0.0000	0	0	0	14.5938
7	Sencor	75	DF	0.33	lb/a	PRE										
7	Lorox	50	DF	1	lb/a	PRE										
7	Sencor	75	DF	0.33	lb/a	POST										
7	Matrix	25	WG	1	oz/a	POST										
7	Activator 90		L	0.25	% v/v	POST										
8	Dual Magnum	7.62	EC	1.33	pt/a	PRE	2.1638	42	0.7013	5	2	0.0000	0	0	0	19.2313
8	Sencor	75	DF	0.33	lb/a	PRE										
8	Lorox	50	DF	1	lb/a	PRE										
8	Non-Treated					POST										
9	Matrix	25	WG	1	oz/a	POST	2.3525	44	1.0350	6	2	0.0000	0	0	1	19.0338
9	Activator 90		L	0.25	% v/v	POST										
10	Handweeded						2.4688	53	1.1125	9	2	0.0675	0	0	0	17.8750
LSD (P=.05)							1.11595	21.8	0.78651	5.2	0.8	0.18335	0.4	0.3	0.7	4.22467
Standard Deviation							0.76910	15.0	0.54206	3.6	0.6	0.12636	0.3	0.2	0.5	2.91159
CV							34.01	32.47	67.14	61.24	28.82	375.8	298.14	632.46	632.46	17.14

Herbicide Effect on Growth Cracks in Production Potato, 2009

Trial ID: P0409 Study Dir.: Andy Chomas
Conducted: MONTCALM RSCH FAM Investigator: Christy Sprague

Trt No.	Treatment Name	Form Conc	Form Type	Rate	Rate Unit	Grow Stg	11	12	13	14	15	16	17	18
Weed Code														
Crop Code							SOLTU	SOLTU	SOLTU	SOLTU	SOLTU	SOLTU	SOLTU	SOLTU
Rating Data Type							yield	Grade A	dry	wet	SPEC. GRAV	HH	VD	IBS
Rating Unit							CWT	count				0-10	0-10	0-10
Rating Date							8/27/09	8/27/09	8/27/09	8/27/09	8/27/09	8/27/09	8/27/09	8/27/09
Trt-Eval Interval							HARVEST	HARVEST	HARVEST	HARVEST	HARVEST	HARVEST	HARVEST	HARVEST
1	Dual Magnum	7.62	EC	1.33	pt/a	PRE	192.8	121.3	9.6288	0.83963	1.0956200	0	0	0
1	Sencor	75	DF	0.33	lb/a	PRE								
1	Prowl H2O	3.8	L	0.5	pt/a	PRE								
1	Sencor	75	DF	0.33	lb/a	POST								
1	Activator 90		L	0.25	% v/v	POST								
2	Dual Magnum	7.62	EC	1.33	pt/a	PRE	222.1	141.3	8.6663	0.76688	1.0971104	2	0	0
2	Sencor	75	DF	0.33	lb/a	PRE								
2	Prowl H2O	3.8	L	0.5	pt/a	PRE								
2	Matrix	25	WG	1	oz/a	POST								
2	Activator 90		L	0.25	% v/v	POST								
3	Dual Magnum	7.62	EC	1.33	pt/a	PRE	206.4	138.5	9.2813	0.80600	1.0951620	0	0	0
3	Sencor	75	DF	0.33	lb/a	PRE								
3	Prowl H2O	3.8	L	0.5	pt/a	PRE								
3	Sencor	75	DF	0.33	lb/a	POST								
3	Matrix	25	WG	1	oz/a	POST								
3	Activator 90		L	0.25	% v/v	POST								
4	Dual Magnum	7.62	EC	1.33	pt/a	PRE	248.4	155.0	8.6025	0.76388	1.0973925	1	0	0
4	Sencor	75	DF	0.33	lb/a	PRE								
4	Prowl H2O	3.8	L	0.5	pt/a	PRE								
4	Non-Treated					POST								
5	Dual Magnum	7.62	EC	1.33	pt/a	PRE	214.3	136.5	9.0750	0.80050	1.0968406	0	0	0
5	Sencor	75	DF	0.33	lb/a	PRE								
5	Lorox	50	DF	1	lb/a	PRE								
5	Sencor	75	DF	0.33	lb/a	POST								
5	Activator 90		L	0.25	% v/v	POST								
6	Dual Magnum	7.62	EC	1.33	pt/a	PRE	260.8	164.8	10.4075	0.89650	1.0938526	1	1	0
6	Sencor	75	DF	0.33	lb/a	PRE								
6	Lorox	50	DF	1	lb/a	PRE								
6	Matrix	25	WG	1	oz/a	POST								
6	Activator 90		L	0.25	% v/v	POST								
7	Dual Magnum	7.62	EC	1.33	pt/a	PRE	197.9	125.3	8.1488	0.70713	1.0950276	1	0	0
7	Sencor	75	DF	0.33	lb/a	PRE								
7	Lorox	50	DF	1	lb/a	PRE								
7	Sencor	75	DF	0.33	lb/a	POST								
7	Matrix	25	WG	1	oz/a	POST								
7	Activator 90		L	0.25	% v/v	POST								
8	Dual Magnum	7.62	EC	1.33	pt/a	PRE	260.8	162.0	9.5938	0.84525	1.0965859	0	0	0
8	Sencor	75	DF	0.33	lb/a	PRE								
8	Lorox	50	DF	1	lb/a	PRE								
8	Non-Treated					POST								
9	Matrix	25	WG	1	oz/a	POST	258.1	160.5	9.7225	0.85213	1.0958688	1	0	0
9	Activator 90		L	0.25	% v/v	POST								
10	Handweeded						242.4	147.0	9.6038	0.84550	1.0965496	1	0	0
LSD (P=.05)							57.28	35.33	1.32164	0.128576	0.00361148	2.3	0.6	0.2
Standard Deviation							39.48	24.35	0.91086	0.088613	0.00248899	1.6	0.4	0.2
CV							17.14	16.77	9.82	10.91	0.23	228.7	380.06	632.46

ARM Action Codes
TY2 = 13.55932*[10]
T1 = ([C13])/([C13]-[C14])

Herbicide Effect on Growth Cracks in Production Potato, 2009

Trial ID: P1409 Study Dir.: Andy Chomas
Conducted: WALTHER FARM Investigator: Christy Sprague

Date Planted: 4/27/09 **Row Spacing:** IN
Variety: FL 2053 **No. of Reps:** 3
Population: **% OM:**
Soil Type: **pH:**
Plot Size: 10 **X** 25 **FT** **Design:** FACTORIAL

Application Description

	A	B
Application Timing:	PRE	
Date Treated:	4/29/09	
Time Treated:	6:00 PM	
% Cloud Cover:	100	
Air Temp., Unit:	62 F	
% Relative Humidity:	55	
Wind Speed/Unit/Dir:	5 mph	
Soil Temp., Unit:	59 F	
Soil/Leaf Surface M:	2	
Soil Moist (1=w 5=d):	3	

Crop Stage at Each Application

	A	B
Crop Name:	SOLTU	SOLTU

Application Equipment

Appl	Sprayer Type	Speed MPH	Nozzle Type
A	BKPK	3.5	XR8003

MSU Weed Science Research Program

Herbicide Effect on Growth Cracks in Production Potato, 2009

Trial ID: P1409 Study Dir.: Andy Chomas

Conducted: WALTHER FARM Investigator: Christy Sprague

Weed Code																
Crop Code							SOLTU	SOLTU	SOLTU	SOLTU	SOLTU	SOLTU	SOLTU	SOLTU	SOLTU	SOLTU
Rating Data Type							<1 7/8"	<1 7/8"	PO crack	PO crack	PickOut	PickOut	oversize	oversize	Grade A	Grade A
Rating Unit							kilogram	count	kilogram	count	kilogram	count	kilogram	count	kilogram	count
Rating Date							9/22/09	9/22/09	9/22/09	9/22/09	9/22/09	9/22/09	9/22/09	9/22/09	9/22/09	9/22/09
Trt-Eval Interval							HARVEST	HARVEST	HARVEST	HARVEST	HARVEST	HARVEST	HARVEST	HARVEST	HARVEST	HARVEST
Trt No.	Treatment Name	Form Conc	Form Type	Rate	Rate Unit	Grow Stg	1	2	3	4	5	6	7	8	9	10
1	Dual Magnum	7.62	EC	1.33	pt/a	PRE	1.0883	23	0.1783	1	1.1167	3	7.3550	38	26.8917	146
1	Sencor	75	DF	0.33	lb/a	PRE										
1	Prowl H2O	3.8	L	0.5	pt/a	PRE										
1	Sencor	75	DF	0.33	lb/a	POST										
1	Activator 90		L	0.25	% v/v	POST										
2	Dual Magnum	7.62	EC	1.33	pt/a	PRE	1.0883	26	0.3533	2	0.5833	4	5.9583	14	29.5517	173
2	Sencor	75	DF	0.33	lb/a	PRE										
2	Prowl H2O	3.8	L	0.5	pt/a	PRE										
2	Matrix	25	WG	1	oz/a	POST										
2	Activator 90		L	0.25	% v/v	POST										
3	Dual Magnum	7.62	EC	1.33	pt/a	PRE	1.3467	30	0.0000	0	0.5233	2	8.4517	20	21.1100	132
3	Sencor	75	DF	0.33	lb/a	PRE										
3	Prowl H2O	3.8	L	0.5	pt/a	PRE										
3	Sencor	75	DF	0.33	lb/a	POST										
3	Matrix	25	WG	1	oz/a	POST										
3	Activator 90		L	0.25	% v/v	POST										
4	Dual Magnum	7.62	EC	1.33	pt/a	PRE	1.0583	26	0.0367	0	0.4567	2	7.9307	18	26.0750	148
4	Sencor	75	DF	0.33	lb/a	PRE										
4	Prowl H2O	3.8	L	0.5	pt/a	PRE										
4	Non-Treated															
5	Dual Magnum	7.62	EC	1.33	pt/a	PRE	1.4333	34	0.2683	1	0.2950	2	6.7550	16	26.9550	158
5	Sencor	75	DF	0.33	lb/a	PRE										
5	Lorox	50	DF	1	lb/a	PRE										
5	Sencor	75	DF	0.33	lb/a	POST										
5	Activator 90		L	0.25	% v/v	POST										
6	Dual Magnum	7.62	EC	1.33	pt/a	PRE	1.1833	28	0.1233	1	0.2250	1	7.1283	16	27.3717	152
6	Sencor	75	DF	0.33	lb/a	PRE										
6	Lorox	50	DF	1	lb/a	PRE										
6	Matrix	25	WG	1	oz/a	POST										
6	Activator 90		L	0.25	% v/v	POST										
7	Dual Magnum	7.62	EC	1.33	pt/a	PRE	1.2733	29	0.1300	1	0.5733	2	8.5983	21	25.3343	152
7	Sencor	75	DF	0.33	lb/a	PRE										
7	Lorox	50	DF	1	lb/a	PRE										
7	Sencor	75	DF	0.33	lb/a	POST										
7	Matrix	25	WG	1	oz/a	POST										
7	Activator 90		L	0.25	% v/v	POST										
8	Dual Magnum	7.62	EC	1.33	pt/a	PRE	1.4050	33	0.2167	1	0.1800	1	8.4500	20	26.7833	139
8	Sencor	75	DF	0.33	lb/a	PRE										
8	Lorox	50	DF	1	lb/a	PRE										
8	Non-Treated															
LSD (P=.05)							0.62612	14.1	0.27651	0.9	0.64673	3.1	4.28312	16.9	7.13250	51.0
Standard Deviation							0.35750	8.1	0.15788	0.5	0.36927	1.8	2.44556	9.7	4.07249	29.1
CV							28.96	28.29	96.66	81.01	74.73	83.11	32.27	47.28	15.51	19.42

Herbicide Effect on Growth Cracks in Production Potato, 2009

Trial ID: P1409 Study Dir.: Andy Chomas
Conducted: WALTHER FARM Investigator: Christy Sprague

Trt No.	Treatment Name	Form Conc	Form Type	Rate	Rate Unit	Grow Stg	11	12	13	14	15
Weed Code											
Crop Code							SOLTU	SOLTU	SOLTU	SOLTU	SOLTU
Rating Data Type							dry	wet	SPEC. GRAV.	HH	VD
Rating Unit										0-10	0-10
Rating Date							9/22/09	9/22/09	9/22/09	9/22/09	9/22/09
Trt-Eval Interval							HARVEST	HARVEST	HARVEST	HARVEST	HARVEST
1	Dual Magnum	7.62	EC	1.33	pt/a	PRE	11.2733	0.97166673	1.0942961	0.0	0.3
1	Sencor	75	DF	0.33	lb/a	PRE					
1	Prowl H2O	3.8	L	0.5	pt/a	PRE					
1	Sencor	75	DF	0.33	lb/a	POST					
1	Activator 90		L	0.25	% v/v	POST					
2	Dual Magnum	7.62	EC	1.33	pt/a	PRE	10.3500	0.90833339	1.0962595	0.3	1.3
2	Sencor	75	DF	0.33	lb/a	PRE					
2	Prowl H2O	3.8	L	0.5	pt/a	PRE					
2	Matrix	25	WG	1	oz/a	POST					
2	Activator 90		L	0.25	% v/v	POST					
3	Dual Magnum	7.62	EC	1.33	pt/a	PRE	10.3150	0.90416679	1.0960938	1.0	1.0
3	Sencor	75	DF	0.33	lb/a	PRE					
3	Prowl H2O	3.8	L	0.5	pt/a	PRE					
3	Sencor	75	DF	0.33	lb/a	POST					
3	Matrix	25	WG	1	oz/a	POST					
3	Activator 90		L	0.25	% v/v	POST					
4	Dual Magnum	7.62	EC	1.33	pt/a	PRE	9.8217	0.82283344	1.0906361	1.0	2.0
4	Sencor	75	DF	0.33	lb/a	PRE					
4	Prowl H2O	3.8	L	0.5	pt/a	PRE					
4	Non-Treated										
5	Dual Magnum	7.62	EC	1.33	pt/a	PRE	9.1333	0.77716674	1.0925081	0.0	2.0
5	Sencor	75	DF	0.33	lb/a	PRE					
5	Lorox	50	DF	1	lb/a	PRE					
5	Sencor	75	DF	0.33	lb/a	POST					
5	Activator 90		L	0.25	% v/v	POST					
6	Dual Magnum	7.62	EC	1.33	pt/a	PRE	11.4300	0.99816684	1.0956647	1.7	0.7
6	Sencor	75	DF	0.33	lb/a	PRE					
6	Lorox	50	DF	1	lb/a	PRE					
6	Matrix	25	WG	1	oz/a	POST					
6	Activator 90		L	0.25	% v/v	POST					
7	Dual Magnum	7.62	EC	1.33	pt/a	PRE	9.4983	0.81066682	1.0933971	2.0	0.7
7	Sencor	75	DF	0.33	lb/a	PRE					
7	Lorox	50	DF	1	lb/a	PRE					
7	Sencor	75	DF	0.33	lb/a	POST					
7	Matrix	25	WG	1	oz/a	POST					
7	Activator 90		L	0.25	% v/v	POST					
8	Dual Magnum	7.62	EC	1.33	pt/a	PRE	8.5133	0.73633344	1.0949454	2.0	0.0
8	Sencor	75	DF	0.33	lb/a	PRE					
8	Lorox	50	DF	1	lb/a	PRE					
8	Non-Treated										
LSD (P=.05)							1.72637	0.167378502	0.00567225	2.21	1.84
Standard Deviation							0.98572	0.095569218	0.00323872	1.26	1.05
CV							9.82	11.03	0.3	126.3	104.94

ARM Action Codes

T1 = ([11])/([11]-[12])

Funded by AgChem Industry
and MAES

Tolerance of herbicides in Silverton Potatoes.

Wesley J. Everman and Andrew J. Chomas. Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824.

Incidences of injury last season in Silverton Russet potatoes following applications of linuron (Lorox) led to interest in determining the factors contributing to the observed injury. In order to determine what effect the timing of herbicide applications has on injury and yield, Lorox and Sencor were applied to Silverton Russets planted at three different times. Silverton Russets were planted April 24, May 8, and May 20, 2009. Herbicide treatments consisted of at cracking applications of Lorox (1.5 lb/A), Sencor (0.5 lb/A), and Lorox (1.5 lb/A) plus Sencor (0. 5 lb/A). All herbicide treatments were compared with a non-treated control treatment, with all plots maintained weed-free by hand weeding. Each treatment was replicated four times. Irrigation and other potato crop management practices utilized closely mirror practices followed by producers. Potato injury was evaluated and plots were harvested with marketable yields determined. At all planting dates, the greatest injury was observed where Lorox was included in the application. Injury persisted longer where potatoes were planted earliest, April 24. Injury symptoms observed following all treatments dissipated by mid-June. Differences in Silverton Russet yield corresponded more closely to time of planting than to herbicide selection.

TOLERANCE OF HERBICIDE IN SILVERTON POTATOES, 2009

Trial ID: P0709 Study Dir.:
Conducted: MONTCALM RSCH FM Investigator: Christy Sprague

Date Planted:	4/24/09	**Row Spacing:**	34 IN
Variety:	SILVERTON	**No. of Reps:**	4
Population:	1/FT	**% OM:**	1.2
Soil Type:	Loamy Sand	**pH:**	5.7
Plot Size:	9 **X** 25 **FT**	**Design:**	SPLIT-PLOT

Tillage: Spring Disc 3X. Spring Chisel. Field Cultivated.
Fertilizer: 20 gal/A of 19-17-0, 12 gal/A of 10-34-0 in Row. 23 gal/A of 28% N at Cultivation. 23 gal/A of 28%N at Hilling. 100 lbs/A of 46-0-0 Broadcast.

Application Description

	A	**B**
Application Timing:	PRE T1	PRE T2&3
Date Treated:	5/17/09	5/20/09
Time Treated:		10:20 AM
% Cloud Cover:	25	0
Air Temp., Unit:	52 F	77 F
% Relative Humidity:	42	50
Wind Speed/Unit/Dir:	6 mph NW	8 mph SW
Soil Temp., Unit:	46 F	63 F
Soil/Leaf Surface M:	5	5
Soil Moist (1=w 5=d):	3	4

Crop Stage at Each Application

	A	**B**
Crop Name:	SOLTU	SOLTU
Height (In.):	N/A	N/A

Weed Stage at Each Application

	A	**B**
Weed 1 Name:	CHEAL	CHEAL
Height (In.):	.5	
Stage (L):	2	

Application Equipment

Appl	**Sprayer Type**	**Speed MPH**	**Nozzle Type**	**Nozzle Size**	**Nozzle Height**	**Nozzle Spacing**	**Boom Width**	**GPA**	**Carrier**	**PSI**
A	BKPK	3.5	FF	8003	18"	20"	120"	20	H2O	30
B	BKPK	3.5	FF	8003	18"	20"	120"	20	H2O	30

Comments: TIMING STUDY HAD THREE PLANTING DATES:
TIMING 1: 4/24/09
TIMING 2: 5/8/09
TIMING 3: 5/20/09

TOLERANCE OF HERBICIDE IN SILVERTON POTATOES, 2009

Trial ID: P0709 Study Dir.:
Conducted: MONTCALM RSCH FM Investigator: Christy Sprague

Weed Code																	
Crop Code							SOLTU	SOLTU	SOLTU	SOLTU	SOLTU	SOLTU	SOLTU	SOLTU	SOLTU	SOLTU	SOLTU	SOLTU
Rating Data Type							emerge	stunt	discolor	injury	stunt	discolor	injury	stunt	discolor	injury	injury	yield
Rating Unit							percent	percent	percent	percent	percent	percent	percent	percent	percent	percent	percent	pounds
Rating Date							5/29/09	5/29/09	5/29/09	5/29/09	6/3/09	6/3/09	6/3/09	6/10/09	6/10/09	6/10/09	6/16/09	8/19/09
Trt-Eval Interval							12 DA-A	12 DA-A	12 DA-A	12 DA-A	17 DA-A	17 DA-A	17 DA-A	24 DA-A	24 DA-A	24 DA-A	30 DA-A	HARVEST
Trt No.	Treatment Name	Form Conc	Form Type	Rate	Rate Unit	Grow Stg	1	2	3	4	5	6	7	8	9	10	11	12
1	PLANTING 1						90	11	12	23	14	14	28	3	0	3	1	25.40
1	Lorox	50	DF	1.5	lb ai/a	PRE												
2	PLANTING 1						94	5	0	5	4	3	5	9	0	9	1	29.45
2	Sencor	75	DF	0.5	lb ai/a	PRE												
3	PLANTING 1						96	8	6	14	5	5	10	8	0	8	2	26.05
3	Lorox	50	DF	1.5	lb ai/a	PRE												
3	Sencor	75	DF	0.5	lb ai/a	PRE												
4	PLANTING 1						96	1	0	1	5	3	8	14	0	14	0	27.55
4	Non-Treated																	
5	PLANTING 2										0	10	8	5	10	15	0	35.80
5	Lorox	50	DF	1.5	lb ai/a	PRE												
6	PLANTING 2										0	4	3	0	0	0	2	38.80
6	Sencor	75	DF	0.5	lb ai/a	PRE												
7	PLANTING 2										0	9	9	6	14	18	0	41.05
7	Lorox	50	DF	1.5	lb ai/a	PRE												
7	Sencor	75	DF	0.5	lb ai/a	PRE												
8	PLANTING 2										0	3	0	5	5	10	1	35.75
8	Non-Treated																	
9	PLANTING 3													0	15	10	1	26.60
9	Lorox	50	DF	1.5	lb ai/a	PRE												
10	PLANTING 3													0	5	5	2	27.85
10	Sencor	75	DF	0.5	lb ai/a	PRE												
11	PLANTING 3													0	10	10	2	27.05
11	Lorox	50	DF	1.5	lb ai/a	PRE												
11	Sencor	75	DF	0.5	lb ai/a	PRE												
12	PLANTING 3													0	5	5	0	33.40
12	Non-Treated																	
LSD (P=.05)							5.4	10.7	6.6	15.6	5.6	9.1	10.5	8.4	9.1	14.5	2.1	8.377
Standard Deviation							3.4	6.7	4.2	9.7	3.8	6.2	7.1	5.8	6.3	10.1	1.4	5.801
CV							3.57	106.67	93.69	91.09	109.19	100.28	82.37	143.76	118.74	115.08	181.66	18.58

TOLERANCE OF HERBICIDE IN SILVERTON POTATOES, 2009

Trial ID: P0709 Study Dir.:
Conducted: MONTCALM RSCH FM Investigator: Christy Sprague

Weed Code							
Crop Code							SOLTU
Rating Data Type							yield
Rating Unit							CWT
Rating Date							8/19/09
Trt-Eval Interval							HARVEST
Trt No.	Treatment Name	Form Conc	Form Type	Rate	Rate Unit	Grow Stg	13
1	PLANTING 1						156.4
1	Lorox	50	DF	1.5	lb ai/a	PRE	
2	PLANTING 1						181.3
2	Sencor	75	DF	0.5	lb ai/a	PRE	
3	PLANTING 1						160.4
3	Lorox	50	DF	1.5	lb ai/a	PRE	
3	Sencor	75	DF	0.5	lb ai/a	PRE	
4	PLANTING 1						169.6
4	Non-Treated						
5	PLANTING 2						220.4
5	Lorox	50	DF	1.5	lb ai/a	PRE	
6	PLANTING 2						238.9
6	Sencor	75	DF	0.5	lb ai/a	PRE	
7	PLANTING 2						252.7
7	Lorox	50	DF	1.5	lb ai/a	PRE	
7	Sencor	75	DF	0.5	lb ai/a	PRE	
8	PLANTING 2						220.1
8	Non-Treated						
9	PLANTING 3						163.8
9	Lorox	50	DF	1.5	lb ai/a	PRE	
10	PLANTING 3						171.5
10	Sencor	75	DF	0.5	lb ai/a	PRE	
11	PLANTING 3						166.5
11	Lorox	50	DF	1.5	lb ai/a	PRE	
11	Sencor	75	DF	0.5	lb ai/a	PRE	
12	PLANTING 3						205.6
12	Non-Treated						
LSD (P=.05)							51.57
Standard Deviation							35.72
CV							18.58

ARM Action Codes
TY1 = 6.15689*[12]

Funded by MAES

Herbicide Timing Effect on Weed Control in Potato.

Wesley J. Everman and Andrew J. Chomas. Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824.

Herbicide application timing is an important consideration in any cropping system, and is of special importance in potatoes which have limited postemergence herbicide options. Through interactions with industry personnel and growers, it seems the common timing of preemergence herbicide application is often as near to potato cracking as possible, often with applications coming after potatoes have emerged. In order to determine what effect the timing of herbicide applications has on weed control and yield herbicide products were applied to Snowden. Herbicide treatments consisted of Dual II Magnum (1 pt/A) plus Lorox (1 lb/A), Dual II Magnum (1 pt/A) plus Lorox (1 lb/A) plus Sencor (0.125 lb/A), Dual II Magnum (1 pt/A) plus Lorox (1 lb/A) followed by Matrix (1 oz/A) plus NIS (0.25% v/v), and Dual II Magnum (1 pt/A) plus Lorox (1 lb/A) followed by Matrix (1 oz/A) plus Sencor (0.33 lb/A) plus NIS (0.25% v/v). Application timings were at planting 10 DAP and 21 DAP. 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. Weed control was evaluated, and plots were harvested and marketable yields determined. Weed control was similar when herbicides were applied at 10 and 21 DAP, regardless of herbicides used or presence of a postemergence application. However, at planting preemergence treatments followed by a postemergence application showed slightly lower levels of control when compared to later application timings. The results of this study, combined with results from 2008, indicate that initial herbicide application timing may depend on weather and growing conditions.

Potato Timing Study, Montcalm, 2008

Trial ID: P0809 Study Dir.:
Conducted: Montcalm Investigator: Christy Sprague

Date Planted:	5/11/09	**Row Spacing:**	34 IN
Variety:	SNOWDEN	**No. of Reps:**	4
Population:	1/FT	**% OM:**	1.1
Soil Type:	Loamy Sand	**pH:**	6.0
Plot Size:	10 **X** 25 **FT**	**Design:**	FACTORIAL

Tillage: Spring Disc 3X. Spring Chisel. Field Cultivated.
Fertilizer: 20 gal/A of 19-17-0, 12 gal/A of 10-34-0 in Row. 23 gal/A of 28% N at Cultivation. 23 gal/A of 28%N at Hilling. 100 lbs/A of 46-0-0 Broadcast.

Application Description

	A	**B**	**C**	**D**
Application Timing:	0 DAP	10 DAP	21 DAP	POST
Date Treated:	5/11/09	5/20/09	5/29/09	7/14/09
Time Treated:	4:15 PM	9:54 PM	10:00 AM	10:00 AM
% Cloud Cover:	50	0	40	5
Air Temp., Unit:	68 F	76 F	65 F	68 F
% Relative Humidity:	37	50	73	42
Wind Speed/Unit/Dir:	6 mph SW	8 mph SW	2 mph W	0 mph
Soil Temp., Unit:	68 F	63 F	63 F	66 F
Soil/Leaf Surface M:		5		5
Soil Moist (1=w 5=d):		4		4

Crop Stage at Each Application

	A	**B**	**C**	**D**
Crop Name:	SOLTU	SOLTU	SOLTU	SOLTU
Stage (L):			CRACK	

Application Equipment

Appl	**Sprayer Type**	**Speed MPH**	**Nozzle Type**	**Nozzle Size**	**Nozzle Height**	**Nozzle Spacing**	**Boom Width**	**GPA**	**Carrier**	**PSI**
A	BKPK	3.5	FF	8003	18"	20"	100"	20	H2O	30
B	BKPK	3.5	FF	8003	18"	20"	100"	20	H2O	30
C	BKPK	3.5	FF	8003	18"	20"	100"	20	H2O	30
D	BKPK	3.5	FF	8003	28"	20"	100"	20	H2O	30

Comments: Spray solution was Buffered to a pH of 6.0

Potato Timing Study, Montcalm, 2008

Trial ID: P0809 Study Dir.:
Conducted: Montcalm Investigator: Christy Sprague

Weed Code								ANGR	CHEAL	CHEAL	AMARE	ANGR	POLCO	POROL		ANGR	CHEAL
Crop Code							SOLTU								SOLTU		
Rating Data Type							injury	control	control	control	control	control	control	control	injury	control	control
Rating Unit							percent	percent	percent	percent	percent	percent	percent	percent	percent	percent	percent
Rating Date							7/14/09	7/14/09	7/14/09	7/28/09	7/28/09	7/28/09	7/28/09	7/28/09	8/12/09	8/12/09	8/12/09
Trt-Eval Interval							AT POST	AT POST	AT POST	14 DAPO	14 DAPO	14 DAPO	14 DAPO	14 DAPO	29 DAPO	29 DAPO	29 DAPO
Trt No.	Treatment Name	Form Conc	Form Type	Rate	Rate Unit	Grow Stg	1	2	3	4	5	6	7	8	9	10	11
1	0 DAP					0 DAP	0	83	84	45	60	60	0	48	0	73	71
1	Dual Magnum	7.62	L	1	pt/a	0 DAP											
1	Lorox	50	DF	1	lb/a	0 DAP											
2	0 DAP					0 DAP	0	82	83	51	73	43	33	48	0	65	66
2	Dual Magnum	7.62	L	1	pt/a	0 DAP											
2	Lorox	50	DF	1	lb/a	0 DAP											
2	Sencor	75	DF	0.125	lb/a	0 DAP											
3	0 DAP					0 DAP	0	83	82	77	99	75	40	71	5	88	85
3	Dual Magnum	7.62	L	1	pt/a	0 DAP											
3	Lorox	50	DF	1	lb/a	0 DAP											
3	Matrix	25	WG	1	oz/a	POST											
3	Activator 90		L	0.25	% v/v	POST											
4	0 DAP					0 DAP	0	86	86	100	100	100	86	100	0	95	91
4	Dual Magnum	7.62	L	1	pt/a	0 DAP											
4	Lorox	50	DF	1	lb/a	0 DAP											
4	Sencor	75	DF	0.33	lb/a	POST											
4	Matrix	25	WG	1	oz/a	POST											
4	Activator 90		L	0.25	% v/v	POST											
5	10 DAP					10 DAP	0	90	90	79	96	87	84	66	0	76	70
5	Dual Magnum	7.62	L	1	pt/a	10 DAP											
5	Lorox	50	DF	1	lb/a	10 DAP											
6	10 DAP					10 DAP	0	92	91	83	94	68	63	44	0	65	68
6	Dual Magnum	7.62	L	1	pt/a	10 DAP											
6	Lorox	50	DF	1	lb/a	10 DAP											
6	Sencor	75	DF	0.125	lb/a	10 DAP											
7	10 DAP					10 DAP	0	91	94	94	98	100	86	90	4	90	90
7	Dual Magnum	7.62	L	1	pt/a	10 DAP											
7	Lorox	50	DF	1	lb/a	10 DAP											
7	Matrix	25	WG	1	oz/a	POST											
7	Activator 90		L	0.25	% v/v	POST											
8	10 DAP					10 DAP	0	94	96	99	99	100	86	100	3	94	95
8	Dual Magnum	7.62	L	1	pt/a	10 DAP											
8	Lorox	50	DF	1	lb/a	10 DAP											
8	Sencor	75	DF	0.33	lb/a	POST											
8	Matrix	25	WG	1	oz/a	POST											
8	Activator 90		L	0.25	% v/v	POST											
9	21 DAP					21 DAP	0	91	91	73	73	73	68	53	0	74	72
9	Dual Magnum	7.62	L	1	pt/a	21 DAP											
9	Lorox	50	DF	1	lb/a	21 DAP											
10	21 DAP					21 DAP	0	87	87	65	70	60	78	20	0	71	78
10	Dual Magnum	7.62	L	1	pt/a	21 DAP											
10	Lorox	50	DF	1	lb/a	21 DAP											
10	Sencor	75	DF	0.125	lb/a	21 DAP											
11	21 DAP					21 DAP	0	90	92	98	100	100	100	95	6	98	99
11	Dual Magnum	7.62	L	1	pt/a	21 DAP											
11	Lorox	50	DF	1	lb/a	21 DAP											
11	Matrix	25	WG	1	oz/a	POST											
11	Activator 90		L	0.25	% v/v	POST											
12	21 DAP					21 DAP	0	90	89	99	100	100	100	100	3	96	100
12	Dual Magnum	7.62	L	1	pt/a	21 DAP											
12	Lorox	50	DF	1	lb/a	21 DAP											
12	Sencor	75	DF	0.33	lb/a	POST											
12	Matrix	25	WG	1	oz/a	POST											
12	Activator 90		L	0.25	% v/v	POST											

Potato Timing Study, Montcalm, 2008

Trial ID: P0809 Study Dir.:
Conducted: Montcalm Investigator: Christy Sprague

Weed Code							ANGR	CHEAL	CHEAL	AMARE	ANGR	POLCO	POROL		ANGR	CHEAL
Crop Code						SOLTU								SOLTU		
Rating Data Type						injury	control	control	control	control	control	control	control	injury	control	control
Rating Unit						percent	percent	percent	percent	percent	percent	percent	percent	percent	percent	percent
Rating Date						7/14/09	7/14/09	7/14/09	7/28/09	7/28/09	7/28/09	7/28/09	7/28/09	8/12/09	8/12/09	8/12/09
Trt-Eval Interval						AT POST	AT POST	AT POST	14 DAPO	14 DAPO	14 DAPO	14 DAPO	14 DAPO	29 DAPO	29 DAPO	29 DAPO
Trt No.	Treatment Name	Form Conc	Form Type	Rate	Rate Unit	Grow Stg										
						1	2	3	4	5	6	7	8	9	10	11
LSD (P=.05)						0.0	3.5	4.2	25.9	29.9	31.1	39.4	35.9	6.1	11.1	13.0
Standard Deviation						0.0	2.4	2.9	18.0	20.7	21.5	27.3	24.9	4.2	7.7	9.0
CV						0.0	2.73	3.28	22.4	23.48	26.81	39.8	35.87	252.37	9.35	10.94

Potato Timing Study, Montcalm, 2008

Trial ID: P0809 Study Dir.:
Conducted: Montcalm Investigator: Christy Sprague

Trt No.	Treatment Name	Form Conc	Form Type	Rate	Rate Unit	Grow Stg	12	13	14	15	16	17	18	19	20	21
Weed Code							AMARE	POLCO	POLPE	CHEAL	ANGR	POLCO				
Crop Code													SOLTU	SOLTU	SOLTU	SOLTU
Rating Data Type							control	control	control	control	control	control	<1 7/8"	<1 7/8"	oversize	oversize
Rating Unit							percent	percent	percent	percent	percent	percent	kilogram	count	kilogram	count
Rating Date							8/12/09	8/12/09	8/12/09	8/27/09	8/27/09	8/27/09	9/17/09	9/17/09	9/17/09	9/17/09
Trt-Eval Interval							29 DAPO	29 DAPO	29 DAPO	44 DAPO	44 DAPO	44 DAPO	HARVEST	HARVEST	HARVEST	HARVEST
1	0 DAP					0 DAP	90	84	75	25	34	3	4.1090	79.5	0.0000	0
1	Dual Magnum	7.62	L	1	pt/a	0 DAP										
1	Lorox	50	DF	1	lb/a	0 DAP										
2	0 DAP					0 DAP	81	86	98	20	13	33	5.0835	95.4	-0.0210	0
2	Dual Magnum	7.62	L	1	pt/a	0 DAP										
2	Lorox	50	DF	1	lb/a	0 DAP										
2	Sencor	75	DF	0.125	lb/a	0 DAP										
3	0 DAP					0 DAP	99	70	100	75	74	21	4.7985	101.0	0.0827	0
3	Dual Magnum	7.62	L	1	pt/a	0 DAP										
3	Lorox	50	DF	1	lb/a	0 DAP										
3	Matrix	25	WG	1	oz/a	POST										
3	Activator 90		L	0.25	% v/v	POST										
4	0 DAP					0 DAP	100	81	100	98	100	84	5.2125	95.8	0.0000	0
4	Dual Magnum	7.62	L	1	pt/a	0 DAP										
4	Lorox	50	DF	1	lb/a	0 DAP										
4	Sencor	75	DF	0.33	lb/a	POST										
4	Matrix	25	WG	1	oz/a	POST										
4	Activator 90		L	0.25	% v/v	POST										
5	10 DAP					10 DAP	92	100	100	45	32	40	5.5428	96.8	0.0080	0
5	Dual Magnum	7.62	L	1	pt/a	10 DAP										
5	Lorox	50	DF	1	lb/a	10 DAP										
6	10 DAP					10 DAP	90	95	100	38	25	83	4.0943	73.8	0.3505	0
6	Dual Magnum	7.62	L	1	pt/a	10 DAP										
6	Lorox	50	DF	1	lb/a	10 DAP										
6	Sencor	75	DF	0.125	lb/a	10 DAP										
7	10 DAP					10 DAP	98	95	100	90	94	73	4.7293	77.3	0.0000	0
7	Dual Magnum	7.62	L	1	pt/a	10 DAP										
7	Lorox	50	DF	1	lb/a	10 DAP										
7	Matrix	25	WG	1	oz/a	POST										
7	Activator 90		L	0.25	% v/v	POST										
8	10 DAP					10 DAP	100	99	100	98	99	96	6.1605	113.5	0.1588	0
8	Dual Magnum	7.62	L	1	pt/a	10 DAP										
8	Lorox	50	DF	1	lb/a	10 DAP										
8	Sencor	75	DF	0.33	lb/a	POST										
8	Matrix	25	WG	1	oz/a	POST										
8	Activator 90		L	0.25	% v/v	POST										
9	21 DAP					21 DAP	93	98	100	58	40	74	5.1975	92.0	0.0000	0
9	Dual Magnum	7.62	L	1	pt/a	21 DAP										
9	Lorox	50	DF	1	lb/a	21 DAP										
10	21 DAP					21 DAP	93	96	98	35	31	73	4.3950	98.2	-0.0067	0
10	Dual Magnum	7.62	L	1	pt/a	21 DAP										
10	Lorox	50	DF	1	lb/a	21 DAP										
10	Sencor	75	DF	0.125	lb/a	21 DAP										
11	21 DAP					21 DAP	100	100	100	97	96	88	4.8728	86.3	0.1188	0
11	Dual Magnum	7.62	L	1	pt/a	21 DAP										
11	Lorox	50	DF	1	lb/a	21 DAP										
11	Matrix	25	WG	1	oz/a	POST										
11	Activator 90		L	0.25	% v/v	POST										
12	21 DAP					21 DAP	100	97	100	98	100	100	4.5050	178.8	0.0000	0
12	Dual Magnum	7.62	L	1	pt/a	21 DAP										
12	Lorox	50	DF	1	lb/a	21 DAP										
12	Sencor	75	DF	0.33	lb/a	POST										
12	Matrix	25	WG	1	oz/a	POST										
12	Activator 90		L	0.25	% v/v	POST										

Potato Timing Study, Montcalm, 2008

Trial ID: P0809 Study Dir.:
Conducted: Montcalm Investigator: Christy Sprague

Weed Code						AMARE	POLCO	POLPE	CHEAL	ANGR	POLCO				
Crop Code												SOLTU	SOLTU	SOLTU	SOLTU
Rating Data Type						control	control	control	control	control	control	<1 7/8"	<1 7/8"	oversize	oversize
Rating Unit						percent	percent	percent	percent	percent	percent	kilogram	count	kilogram	count
Rating Date						8/12/09	8/12/09	8/12/09	8/27/09	8/27/09	8/27/09	9/17/09	9/17/09	9/17/09	9/17/09
Trt-Eval Interval						29 DAPO	29 DAPO	29 DAPO	44 DAPO	44 DAPO	44 DAPO	HARVEST	HARVEST	HARVEST	HARVEST
Trt No.	Treatment Name	Form Conc	Form Type	Rate	Rate Unit / Grow Stg	12	13	14	15	16	17	18	19	20	21
LSD (P=.05)						11.9	16.5	21.5	23.9	30.0	38.9	1.52143	74.01	0.37215	0.4
Standard Deviation						8.2	11.4	14.9	16.6	20.8	27.0	1.05214	51.18	0.25736	0.3
CV						8.7	12.44	15.26	25.63	33.86	42.32	21.51	51.69	446.97	350.61

Potato Timing Study, Montcalm, 2008

Trial ID: P0809 Study Dir.:
Conducted: Montcalm Investigator: Christy Sprague

Trt No.	Treatment Name	Form Conc	Form Type	Rate	Rate Unit	Grow Stg	22	23	24	25	26	27	28	29
Weed Code														
Crop Code							SOLTU	SOLTU	SOLTU	SOLTU	SOLTU	SOLTU	SOLTU	SOLTU
Rating Data Type							Grade A	Grade A	dry	wet	SPEC. GRAV.	HH	VD	BC
Rating Unit							kilogram	count				0-10	0-10	0-10
Rating Date							9/17/09	9/17/09	9/17/09	9/17/09	9/17/09	9/17/09	9/17/09	9/17/09
Trt-Eval Interval							HARVEST	HARVEST	HARVEST	HARVEST	HARVEST	HARVEST	HARVEST	HARVEST
1	0 DAP					0 DAP	17.6218	177	9.9905	0.7618	1.0822811	0	3	0
1	Dual Magnum	7.62	L	1	pt/a	0 DAP								
1	Lorox	50	DF	1	lb/a	0 DAP								
2	0 DAP					0 DAP	9.7564	76	10.0018	0.7038	1.0754509	0	2	0
2	Dual Magnum	7.62	L	1	pt/a	0 DAP								
2	Lorox	50	DF	1	lb/a	0 DAP								
2	Sencor	75	DF	0.125	lb/a	0 DAP								
3	0 DAP					0 DAP	12.1491	105	8.3798	0.6412	1.0828825	0	3	0
3	Dual Magnum	7.62	L	1	pt/a	0 DAP								
3	Lorox	50	DF	1	lb/a	0 DAP								
3	Matrix	25	WG	1	oz/a	POST								
3	Activator 90		L	0.25	% v/v	POST								
4	0 DAP					0 DAP	10.1738	89	10.1738	0.7810	1.0830363	0	5	0
4	Dual Magnum	7.62	L	1	pt/a	0 DAP								
4	Lorox	50	DF	1	lb/a	0 DAP								
4	Sencor	75	DF	0.33	lb/a	POST								
4	Matrix	25	WG	1	oz/a	POST								
4	Activator 90		L	0.25	% v/v	POST								
5	10 DAP					10 DAP	11.4286	103	9.9506	0.8046	1.0877403	1	3	0
5	Dual Magnum	7.62	L	1	pt/a	10 DAP								
5	Lorox	50	DF	1	lb/a	10 DAP								
6	10 DAP					10 DAP	14.9955	118	9.8053	0.7548	1.0833509	0	4	0
6	Dual Magnum	7.62	L	1	pt/a	10 DAP								
6	Lorox	50	DF	1	lb/a	10 DAP								
6	Sencor	75	DF	0.125	lb/a	10 DAP								
7	10 DAP					10 DAP	16.0698	133	10.1173	0.7670	1.0821638	0	4	0
7	Dual Magnum	7.62	L	1	pt/a	10 DAP								
7	Lorox	50	DF	1	lb/a	10 DAP								
7	Matrix	25	WG	1	oz/a	POST								
7	Activator 90		L	0.25	% v/v	POST								
8	10 DAP					10 DAP	10.1575	105	7.3070	0.5643	1.0836302	0	3	0
8	Dual Magnum	7.62	L	1	pt/a	10 DAP								
8	Lorox	50	DF	1	lb/a	10 DAP								
8	Sencor	75	DF	0.33	lb/a	POST								
8	Matrix	25	WG	1	oz/a	POST								
8	Activator 90		L	0.25	% v/v	POST								
9	21 DAP					21 DAP	13.9338	119	10.7860	0.8130	1.0816194	0	4	0
9	Dual Magnum	7.62	L	1	pt/a	21 DAP								
9	Lorox	50	DF	1	lb/a	21 DAP								
10	21 DAP					21 DAP	11.0737	91	9.7858	0.7223	1.0796920	1	3	0
10	Dual Magnum	7.62	L	1	pt/a	21 DAP								
10	Lorox	50	DF	1	lb/a	21 DAP								
10	Sencor	75	DF	0.125	lb/a	21 DAP								
11	21 DAP					21 DAP	11.4893	94	9.4723	0.7253	1.0831549	0	3	0
11	Dual Magnum	7.62	L	1	pt/a	21 DAP								
11	Lorox	50	DF	1	lb/a	21 DAP								
11	Matrix	25	WG	1	oz/a	POST								
11	Activator 90		L	0.25	% v/v	POST								
12	21 DAP					21 DAP	10.0838	90	10.0838	0.7755	1.0834646	0	4	0
12	Dual Magnum	7.62	L	1	pt/a	21 DAP								
12	Lorox	50	DF	1	lb/a	21 DAP								
12	Sencor	75	DF	0.33	lb/a	POST								
12	Matrix	25	WG	1	oz/a	POST								
12	Activator 90		L	0.25	% v/v	POST								

Potato Timing Study, Montcalm, 2008

Trial ID: P0809 Study Dir.:
Conducted: Montcalm Investigator: Christy Sprague

Weed Code													
Crop Code						SOLTU	SOLTU	SOLTU	SOLTU	SOLTU	SOLTU	SOLTU	SOLTU
Rating Data Type						Grade A	Grade A	dry	wet	SPEC. GRAV.	HH	VD	BC
Rating Unit						kilogram	count				0-10	0-10	0-10
Rating Date						9/17/09	9/17/09	9/17/09	9/17/09	9/17/09	9/17/09	9/17/09	9/17/09
Trt-Eval Interval						HARVEST	HARVEST	HARVEST	HARVEST	HARVEST	HARVEST	HARVEST	HARVEST
Trt No.	Treatment Name	Form Conc	Form Type	Rate	Rate Unit Grow Stg	22	23	24	25	26	27	28	29
LSD (P=.05)						5.26150	44.1	2.08632	0.16638	0.00533230	0.7	2.3	0.2
Standard Deviation						3.63857	30.5	1.44279	0.11506	0.00368753	0.5	1.6	0.1
CV						29.32	28.15	14.94	15.66	0.34	254.61	49.15	692.82

ARM Action Codes

T1 = ([24])/([24]-[25])

Funding: Agrochemical Industry

Seed Treatment Trials 2008-2009.

W. W. Kirk, R. L Schafer and P. Tumbalam
Department of Plant Pathology, Michigan State University, East Lansing, MI 48824

Seed treatments and seed plus foliar treatments for control of seed- and soil-borne Rhizoctonia, 2008.

Potatoes with *Rhizoctonia solani* (black scurf), 2- 5% tuber surface area infected, were selected for the trials. Potato seed 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 Muck Soils Experimental Station, Bath, MI on 4 Jun 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 five-foot unplanted row. Dust formulations were measured and added to cut seed pieces in a Gustafson revolving drum seed treater and mixed for two minutes 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 H2O/A in a 7" 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*. 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 20 Sep). Plots (20-ft row) were harvested on 16 Oct and individual treatments were weighed and graded. Four plants per plot were harvested 10-days after the final treatment application (13 Jul) and the percentage of stems and stolons with greater than 5% of the total surface area were counted. An index of below ground health was evaluated 35 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 Rhizoctonia. 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, latitude 42.8269 and longitude -84.365deg. Maximum, minimum and average daily air temperature (^{o}F) were 81.2, 25.3 and 53.1 and 0-d with maximum temperature >90^{o}F (May); 91.9, 39.6 and 66.7 and 1-d with maximum temperature >90^{o}F (Jun); 89.9, 38.3 and 68.5 and 0-d with maximum temperature >90^{o}F (Jul); 87.9, 35.5 and 65.6 and 0-d with maximum temperature >90^{o}F (Aug); 91.7, 33.3 and 59.3 and 1-d with maximum temperature >90^{o}F (Sep). Maximum, minimum and average daily soil temperature (^{o}F) were 78.0, 41.4 and 58.1 (May); 81.6, 52.6 and 67.7 (Jun); 82.2, 55.8 and 71.1 (Jul); 85.7, 55.2 and 71.4 (Aug); 81.8, 51.6 and 65.3 (Sep). Maximum, minimum and average soil moisture (% of field capacity) 80.2, 74.0 and 76.6 (May); 91.1, 73.5 and 81.5 (Jun); 100.8, 77.0 and 83.2 (Jul); 97.0, 76.5 and 81.0 (Aug); 123.1 (flooding), 76.6 and 84.3 (Sep). Precipitation was 1.08 in. (May), 3.59 in. (Jun), 3.69 in. (Jul), 1.56 in. (Aug) and 7.02 in. (Sep). 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. Seven treatments resulted in significantly improved seed emergence rates 31 DAP (RAUEPC values greater than 14.2) compared to the untreated check (RAUEPC = 9.4). Marketable yield and total ranged from 236 to 324 cwt/A (untreated check = 255 cwt/A) and 265 to 354 cwt/A (untreated check = 288 cwt/A), respectively, but no treatments were significantly different from the untreated check or from the standard commercial seed treatment Maxim FS. No treatment affected the total number of stolons or stem number per plant. Treatments with less than 51.6% incidences of stems with >5% girdling due to Rhizoctonia stem canker were significantly different from the untreated check. No treatments had significantly less stolon canker incidence in comparison to Maxim FS or the untreated check. Treatments resulting in less than 42.5% incidence of tubers with black scurf were significantly lower than the untreated check. Treatments with less than 38.8% incidence of tubers with black scurf were not significantly different from Maxim FS. Treatments with less than 19.1% severity index of tubers with black scurf were significantly lower than the untreated check (29.4%). Treatments with less than 16.3% severity index of tubers with black scurf were not significantly different from Maxim FS (6.3%). Seed treatments and seed treatment plus fungicide applications of fungicides were not phytotoxic.

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])…	84.5	a[x]	11.1	bcd	278	a	310	a
LEM 17 200EC 0.67 fl oz (B)…...	89.0	a	15.1	ab	257	a	286	a
LEM 17 200EC 1.15 fl oz (B)…...	90.5	a	16.6	a	324	a	354	a
LEM 17 200EC 1.6 fl oz (B)……..	91.5	a	14.2	abc	290	a	321	a
LEM 200SC 1.6 fl oz (B)…………	87.5	a	13.6	a-d	280	a	311	a
Quadris 2.08SC 0.4 fl oz (B)……..	87.0	a	14.6	ab	286	a	316	a
Evito 4FL 0.26 fl oz (B)………....	88.0	a	16.9	a	293	a	325	a
BUPOT-1 3.4SC 0.3 fl oz/cwt (A)..	85.5	a	13.2	a-d	317	a	351	a
BUPOT-1 3.4SC 0.5 fl oz/cwt (A)..	89.5	a	12.2	bcd	305	a	337	a
BUPOT-3 3.4SC 0.3 fl oz/cwt (A)..	91.0	a	15.2	ab	264	a	296	a
BUPOT-3 3.4SC 0.5 fl oz/cwt (A)..	85.5	a	10.4	cd	286	a	319	a
BUPOT-5 3.4SC 0.3 fl oz/cwt (A)..	85.0	a	11.3	bcd	254	a	288	a
BUPOT-5 3.4SC 0.5 fl oz/cwt (A)..	89.0	a	10.3	cd	236	a	265	a
BUPOT-7 3.4SC 0.3 fl oz/cwt (A)..	87.5	a	13.0	a-d	270	a	306	a
BUPOT-7 3.4SC 0.5 fl oz/cwt (A)..	88.0	a	13.5	a-d	275	a	307	a
WE1042-1 6DS 0.75 lb/cwt (A)…..	91.0	a	14.4	abc	252	a	284	a
WE1043-1 6DS 0.75 lb/cwt (A)…..	84.5	a	13.4	a-d	270	a	309	a
WE1044-1 6DS 0.75 lb/cwt (A)…..	89.5	a	12.8	a-d	275	a	305	a
Untreated Check………………....	68.0	a	9.4	d	255	a	288	a
$HSD_{0.05}$	14.18		4.26		59.6		61.0	

Treatment and rate/1000 row feet and rate/cwt potato seed[z]	Stems (35 DAP) Num -ber	Stems (35 DAP) Percent infected[w]		Stolons (35 DAP) Num ber/ plant	Stolons (35 DAP) Girdling[v] > 5%		Root and lower stem canker index 35 DAP[u] (0 – 5)		Tuber black scurf Incidence (%)		Tuber black scurf Severity scale (0 - 100)	
Maxim 4FS 0.16 fl oz/cwt (A)……	3.8	31.7	d-g	8.4	6.5	a	1.7	a-e	20	f	6.3	d
LEM 17 200EC 0.67 fl oz (B)…...	3.6	29.5	d-g	7.3	4.5	a	1.3	c-e	35	b-f	12.8	cd
LEM 17 200EC 1.15 fl oz (B)…...	4.1	42.0	cde	7.1	12.4	a	1.5	b-e	42.5	bcd	16.3	bcd
LEM 17 200EC 1.6 fl oz (B)…….	3.8	34.3	def	7.8	9.9	a	1.3	cde	21.3	ef	7.2	d
LEM 200SC 1.6 fl oz (B)………..	3.9	21.0	fg	8.9	7.0	a	1.0	e	37.5	b-f	15.3	bcd
Quadris 2.08SC 0.4 fl oz (B)…….	4.3	16.7	g	9.4	7.6	a	1.1	de	33.8	b-f	12.8	cd
Evito 4FL 0.26 fl oz (B)………....	3.6	24.3	fg	7.7	7.8	a	1.0	e	26.3	def	12.2	cd
BUPOT-1 3.4SC 0.3 fl oz/cwt (A).	4.4	26.8	e-g	7.6	4.1	a	1.4	b-e	22.5	ef	8.8	cd
BUPOT-1 3.4SC 0.5 fl oz/cwt (A).	4.2	63.1	ab	7.1	19.8	a	2.1	ab	25	def	9.1	cd
BUPOT-3 3.4SC 0.3 fl oz/cwt (A).	3.9	51.6	bc	7.8	8.7	a	1.9	a-d	38.8	b-f	14.7	bcd
BUPOT-3 3.4SC 0.5 fl oz/cwt (A).	4.1	55.3	abc	6.9	7.5	a	1.7	a-e	26.3	def	10.0	cd
BUPOT-5 3.4SC 0.3 fl oz/cwt (A).	3.6	33.0	d-f	8.0	4.2	a	1.7	a-e	36.3	b-f	13.8	bcd
BUPOT-5 3.4SC 0.5 fl oz/cwt (A).	4.3	40.9	c-e	7.7	6.3	a	2.3	a	32.5	b-f	12.8	cd
BUPOT-7 3.4SC 0.3 fl oz/cwt (A).	4.2	44.0	cd	8.4	10.5	a	2.0	abc	28.8	c-f	8.8	cd
BUPOT-7 3.4SC 0.5 fl oz/cwt (A).	4.2	33.2	d-f	8.3	9.3	a	1.9	a-d	40	b-e	14.1	bcd
WE1042-1 6DS 0.75 lb/cwt (A)….	3.5	42.1	cde	8.1	8.9	a	1.9	a-d	51.3	ab	24.1	ab
WE1043-1 6DS 0.75 lb/cwt (A)….	3.8	41.4	cde	7.6	11.5	a	1.8	a-d	36.3	b-f	15.0	bcd
WE1043-1 6DS 0.75 lb/cwt (A)….	3.9	30.8	d-f	8.9	9.2	a	1.7	a-e	46.3	abc	19.1	abc
Untreated Check………………....	4.6	71.7	a	9.5	15.9	a	2.3	a	65.0	a	29.4	a
$HSD_{0.05}$	1.10	15.81		1.95	10.05		0.75		19.96		10.33	

[z] RAUEPC = Relative area under the emergence progress curve measured from planting to 31 days after planting
[y] Application dates: A= 4 Jun (liquid formulations for seed piece application at 0.2 pt/cwt; B= 4 Jun (in-furrow); C= 29 Jun (banded over row).
[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)

Seed treatments and seed plus foliar treatments for control of seed- and soil-borne Rhizoctonia, 2009.

Potatoes with *Rhizoctonia solani* (black scurf), 2- 5% tuber surface area infected, were selected for the trials. Potato seed was prepared for planting by cutting and treating with fungicidal seed treatments two days prior to planting. Seed was planted at the Michigan State University Muck Soils Experimental Station, Bath, MI on 4 Jun 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. Due to flooding (see meteorological data below) the plots were destroyed and replanted on 8 Jul. The two-row beds were separated by a five-foot unplanted row. Dust formulations were measured and added to cut seed pieces in a Gustafson revolving drum seed treater and mixed for two minutes 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 H2O/A in a 7” band using a single XR11003VS nozzle at 30 p.s.i. Foliar applications of Previcur Flex 0.7 pt/A + Bravo WS 6SC 1.5 pt/A were applied for maintenance on a 7-day schedule from 10 Aug to 15 Sep 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). 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 48 DAP. Insects were controlled with Admire 2F at 1.25 pt/A at planting (except where CruiserMaxx and Valent formulations were applied), Sevin 80S at 1.25 lb/A 31 and 55 DAP, Thiodan 3 EC at 2.33 pt/A 65 DAP and Pounce 3.2EC at 8 oz/A 48 DAP. Vines were killed with Reglone 2EC (1 pt/A on 20 Sep). Plots (20-ft row) were harvested on 16 Oct however there was insufficient tuber development to justify yield analyses. Four plants per plot were harvested 105 DAP and the percentage of stems and stolons with greater than 5% of the total surface area were counted. An index of below ground health was evaluated 35 DAP on a scale of 0 - 5 where 0 = no symptoms of stem canker, 1 = 1 – 10%, 2 = 11 – 20%, 3 = 21 – 30%, 4 = 31 – 50%, 5 = 51 – 100% of the surface of roots, stolons and stem affected by Rhizoctonia calculated by adding the % incidence and % severity and dividing by 2. Samples of 20 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 in 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, latitude 42.8269 and longitude -84.365deg. Maximum, minimum and average daily air temperature (^{o}F) were 84.2, 28.9 and 55.9 and 0-d with maximum temperature >90^{o}F (May); 95.8, 35.9 and 64.9 and 2-d with maximum temperature >90^{o}F (Jun); 82.9, 40.1 and 64.2 and 0-d with maximum temperature >90^{o}F (Jul); 91.5, 37.4 and 67.0 and 2-d with maximum temperature >90^{o}F (Aug); 83.1, 31.8 and 60.4 and 0-d with maximum temperature >90^{o}F (Sep); 62.7, 23.8 and 44.5 and 0-d with maximum temperature >90^{o}F (to 15 Oct). Maximum, minimum and average daily soil temperature (^{o}F) were 68.1, 47.4 and 57.9 (May); 78.7, 55.9 and 66.6 (Jun); 73.3, 61.4 and 67.4 (Jul); 75.6, 59.7 and 69.2 (Aug); 68.4, 55.9 and 63.6 (Sep); 56.3, 45.6 and 51.8^{o}F (to 15 Oct). Maximum, minimum and average soil moisture (% of field capacity) 77.2, 62.4 and 66.9 (May); 77.0, 60.8 and 67.2 (Jun); 76.7, 58.2 and 63.7 (Jul); 75.0, 55.1 and 61.7 (Aug); 58.7, 52.1 and 54.2 (Sep); 57.4, 52.5 and 54.5^{o}F (to 15 Oct). Precipitation was 2.98 in. (May), 5.76 in. (Jun), 5.62 in. (Jul), 5.25 in. (Aug), 1.09 in. (Sep) and 1.25 in. to 15 Oct. Plots were irrigated to supplement precipitation to about 0.1 in./A/4 day period with overhead sprinkle irrigation.

The plots were flooded in Jun due to extensive rainfall. Seed tubers were treated and plots were replanted on 8 Jul after the soil had dried sufficiently. The plots flooded again in late Jul and again in mid Aug. Emergence was reduced by these events. The final plant stand in the untreated control (63.0%) was not significantly different from any of the treatments, which ranged from 63.0 to 76.5%. No significant differences in seed emergence at 31 DAP (RAUEPC values ranged from 21.5 to 31.2 with the untreated control = 21.5), were observed. Marketable yield and total yield were not measured due to insufficient development of tubers. Only Maxim had significantly greater stems/plant in comparison to the untreated control (5.0 stems/plant) and LEM17 200EC 1.63 fl oz had significantly fewer. No differences were found among the treatments in terms of stolon number per stem, which ranged from 7.6 to 10.6; (untreated control = 7.9). All treatments had significantly lower incidence of stems with >5% girdling due to Rhizoctonia stem canker in comparison to the untreated control (71.2%). All treatments had significantly less stolon canker in comparison to the untreated control (61.5%). Treatments resulting in greater than 43.3% stems/plant girdled had significantly higher canker incidence in comparison to Maxim MZ, the standard commercial seed treatment (34.4%). The overall severity index of root and lower stem canker indicated that treatments with an index value lower than 4.3 had significantly less Rhizoctonia stem and stolon canker than the untreated control (4.9). No treatments had significantly less Rhizoctonia stem and stolon canker in comparison with Maxim MZ (3.4). Two treatments (LEM17 200EC 1.63 fl oz and YT6692.08SC 0.85 fl oz) resulted in significantly lower tuber black scurf incidence than the use of Quadris. Only one treatment (Actinovate) showed no significant reduction in tuber black scurf incidence relative to the untreated control. The severity of tuber black scurf in all treatments was significantly less than in the untreated control (37.8%). No treatments were significantly different in comparison to Maxim MZ (19.7). No phytotoxicity was observed in any treatment.

Funding: Agrochemical Industry

Treatment rate/cwt potato seed (A)[z] and rate/1000 row feet (B)	Final plant stand (%)		RAUEPC[y]		Stem number/plant		Stolon number/stem	
LEM17 200EC 0.72 fl oz (B[x])………	70.0	a[w]	22.8	a	5.4	bc	9.9	a
LEM17 200EC 1.63 fl oz (B)……….	72.0	a	31.2	a	3.8	d	8.1	a
LEM17 200EC 3.26 fl oz (B)……….	76.5	a	28.7	a	4.7	cd	10.0	a
YT669 2.08SC 0.85 fl oz (B)……….	72.0	a	26.7	a	4.8	bcd	10.6	a
YT669 2.08SC 1.27 fl oz (B)……….	69.0	a	24.4	a	4.6	cd	10.1	a
LEM17 200EC 1.25 fl oz (A)……….	70.0	a	26.5	a	4.9	bcd	8.9	a
Quadris 2.08SC 0.576 fl oz (B)……..	71.0	a	21.9	a	5.8	b	9.2	a
Maxim MZ 10.1DS 0.5 lb (A)………	71.0	a	27.1	a	7.2	a	9.9	a
Actinovate 0.0371WP 0.103 oz (B)…	66.5	a	27.6	a	4.6	cd	7.6	a
Untreated Control…………………...	63.0	a	21.5	a	5.0	bc	7.9	a
$LSD_{0.05}$	7.97		8.44		1.11		2.24	

Treatment rate/cwt potato seed (A)[z]	Percent stem girdling[v] >5%		Percent stolon girdling[u] > 5%		Root and lower stem canker index 35 DAP[t] (0 – 5)		Tuber black scurf Incidence (%)		Tuber black scurf Severity scale (0 - 100)	
LEM17 200EC 0.72 fl oz (B)……….	39.0	cd	47.1	bc	4.1	bc	48.8	bc	17.5	bc
LEM17 200EC 1.63 fl oz (B)……….	44.8	bc	31.6	d	3.8	cd	42.5	c	14.7	c
LEM17 200EC 3.26 fl oz (B)……….	37.7	cd	31.9	d	3.8	cd	46.3	bc	19.1	bc
YT669 2.08SC 0.85 fl oz (B)……….	50.0	b	40.5	c	4.3	b	40.0	c	15.6	c
YT669 2.08SC 1.27 fl oz (B)……….	50.5	b	47.5	bc	4.3	b	47.5	bc	19.4	bc
LEM17 200EC 1.25 fl oz (A)……….	46.7	bc	49.8	b	4.3	b	47.5	bc	20.0	bc
Quadris 2.08SC 0.041 fl oz (B)……..	43.3	bcd	39.9	c	3.8	cd	57.5	b	24.1	b
Maxim MZ 10.1DS 0.5 lb (A)………	34.4	d	25.1	d	3.4	d	47.5	bc	19.7	bc
Actinovate 0.0371WP 0.103 oz (B)…	44.7	bc	27.3	d	3.8	cd	60.0	ab	23.4	b
Untreated Control…………………...	71.2	a	61.5	a	4.9	a	73.8	a	37.8	a
$LSD_{0.05}$	9.12		8.03		0.39		12.91		6.51	

[z] Application type; rate per 1000 row ft for in-furrow applications; rate per cwt of potato seed-piece application prior to planting; liquid formulations for seed piece application at 0.2 pt/cwt.
[y] RAUEPC = Relative area under the emergence progress curve measured from planting to 31 days after planting.
[x] Application dates: A= 8 Jul (liquid formulations for seed piece application at 0.2 pt/cwt); B= 8 Jul (in-furrow).
[w] Values followed by the same letter are not significantly different at $p = 0.05$ (Fishers LSD).
[v] Stems with greater than 5% of area with stem canker due to *Rhizoctonia solani*.
[u] Stolons with greater than 5% of area with stolon canker due to *Rhizoctonia solani*.
[t] An index of below ground health was evaluated 35 DAP on a scale of 0 - 5 where 0 = no symptoms of stem canker, 1 = 1 – 10%, 2 = 10 – 20%, 3 = 21 – 30%, 4 = 31 – 50%, 5 = 51 – 100% of the surface of roots, stolons and stem affected by Rhizoctonia.

A.S. Grandy
MPIC
2009 Research Report

Long-Term Research: Simultaneous Management of Disease Suppression and Soil Quality in Potatoes

Introduction Potato cropping systems present two fundamental challenges: maintaining soil quality and keeping plant diseases below economic thresholds. We believe that these challenges are intertwined and that declines in organic matter and biological function may contribute to increased severity of soil diseases, such as potato common scab (*Streptomyces scabies*). Diseases are ubiquitous in Michigan potato production systems and their effects on yield or quality can be dramatic. Organic amendments, such as compost or manure, can build soil quality and may provide an additional line of defense against disease. Organic amendment applications, especially in sandy soils used to produce potatoes and many other vegetable crops have been shown to suppress a range of common plant diseases. Michigan potato producers have begun using compost and manure to build organic matter and associated functions but there has, to date, been little research on optimizing compost or manure application rates, timing, and quality to increase soil health and maximize yields and income. The key to broader deployment of these soil-building practices is to demonstrate their advantages and develop specific, economical recommendations for their use. My overall objective in 2009 was to examine the effects of different organic amendment application rates on soil quality, disease, and yield.

Approach In 2009, we initiated a study investigating 7 different treatments (Table 1). The first set of treatments (treatments 1-3) receives a total of 6.8 tons of amendment C ha^{-1} (Herbruck chicken manure compost) during the experiment. This C is applied once (treatment 1), two (treatment 2), or four applications (treatment 3). Treatments 4-6 receive 13.6 tons of amendment C ha^{-1} applied at different frequencies, similar to treatments one through three. The seventh treatment is a control that receives no organic amendments. Plot management conforms to Michigan State University recommendations and the amendment is a chicken manure-based product from Herbruck's, one of the primary suppliers to the MI potato industry. The site that we initiated this experiment on in 2009 has heavy scab pressure. In 2009 there was only one amendment application so soil and crop responses to the frequency of amendment applications cannot be assessed yet.

Results and Discussion

We found that aged chicken manure increased yields relative to the control (Figure 1). The highest yields were associated with the highest application rates. Treatments 1 (6.8 ton C ha^{-1}), 4 (13.6 ton C ha^{-1}) and 5 (6.8 ton C ha^{-1}) had the highest yields of potatoes and also the highest amendment application rates. Some of the lower manure application rates gave marginally higher yields than the control treatment but the experiment needs to be repeated to confirm if these trends are stable through different environmental conditions. We also found that the lowest scab incidence was associated with treatments 1, 4, and 5 but the lower application rates had little effect on scab or vascular discoloration (Figure 2). In contrast, vascular discoloration seemed marginally higher in the treatments with the highest application rates.

Table 1. Organic amendment treatments that we use in the amendment rate x timing study at the Montcalm Research Farm. The potato variety that we use is Snowden.

Treatment	Rate of amendment addition	Total number of applications	Timing of amendment applications	Total C addition over entire experiment
	ton C ha^{-1}			ton C ha^{-1}
1	6.8	1	1) Initiation (early spring year 1)	6.8
2	3.4	2	1) Initiation (early spring year 1); 2) after wheat harvest (year 2)	6.8
3	1.7	4	1) Initiation (early spring year 1); 2) after potato harvest (year 1); 3) after wheat harvest (year 2); 4) prior to potato planting (year 3)	6.8
4	13.6	1	same as above for 1 application	13.6
5	6.8	2	same as above for 2 applications	13.6
6	3.4	4	same as above for 4 applications	13.6
Control (7)	0	0	.	0

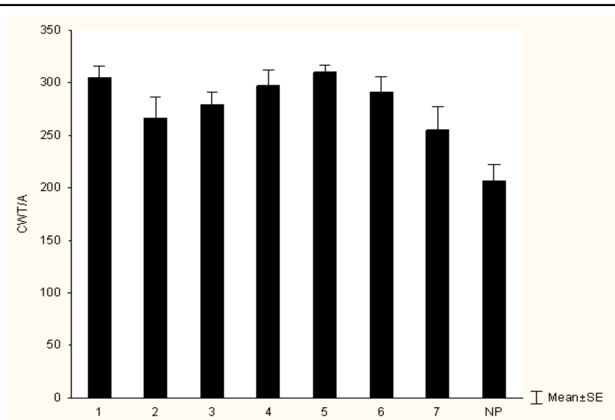


Figure 1. Amendment effects on potato crop yield. See Table 1 for description of treatments. NP is an unfertilized treatment while treatment 7 is the conventionally managed control.

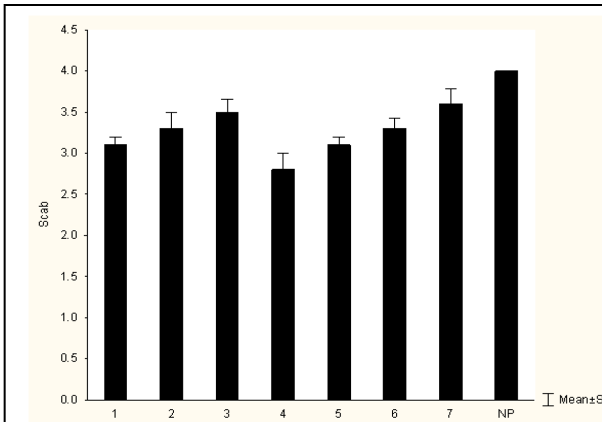


Figure 2. Amendment effects on potato scab. See table 1 for description of treatments. NP is an unfertilized treatment while treatment 7 is the conventionally managed control.

Soil inorganic nitrogen, both ammonium and nitrate, were generally increased by organic amendments (Figure 3). In August, 2009, the highest soil nitrate and ammonium concentrations were found in treatment 4. Higher levels of nitrate were found in all of the amended treatments relative to the control and ammonium concentrations were also quite a bit higher in all of the amended treatments except treatment 3. It is likely that the organic amendment provides a source of N that begins mineralizing in June when the soil temperature is substantially warmer and continues releasing N during the growing season provided that supply is not exhausted and there is an adequate supply of soil water.

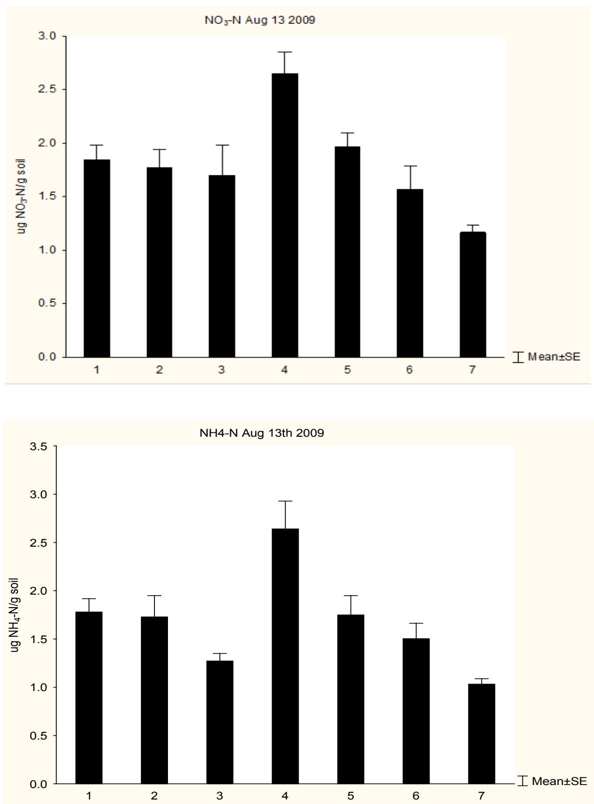


Figure 3. Organic amendment effects on soil nitrate (top) and ammonium (bottom). See Table 1 for treatment details.

Soil biological processes were increased by amendment application but the extent of the increase varied. The highest microbial biomass carbon was found in treatment 5 and the highest microbial biomass nitrogen in treatments 4 and 5 (Figure 4). However, all of the treatments, except 1 and 2, exhibited higher microbial biomass nitrogen than the control. We also found that amendments tended to increase amendment soil enzyme activities but, interestingly, these increases were erratic (Figure 5). The highest application rate, treatment 4, exhibited consistently lower enzyme activities than some of the other amended treatments.

We are in the process of analyzing data from the rest of the summer. It is too early to make any definitive conclusions from the limited data set we present here. In general, it appears that organic amendments applied at high rates can increase yields and decrease scab despite increasing pH. Indeed, the pH differences among the sites is interesting and we need to go and look more closely at whether these large differences occur throughout the season in response to amendments or whether the one date presented here is an anomaly (Figure 6). The greater microbial biomass carbon and nitrogen and higher enzyme activities in the amended plots suggest that this product does have the potential to significantly enhance soil biological activity. More research is needed to determine whether changes in soil nitrogen, biological activity, or some other factor resulted in the yield differences that we measured.

We began this experiment in part wanting to determine whether low rates of organic amendment application could improve soil quality and yields. It is clear from this study that very high rates of application can improve soil quality and increase potato yields, at least in the short term. It is less clear from the limited data that we currently have available whether or not very low rates of application improve soil quality and yields. While there are indications that low application rates are nudging soils and yields in a positive direction it is too early tell what the long-term implications will be. One key question is whether long-term low application rates can result in the kind of differences we see in the short term with higher rates.

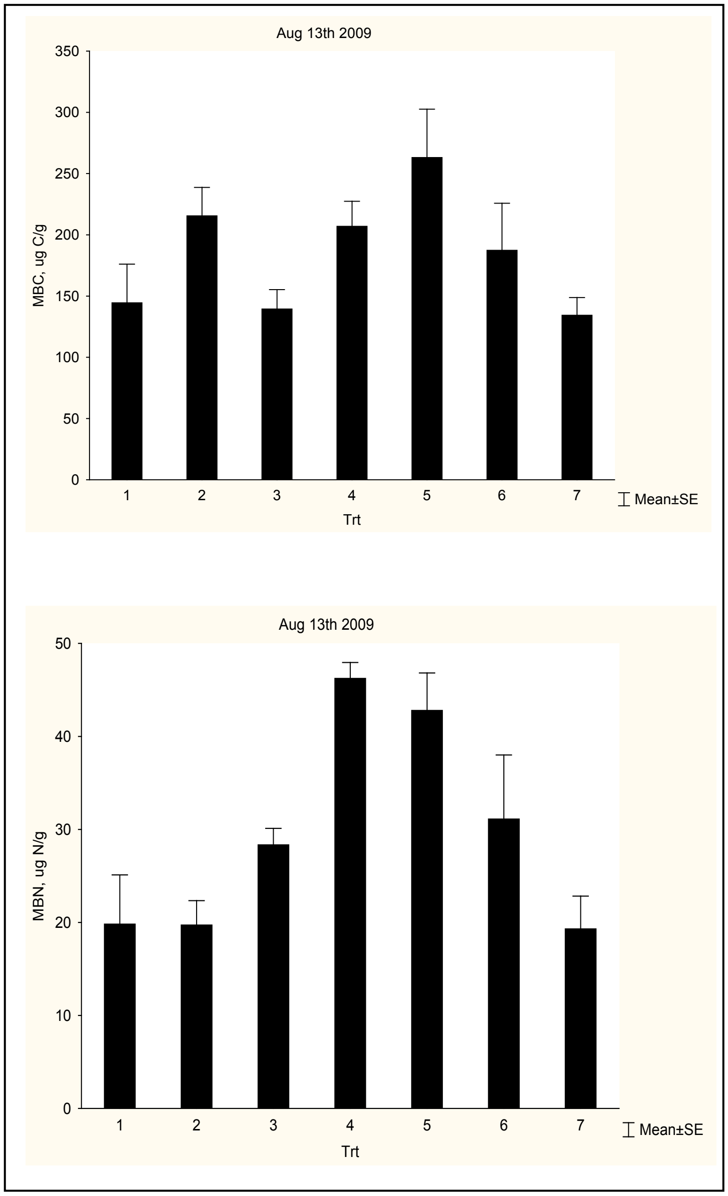


Figure 4. Amendment effects on microbial biomass carbon (top) and nitrogen (bottom). See Table 1 for amendment treatments.

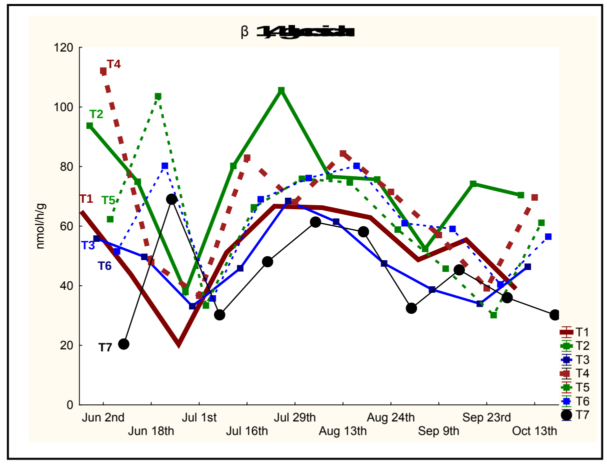


Figure 5. Amendment effects on soil enzymes. See Table 1 for amendment treatments.

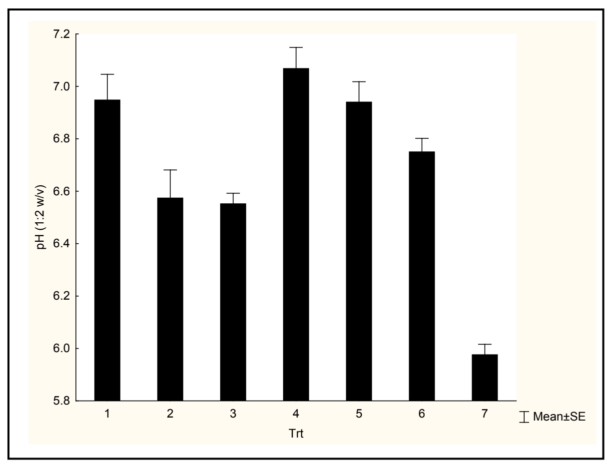


Figure 6. Amendment effects on pH. See Table 1 for amendment treatments.

Potato Insect Biology and Management

Report to the Michigan Potato Industry Commission
14 January 2010

Adam M. Byrne, Walter L. Pett, Zsofia Szendrei, and Edward J. Grafius

Outline.

I. Resistance to Colorado potato beetle populations to imidacloprid and thiamethoxam was evaluated for field populations from Michigan, as well as other locations in the Midwest and locations in the northeastern U.S.

II. Field insecticide evaluations of registered and experimental insecticides.

I. Resistance of Colorado potato beetle populations to imidacloprid and thiamethoxam.

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 objectives were 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. A second objective was to monitor the correlations between imidacloprid and thiamethoxam susceptibility. To accomplish these objectives, 27 Colorado potato beetle populations (13 Michigan populations, 12 populations collected in other states, and two laboratory populations) were bioassayed with imidacloprid and/or thiamethoxam.

Methods

During 2009, 13 Colorado potato beetle populations were collected from four Michigan counties (Isabella, Kalkaska, Mecosta, and Montcalm). Cooperators also provided single populations from Delaware, Minnesota, and New York; two populations from Maine and Virginia; and five populations from Wisconsin. Two laboratory strains were also tested (Table I.1).

Colorado potato beetle adults were either kept at room temperature (25±1° C) and fed foliage daily or, for longer term storage, kept in controlled environment chambers (11±1° C) and fed weekly. A preliminary screen was conducted on some populations (for populations tested in previous years, screening was sometimes not necessary) to determine relative susceptibility to imidacloprid and thiamethoxam by testing 15 beetles each with one concentration of insecticide/acetone solution. Based on the results from these screens, a range of five concentrations was selected for each population to be assayed and each bioassay was replicated up to three times. In each replicate, 7-15 beetles were treated with each concentration (three to five beetles per dish and two to three dishes per concentration).

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. 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® System v9.1.3, SAS Institute 2006).

Results

The imidacloprid LD_{50} value (dose lethal to 50% of the beetles) for the susceptible laboratory strain (New Jersey) was 0.065 µg/beetle (Table I.2), slightly higher but still statistically similar to values from previous years. The LD_{50} values from the field for imidacloprid ranged from 0.403 µg/beetle (overwintered adults from Andersen Brothers field 41) to 2.297 µg/beetle (Paul Main field R5) for Michigan populations (Figure I.1) and from 0.069 µg/beetle (Crookston, MN) to 4.981 µg/beetle (Delaware, DE) for out-of-state populations (Figure I.2A, Table I.2).

Significant levels of resistance to imidacloprid were again present in Michigan. All but one Michigan population tested was greater than 10-fold resistant to imidacloprid; between 10 and 20-fold is often where control problems begin to appear in the field. The proportion of Michigan samples showing greater than 10-fold resistance to imidacloprid was down slightly from 90% in 2008 to 85% in 2009. However, all samples had significantly higher LD_{50} values than the susceptible New Jersey strain.

A population from Delaware again showed very high levels of resistance to imidacloprid, consistent with findings from previous years. Populations tested from Maine and Virginia were less than 10-fold resistant, but still differed significantly from the susceptible; the lone Minnesota population tested was susceptible. The Wisconsin populations submitted to us for testing did not show high levels of resistance this season. However, elevated levels of resistance are still present in some areas of Wisconsin (pers. comm. Russell Groves, University of Wisconsin), but overall values remain lower than those recorded in Michigan.

The thiamethoxam LD_{50} value for the susceptible laboratory strain (New Jersey) was 0.038 µg/beetle (Table I.3). The LD_{50} values for thiamethoxam ranged from 0.135 µg/beetle (overwintered adults from Andersen Brothers field 41) to 0.374 µg/beetle (Sackett Potatoes fields 154-155) for Michigan populations (Figure I.3) and from 0.048 µg/beetle (overwintered adults from Aroostook, ME) to 0.928 µg/beetle (Delaware, DE) for out-of-state populations (Figure I.2.B, Table I.3).

As in 2008, no Michigan populations had greater than 10-fold resistance to thiamethoxam. However, as in 2008, all populations tested had LD_{50} values significantly higher than the susceptible New Jersey strain, up from 88% in 2007.

Susceptibility to imidacloprid (as measured by LD_{50}) in field-collected Colorado potato beetle populations was highly correlated with susceptibility to thiamethoxam (r^2=0.73, Figure I.4). This result was also found in previous years (e.g. Grafius et al. 2004, 2005; Byrne et al. 2006, 2007, 2008). This high correlation is a strong indicator that alternation between imidacloprid and thiamethoxam would not be an effective or wise resistance management strategy.

The NY-Sel laboratory strain has been selected for imidacloprid resistance. Adults from most generations were selected with imidacloprid doses causing 38-88% mortality. Survivors from selections were used to maintain the laboratory strains. Bioassays were conducted roughly every fourth generation, allowing us to follow resistance development under a high selection pressure scenario. The imidacloprid LD_{50} value for the NY-Sel was 9.957 µg/beetle, greater than 150-fold resistant, compared to the susceptible New Jersey strain.

Table I.1. Colorado potato beetle populations tested for susceptibility to imidacloprid and thiamethoxam in 2009.

Michigan populations
Andersen Brothers Farm Adults were collected by Mark Otto, Agri-Business Consultants, Inc. from commercial potato fields in Montcalm and Isabella Counties, MI.
Field 2 Summer adults were collected on 1 August 2009. Source of beetles was overwintered adults from field 5 in Montcalm County that migrated to field 2.
Field 41 Overwintered adults were collected on 19 June 2009 and summer adults on 1 August 2009 by Mark Otto, Agri-Business Consultants, Inc. from commercial potato field in Isabella County, MI.
Kalkaska Summer adults were collected on 12 August 2009 by Russ Tiller, Bayer CropScience, from a commercial potato field in Excelcior Twp., Kalkaska County, MI.
Montcalm Farm Summer adults were collected on 22 July 2009 from untreated potatoes at the Michigan State University Montcalm Potato Research Farm, Entrican, MI.
Paul Main Farm Adults were collected by Mark Otto, Agri-Business Consultants, Inc. from commercial potato fields in Mecosta County.
Field R5 Summer adults were collected on 30 August 2009. Source of beetles was overwintered beetles that probably migrated from R11 and reproduced in R5.
Field R6 Summer adults were collected on 6 August 2009. Source of beetles was overwintered beetles from R17 that reproduced in R6.
Sackett Potatoes Adults were collected by Mark Otto, Agri-Business Consultants, Inc., and Michigan State University researchers from commercial potato fields in Mecosta and Montcalm Counties, MI.
Fields 2&30 Overwintered adults were collected on 11 June 2009.
Field 5&8 Summer adults were collected on 12 August 2009.
Field 15 Overwintered adults were collected on 15 June 2009.
Field 75 Summer adults were collected on 12 August 2009.
Field 103 Summer adults were collected on 11 August 2009.
Fields 151&155 Overwintered adults were collected on 15 June 2009.
Fields 154-155 Summer adults were collected on 12 August 2009.
Out-of-state populations
Arlington, Wisconsin Summer adults were collected on 15 July 2009 by Russell Groves, University of Wisconsin, from potatoes at the Arlington Agricultural Experiment Station, Arlington, WI.
Aroostook, Maine Overwintered adults were collected on 23 June 2009 and summer adults on 20 August 2009 by Gary Sewell, University of Maine, from untreated potato research plots near Presque Isle, ME.
Coloma, Wisconsin Overwintered adults were collected on 17 June 2009 by Russell Groves, University of Wisconsin, from a commercial potato field in Coloma, WI.
Crookston, Minnesota Overwintered adults were collected on 23 June 2009 by Ian MacRae, University of Minnesota, from an untreated potato field near Crookston, MN.
Delaware, Delaware Summer adults were collected on 3 August 2009 by Joanne Whalen, University of Delaware, from a commercial potato field near Little Creek, DE, treated at planting with Platinum ® and with foliar application of SpinTor ®.

Table I.1. cont'd. Colorado potato beetle populations tested for susceptibility to imidacloprid and thiamethoxam in 2009.

<u>*Fryeburg, Maine*</u> Summer adults were collected on 13 August 2009 by Megan Patterson, from a commercial, organic potato field near Fryeburg, ME, treated with Entrust ® and Pyganic ®.
<u>*Hancock Field C-19, Wisconsin*</u> Overwintered adults were collected on 17 June 2009 by Russell Groves, University of Wisconsin, from potato research plots in Hancock, WI.
<u>*Hancock West Field H-53, Wisconsin*</u> Overwintered adults were collected on 15 June 2009 by Russell Groves, University of Wisconsin, from a commercial potato field near Hancock, WI.
<u>*Jamesport, New York*</u> Overwintered adults were collected on 27 May 2009 by Sandra Menasha, Cornell Cooperative Extension, from a commercial potato field in Suffolk County, NY that was treated at planting with Admire ® (0.35 fl oz/A) and with foliar applications of SpinTor ® and Kryocide ®.
<u>*New Church, Virginia*</u> Overwintered adults were collected on 15 May 2009 by Tom Kuhar, Virginia Polytechnic Institute and State University, from a commercial potato field near New Church, VA that was treated with Platinum ® and Regent ® at planting.
<u>*Painter, Virginia*</u> Overwintered adutls were collected on 12-13 May 2009 by Tom Kuhar, Virginia Polytechnic Institute and State University, from a potato field in Painter, VA that was treated with Platinum ® at planting.
<u>*Plover, Wisconsin*</u> Overwintered adults were collected on 24 June 2009 by Russell Groves, University of Wisconsin, from a commercial potato field near Plover, WI.
Laboratory strains
<u>*New Jersey*</u> 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
<u>*NY-Select*</u> Collected from Long Island, NY in 1997. Adults from most generations selected with imidacloprid doses targeting 60-80% mortality.

Table I.2. LD_{50} values (µg/beetle) and 95% fiducial limits for Colorado potato beetle populations treated with imidacloprid at 7 days after treatment.

	LD_{50}	95% fiducial limits
Michigan populations		
Andersen Brothers Field 2	0.555[1]	0.420-0.769
Andersen Brothers Field 41 (winter)	0.403[1]	0.333-0.503
Andersen Brothers Field 41 (summer)	1.988[2]	1.307-3.245
Kalkaska	0.972[2]	0.798-1.241
Montcalm	0.555[1]	0.420-0.758
Paul Main Farm		
Field R5	2.297[2]	1.859-3.198
Field R6	1.067	*
Sackett Potatoes		
Fields 2&30	0.470[1]	0.395-0.581
Fields 5-8	1.382[2]	1.041-1.762
Field 15	0.706[2]	0.632-0.783
Field 75	2.139[2]	1.645-2.784
Field 103	1.006[2]	0.878-1.143
Fields 151&155	0.697[2]	0.563-0.818
Fields 154-155	1.392[2]	1.023-1.861
out-of-state populations		
Arlington, WI	0.089	*
Aroostook, ME (winter)	0.086	0.069-0.111
Aroostook, ME (summer)	0.181[1]	0.149-0.223
Coloma, WI	0.195[1]	0.095-0.289
Crookston, MN	0.069	0.061-0.079
Delaware, DE	4.981[2]	4.146-5.986
Fryeburg, ME	1.985[1]	1.539-2.734
Hancock C-19, WI	0.347[1]	0.143-0.486
Hancock H-53, WI	0.437[1]	0.377-0.504
Jamesport, NY	1.924[2]	1.635-2.287
New Church, VA	0.327[1]	0.255-0.425
Plover, WI	0.551	*
laboratory strains		
New Jersey	0.065	0.054-0.076
NY-Sel	9.957[2]	6.568-16.476

[1] significantly greater than LD_{50} value for susceptible New Jersey strain
[2] greater than 10 times the LD_{50} value for susceptible New Jersey strain

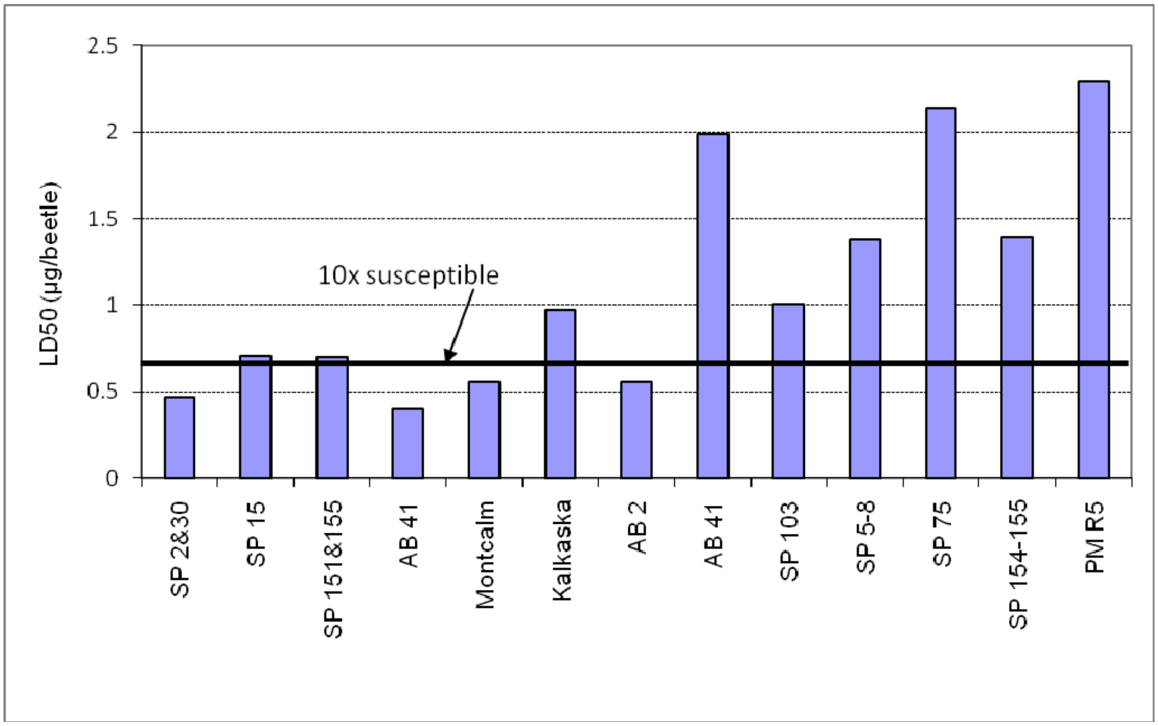
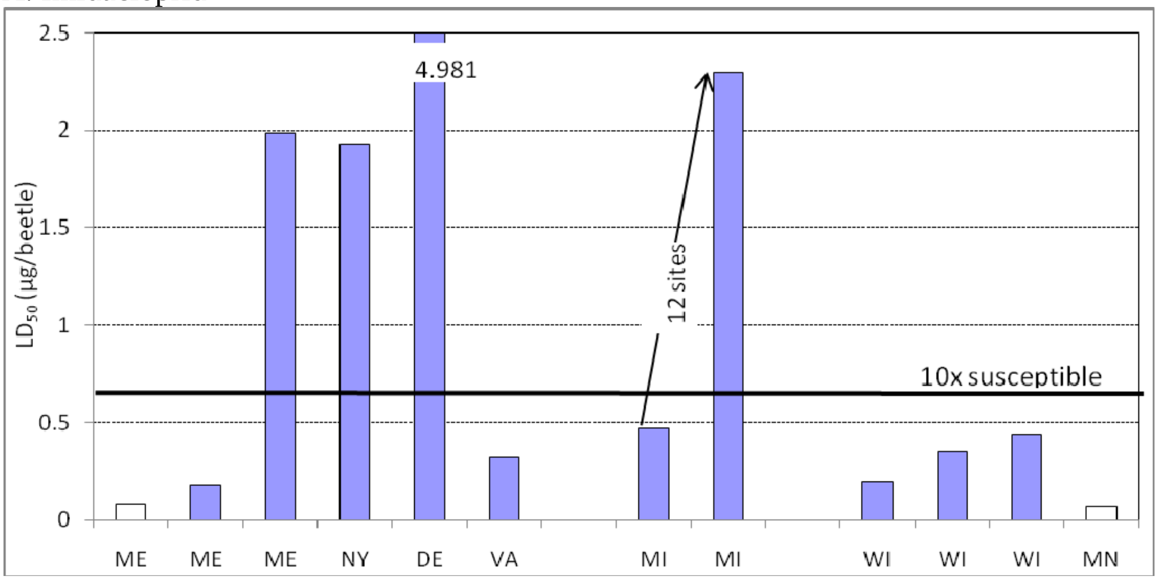


Figure I.1. Susceptibility of Michigan field populations of Colorado potato beetle to imidacloprid. Colored bars represent LD_{50} values that were significantly greater than the LD_{50} value of the susceptible strain. Populations are arranged by collection date, the first four samples represent overwintering populations, the remaining samples were from the summer generation.

A. Imidacloprid



B. Thiamethoxam

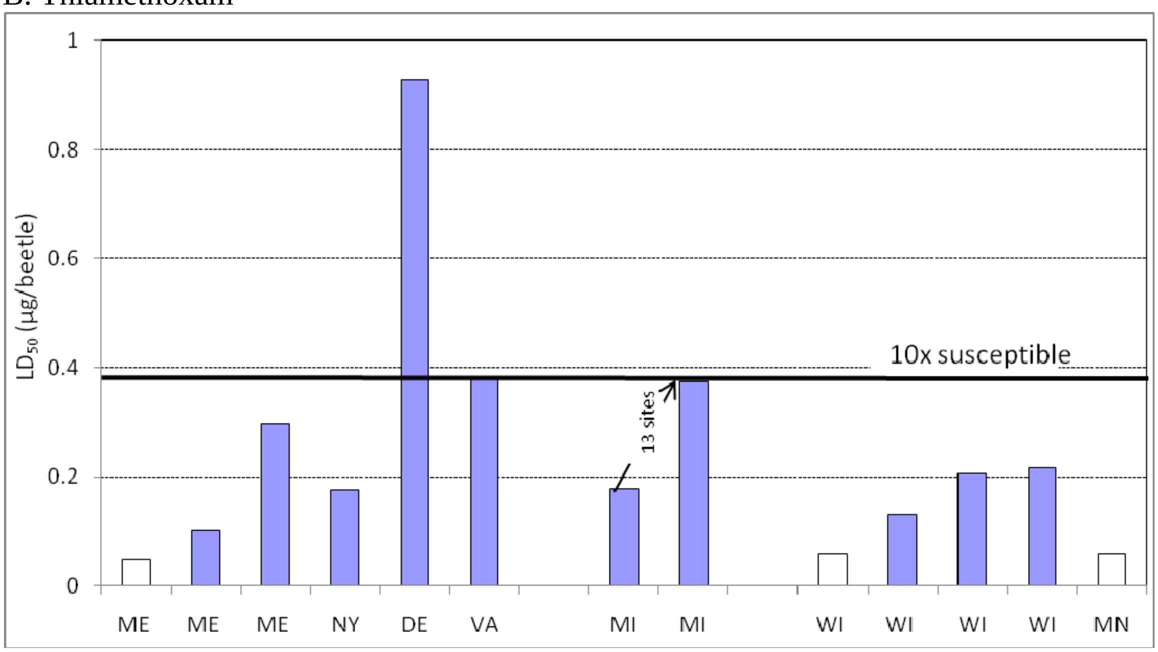


Figure I.2. Susceptibility of field populations of Colorado potato beetle to imidacloprid (A) and thiamethoxam (B). Michigan values represented as a range from lowest to highest value. Colored bars represent LD_{50} values that were significantly greater than the LD_{50} value of the susceptible strain.

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

	LD_{50}	95% fiducial limits
Michigan populations		
Andersen Brothers Field 2	0.177[1]	0.142-0.220
Andersen Brothers Field 41 (winter)	0.135[1]	0.118-0.156
Andersen Brothers Field 41 (summer)	0.361[1]	0.306-0.428
Kalkaska	0.189[1]	0.163-0.224
Montcalm	0.211[1]	0.172-0.264
Paul Main Farm		
Field R5	0.322[1]	0.261-0.388
Field R6	0.266[1]	0.197-0.324
Sackett Potatoes		
Fields 2&30	0.189[1]	0.165-0.216
Fields 5-8	0.255[1]	0.220-0.292
Field 15	0.157[1]	0.104-0.220
Field 75	0.242[1]	0.203-0.283
Field 103	0.259[1]	0.215-0.306
Fields 151&155	0.263[1]	0.217-0.315
Fields 154-155	0.374[1]	0.319-0.440
out-of-state populations		
Arlington, WI	0.059	0.044-0.077
Aroostook, ME (winter)	0.048	0.031-0.125
Aroostook, ME (summer)	0.101[1]	0.078-0.141
Coloma, WI	0.129[1]	0.093-0.165
Crookston, MN	0.058	0.051-0.067
Delaware, DE	0.928[2]	0.755-1.161
Fryeburg, ME	0.297[1]	0.148-2.563
Hancock C-19, WI	0.206[1]	0.176-0.243
Hancock H-53, WI	0.217[1]	0.171-0.281
Jamesport, NY	0.175[1]	0.129-0.217
New Church, VA	0.380[1]	0.323-0.453
Painter, VA	0.026	*
laboratory strains		
New Jersey	0.038	0.017-0.064
NY-Sel	0.264[1]	0.220-0.313

[1] significantly greater than LD_{50} value for susceptible New Jersey strain
[2] greater than 10 times the LD_{50} value for susceptible New Jersey strain

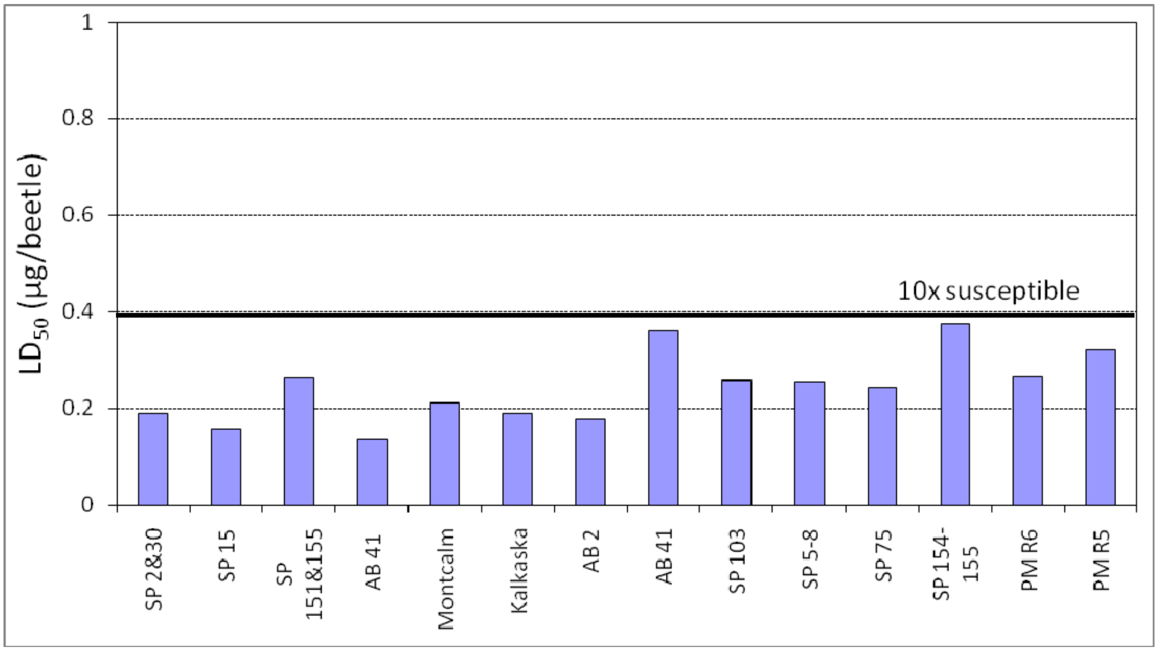


Figure I.3. Susceptibility of Michigan field populations of Colorado potato beetle to thiamethoxam. All LD_{50} values were significantly greater than the LD_{50} value for the susceptible strain. Populations are arranged by collection date, the first four samples represent overwintering populations, the remaining were from the summer generation.

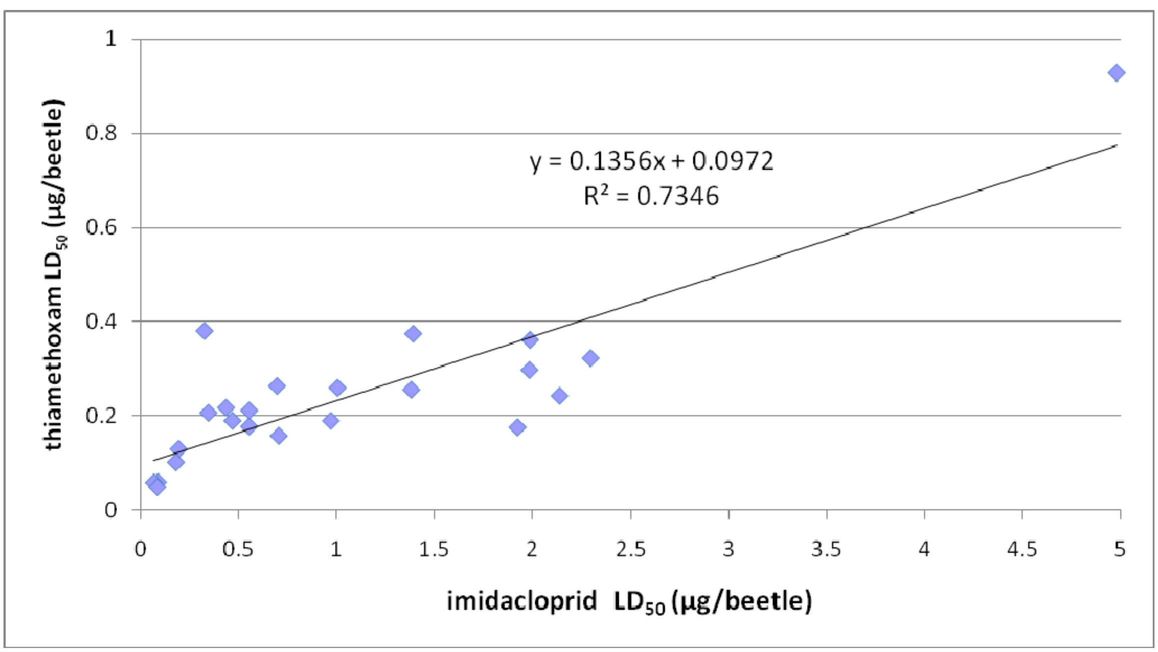


Figure I.4. Correlation between susceptibility to imidacloprid and thiamethoxam for all field populations tested in 2009 (n=31).

II. Field insecticide evaluations of registered and experimental insecticides.

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

Methods

Twenty-one insecticide treatments plus an untreated check (Table II.1) were tested at the Michigan State University Montcalm Research Farm, Entrican, MI for control of Colorado potato beetle. 'Atlantic' seed pieces were planted 12 in. apart, with 34 in. row spacing on 12 May 2009. Treatments were replicated four times in a randomized complete block design. Plots were 40 ft long and three rows wide with untreated guard rows planted on either side of each plot.

Admire Pro, Belay 2.13 SC, Capture LFR (infurrow portion), and Platinum 75 SG treatments were applied in-furrow at planting using a single-nozzle hand-held boom (30 gpa, 30 psi). Foliar treatments were first applied at greater than 50% egg hatch on 24 June. Subsequent first-generation sprays were applied on 2 & 16 July, depending on treatment (Table II.1).

Post-spray counts of Colorado potato beetle adults, small larvae (1st and 2nd instars), and large larvae (3rd and 4th instars) of five randomly selected plants from the middle row of each plot were made 6 days after each foliar application. On 17 September, the middle row of each plot was harvested mechanically and the tubers were separated by size and weighed. Data were analyzed using two-way ANOVA (treatment and block) and significant differences were determined with Fisher's Protected LSD test ($p=0.05$).

Results

There were significant differences between treated and untreated plots in the seasonal means of small larvae, large larvae, and adults (Table II.1). All treatments resulted in significantly fewer large larvae and adults than the untreated plots. All treatments also kept large larvae and adults below the economic threshold of one large larvae or adult per plant. However, overall beetle pressure was very low this summer, mostly due to a cold and late spring and the very protracted and reduced beetle emergence from diapause. This was best illustrated by the fact that adult numbers averaged below the economic threshold even on the untreated plots; large larvae, however, did average above the threshold in the untreated plots. There were also significant differences between treated and untreated plots with respect to overall yield (Table II.1). About half of the treatments (10 of 21) resulted in significantly higher yields than the untreated plots. The lack of beetle pressure this season likely masked any subtle differences in both insect numbers and overall yield that might have occurred between the various treatments.

Table II.1. Seasonal mean number of Colorado potato beetle egg masses, small larvae, large larvae, and adults per plant, and total yield.

			Seasonal mean of 1st-generation (#/plant)			
Treatment/formulation	Rate	Application dates	Small Larvae	Large Larvae	Adults	Total Yield
Actara 25 WG	5.5 oz/acre	24 Jun, 2 Jul	0.0a	0.5 b	0.1ab	21.3 bcde
Admire Pro	7.0 fl oz/acre	at planting	0.0a	0.0a	0.1ab	23.4 bcde
Admire Pro	8.7 fl oz/acre	at planting	0.0a	0.0a	0.1ab	21.5 bcde
Agri-Flex 1.55 SC + NIS[a]	4.5 fl oz/acre	24 Jun	0.0a	0.1ab	0.1ab	23.1 bcde
Agrimek 0.70 SC + NIS	1.75 fl oz/acre	24 Jun, 16 Jul	0.8 bc	0.2ab	0.0a	17.8abcd
Belay 2.13 SC	9.6 fl oz/acre	at planting	0.0a	0.0a	0.1ab	26.6 e
Belay 2.13 SC	12.0 fl oz/acre	at planting	0.0a	0.0a	0.1ab	26.2 e
Belay 2.13 SC	3.0 fl oz/acre	24 Jun	0.4ab	0.0a	0.0ab	20.9abcde
Blackhawk	3.3 oz/acre	24 Jun	0.2ab	0.0a	0.1ab	17.3abcd
Capture LFR + Brigadier	25.5 fl oz/acre + 6.14 fl oz/acre	at planting 24 Jun	0.5ab	0.1ab	0.1ab	22.0 bcde
Coragen	7.0 fl oz/acre	24 Jun	0.0a	0.0a	0.0a	17.0abc
Endigo 2.06 ZC + NIS	4.0 fl oz/acre	24 Jun	0.0a	0.0a	0.2b	19.8abcde
HGW86 10 OD	3.37 fl oz/acre	24 Jun	0.0a	0.1ab	0.1ab	19.8abcde
HGW86 10 OD + MSO[b]	3.37 fl oz/acre	24 Jun	0.3ab	0.0a	0.0ab	19.1abcde
HGW86 10 OD	6.75 fl oz/acre	24 Jun	0.3ab	0.0a	0.0ab	16.7ab
HGW86 10 OD	10.1 fl oz/acre	24 Jun	0.3ab	0.0a	0.0a	18.4abcd
HGW86 10 OD	20.5 fl oz/acre	24 Jun	0.1a	0.0a	0.0a	24.5 cde
Platinum 75 WG	2.7 fl oz/acre	at planting	0.0a	0.0a	0.0ab	24.8 de
Voliam Flexi 40 WG + NIS	4.0 oz/acre	24 Jun	0.2a	0.0a	0.0ab	23.4 bcde
Voliam Xpress 1.25 ZC + NIS	7.0 fl oz/acre	24 Jun, 16 Jul	0.0a	0.3ab	0.1ab	16.1ab
Warrior	3.2 fl oz/acre	24 Jun	0.3ab	0.1ab	0.0a	21.1abcde
Untreated check			1.5 c	2.7 c	0.8 c	13.7a

Means within a column followed by different letters are significantly different ($P<0.05$, Fisher's Protected LSD). Data transformed for analysis with log (x+1), means presented in non-transformed units.

[a] NIS applied at 0.25% v/v

[b] MSO applied at 0.5% v/v

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Excretion of ^{14}C-thiamethoxam in Michigan Colorado potato beetles

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I. PROBLEM STATEMENT

Resistance to imidacloprid in a CPB population from Long Island, NY also resulted in cross-resistance to several neonicotinoids never used on the field including thiamethoxam, dinotefuran, chlothianidin, thiacloprid, and acetamiprid (Mota-Sanchez et al. 2006). Resistance to imidacloprid and cross-resistence to thiamethoxam and chlothianidin has been detected in other areas of the eastern US and Canada (Alyokhin et al. 2007, Alyokhin et al. 2008). In Michigan, CPB resistance to imidacloprid and low levels of resistance to thiamethoxam were detected in 2004 and more resistance cases have appeared close to the original site of detection (Grafius 2006). Intense insecticide resistance management efforts have been implemented including crop rotation and trap crop (Grafius 2006). Despite some resistance cases, many Colorado potato beetle populations are still susceptible to imidacloprid and other neonicotinoids including thiamethoxam. Taking a proactive approach at this point in time will help to preserve the efficiency of this class of chemicals. One of the key strategies to manage resistance is the determination of the mechanism of resistance of CPB thiamethoxam.

Mechanism of resistance of CPB

CPB resistance to imidacloprid does not confer the same level of resistance to thiamethoxam and other neonicotinoids (Dively 2006, Mota-Sanchez et al. 2006, Alyokhin et al. 2007). For instance, 300-fold resistance to imidacloprid resulted only in 15-fold resistance to thiamethoxam (Mota-Sanchez et al. 2006). Thiamethoxam is converted inside plants and insects to chlothianidin (Nauen et al. 2003). The former compound targets the nervous system, and perhaps this is the reason for low levels of resistance of CPB in comparison with imidacloprid. Research on the mechanism of CPB resistance to imidacloprid and thiamethoxam are essential to effectively manage resistance to neonicotinoids in Michigan. Our research approach is to use labeled compound (^{14}C-thiamethoxam) to study the rate of excretion of this compound applied orally. The metabolism and suppression of metabolism of this labeled compound will provide insights to the mechanism of resistance to thiamethoxam of CPB populations from Michigan as compared to a susceptible strain.

II.SPECIFIC OBJECTIVE

Specific objectives:

1) Determine the rates of excretion of ^{14}C-thiamethoxam in Michigan potato beetles treated with this compound.

III. SPECIFIC METHODS AND PROCEDURES

The rate of excretion and metabolism of thiamethoxam in Michigan resistant and susceptible populations were compared with a susceptible strain. Fractions of excreta, and internal body were extracted with solvents methanol and acetonitrile. Samples were dried with nitrogen and condensed samples were spotted and thin layer chromatography was used to determine the amount of thiamethoxam metabolism.

Insects. Populations of CPB resistant to imidacloprid from Michigan as reported by Dr. E. Grafius were used in this study (Sackett farm).

Dosing. ^{14}C-thiamethoxam was applied via oral application , a procedure that closely approaches the form in which beetles come in contact with thiamethoxam when they feed in potato plants in the field: a low dose (700 dpm/beetle, about 5ng 14C-thiamethoxam/insect) in both the resistant and susceptible strains. After feeding, beetles were transferred to a 20 ml glass scintillation vial. Up to five beetles were held in a vial. Two time intervals were used (1h and 24h). At the end of each time interval, beetles were frozen at -20 C for an hour.

Excretion. To calculate the amount of excreted ^{14}C from thiamethoxam, holding vials for each time period were rinsed with 2 ml of methanol. An aliquot of 100 µl of acetone was put in a scintillation vial with 15 ml of cocktail fluid and were counted.

Metabolism. Metabolism was determined in excreta and internal body at 1, and 24 h. Beetles were homogenized with acetonitrile using a high speed mechanical homogenizer (VirTishear). Following homogenization, tubes were centrifuged. The supernatant were decanted into a scintillation vial. An aliquot was taken from each extract to count the radioactivity. Aliquots from the excreted and internal samples were put in scintillation vials and dried with nitrogen in a to a volume of 100 µl. Samples were spotted on TLC plates. The plates were developed by using a mobile phase of single dimension system. After drying, the plates were covered by a thin mylar film (0.001 mm) and put in a phosphor screen. A day after exposure, the screen were scanned in a phosphorimager analyzer (BioRad).

IV. RESULTS AND DISCUSSION.

Excretion and Internal fractions. Excretion of ^{14}C-thiamethoxam was faster in the resistant Michigan strain at 1 h after treatment (Fig 1). At 1 h after treatment the percentage of excreted radioactivity was about 5% for the susceptible, and 10% for the Michigan resistant strain, respectively. At 24 h after treatment, the excretion in both strains was about 28%. The amount of 14C-thiamethoxam in the internal fractions was 67% and 73% of the applied doses at 1h after treatment for the resistant Michigan beetles and the susceptible strain, respectively. At 24 h after treatment, the amount in the internal fractions was 39% in the resistant strain and 41 % in the susceptible strain, although the variability was high in both strains.

Regarding the metabolism of thiamethoxam we have observed about 25% of the dose converted thiamethoxam to clothianidin in both strains at 24 h after treatment. Given the high variability in this experiment we increased the number of replications and currently we are processing more samples. This can give us a better estimation of the differences in pharmacokinetics and metabolism of thiamethoxam in Michigan resistant beetles versus susceptible beetles, or perhaps the levels of resistance are still low to detect differences in the pharmacokinetics and metabolism studies.

With respect to symptoms of intoxication, some intoxication was observed 1 h after treatment in the susceptible beetles, but these symptoms were mild in comparison to beetles treated with imidacloprid (previous experiments). In addition, we have observed less excretion and higher amount of 14C-thiamethoxam in the insect body than previous experiments with 14C-imidacloprid. Perhaps this is one the reasons of less levels of resistance in this insecticide in comparison with imidacloprid. Further experiments are critical to elucidate the mechanism of resistance of CPB to thiamethoxam and explain why CPB developed low levels of resistance to this compound in comparison with imidacloprid. By determining the mechanism of this low level of resistance, we could use this as a tool to manage the resistance of Colorado potato beetle to neonicotinoids.

V. AKNOWLEDGEMENTS

We deeply appreciate the kind support of the MPIC for this proposal and also the valuable help of Mark Otto, Adam Byrne and Ed Grafius to provide Michigan beetles.

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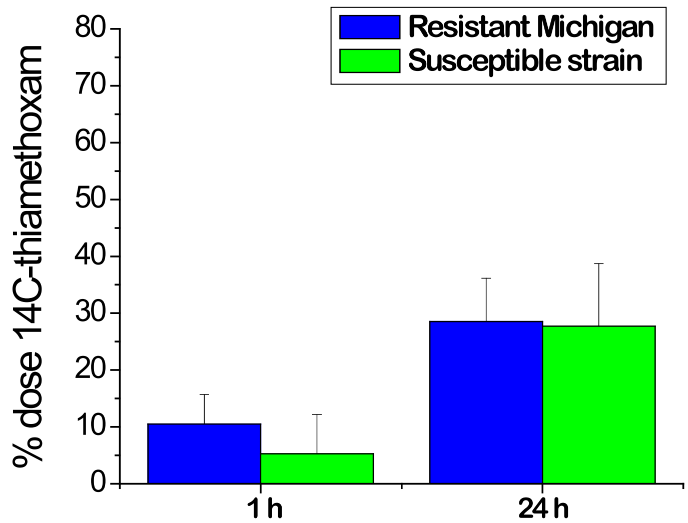

Fig 1 Excretion of 14C-thiamethoxam

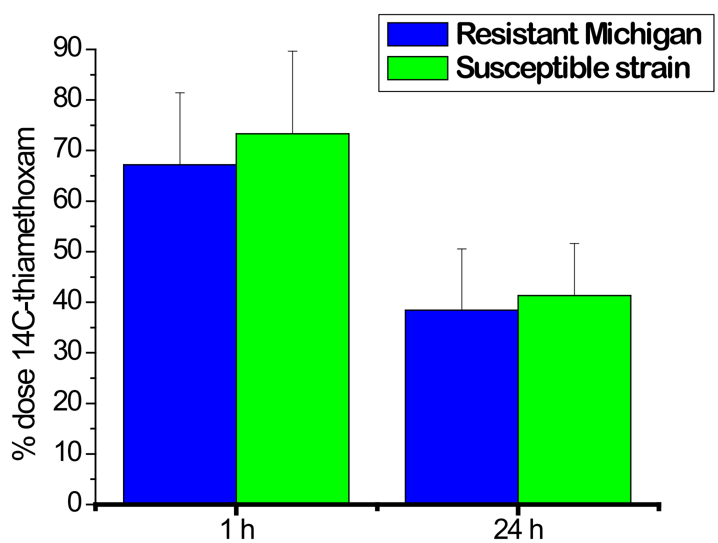

Fig2 Internal amount of 14-thiamethoxam

Funding: Agrochemical industry

Fungicide Trials 2008-2009.

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Evaluation of fungicide programs for potato late blight control: 2008.

Potatoes (cut seed, treated with Maxim FS at 0.16 fl oz/cwt) were planted at the Michigan State University Muck Soils Experimental Station, Bath, MI on 25 May into two-row by 25-ft plots (34-in row spacing), separated by a five-foot unplanted row and 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 27 Jul. All fungicides in this trial were applied on a 7-day interval from 30 Jun to 27 Aug (9 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 25 May), 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 and on 28 Jun), 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 30 Jul; 14, 21, 28 Aug and 4 Sep [13 days after final application (DAFA), 40 days after inoculation (DAI)] when there was about 100% foliar infection in the untreated plots. The relative area under the disease progress curve was calculated for each treatment from date of inoculation, 30 Jul to 5 Sep, a period of 36 days. Vines were killed with Reglone 2EC (1 pt/A on 6 Sep). Plots (2 x 25-ft row) were harvested on 17 Sep and individual treatments were weighed and graded. 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 40 days. Meteorological variables were measured with a Campbell weather station located at the farm, latitude 42.8269 and longitude -84.365deg. Maximum, minimum and average daily air temperature (^{o}F) were 81.2, 25.3 and 53.1 (May); 91.9, 39.6 and 66.7 and 1-d with maximum temperature >90^{o}F (Jun); 89.9, 38.3 and 68.5 (Jul); 87.9, 35.5 and 65.6 (Aug); 91.7, 33.3 and 59.3 and 1-d with maximum temperature >90^{o}F (Sep). Maximum, minimum and average daily soil temperature (^{o}F) were 78.0, 41.4 and 58.1 (May); 81.6, 52.6 and 67.7 (Jun); 82.2, 55.8 and 71.1 (Jul); 85.7, 55.2 and 71.4 (Aug); 81.8, 51.6 and 65.3 (Sep). Maximum, minimum and average soil moisture (% of field capacity) 80.2, 74.0 and 76.6 (May); 91.1, 73.5 and 81.5 (Jun); 100.8, 77.0 and 83.2 (Jul); 97.0, 76.5 and 81.0 (Aug); 123.1 (flooding), 76.6 and 84.3 (Sep). Maximum, minimum and average daily soil temperature (^{o}F) were 78.0, 41.4 and 58.1 (May); 81.6, 52.6 and 67.7 (Jun); 82.2, 55.8 and 71.1 (Jul); 85.7, 55.2 and 71.4 (Aug); 81.8, 51.6 and 65.3 (Sep). Maximum, minimum and average relative humidity were 95.0, 16.0 and 62.8 (May); 95.6, 28.5 and 68.3 (Jun); 95.9, 29.1 and 69.4 (Jul); 96.3, 25.7 and 69.1 (Aug); 96.9, 28.8 and 73.7 (Sep). Precipitation was 1.08 in. (May), 3.59 in. (Jun), 3.69 in. (Jul), 1.56 in. (Aug) and 7.02 in. (Sep). The total number of late blight disease severity values (DSV) over the disease development period was 80 using 90% ambient %RH as bases for DSV accumulation. Plots were irrigated to supplement precipitation to about 0.1 in./A/4-day period with overhead sprinkle irrigation.

Late blight developed steadily after inoculation and untreated controls reached 100% foliar infection by 5 Sep. Up to 40 DAI, all fungicide programs reduced foliar late blight significantly compared to the untreated control and up to 26 DAI were not significantly different from each other. All fungicide programs significantly reduced the average amount of foliar late blight over the season (RAUDPC, 0 to 40 DAI) compared to the untreated control. There were no significant differences in marketable or total yield among treatments. There were significant differences in the incidence of tuber late blight 40 days after harvest among treatments. The untreated check had 14.9% incidence of tuber blight and only treatments with 4.2% incidence or less had significantly less tuber blight than the untreated check. The Bravo WS program had 23.8% incidence of tuber blight, which was significantly higher than the untreated check. Phytotoxicity was not noted in any of the treatments.

Funding: Agrochemical industry

Treatment and rate/A	Foliar late blight (%) 5 Aug 9 DAI[z]	22 Aug 26 DAI	29 Aug 33 DAI	5 Sep 40 DAI 5 DAFA[y]	RAUDPC Max = 100[x] 0 - 40 DAI	Yield (cwt/A) US1	Total	Tuber blight (%)[w]
BravoWS 6SC 1.5 pt (A-I)…………………………..…..	0.0c	0.2b	3.0d	6.8c	0.8d	326	407	23.8a
Revus Top 4.17SC 5.5 fl oz + Induce SL 0.25 pt (A,B,D,G,E,H); BravoWS 6SC 1.5 pt (C,F, I)………………………….	0.0c	0.4b	4.3d	7.5c	1.1d	296	347	14.6bc
Revus Top 4.17SC 7.0 fl oz + Induce SL 0.25 pt (A,B,D,G,E,H); BravoWS 6SC 1.5 pt (C,F, I)………………………….	0.0c	0.1b	2.3d	6.3c	0.7d	323	397	4.0e
JE 874 2.1 SE 0.5 pt + Curzate 60DF 3.2 oz + Manzate 1.5 lb (A,C,G,E,I); BravoWS 6SC 1.5 pt (B,D,F,H)……………………….	0.0c	0.5b	2.8d	11.8c	1.1d	329	403	15.3bc
Revus Opti 3.67SC 2.5 pt + Induce SL 0.25 pt (A,C,E,G,I); BravoWS 6SC 1.5 pt (B,D,F,H)……………………….	0.0c	0.3b	2.5d	9.5c	1.0d	289	366	11.6cd
Penncozeb 75DF 1.0 lb (A); Penncozeb 75DF 2.0 lb (B,C,D); Penncozeb 75DF 2.0 lb + Super Tin 80WP 3.25 oz (E,F,G,H,I)………………….	0.0c	0.6b	11.3c	36.3b	3.8c	295	377	8.1cde
Penncozeb 75DF 2.0 lb (A-I)……………………..…...	0.3bc	0.6b	10.0c	36.3b	3.7c	318	392	4.2de
TD 2368-01 4DF 3.0 lb (A-I)…………………...……..	0.1c	0.8b	12.5c	38.8b	4.1bc	310	369	15.0bc
TD 2368-01 4DF 4.0 lb (A-I)…………………...……..	0.5b	0.9b	18.8b	42.5b	5.3b	350	422	19.5ab
Bravo WS 6SC pt (A,B,C,E,G,I); Ranman 3.33 SC 0.17 pt + Manzate 75DF 2.0 lb + NIS 0.125 pt (D,F,H)…………………………………..	0.0c	0.1b	1.0d	4.8c	0.4d	308	371	13.5bc
Untreated...	1.2a	5.5a	82.5a	100a	18.5a	293	373	14.9bc
$HSD_{0.05}$	0.36	1.49	5.24	9.08	1.29	52.8	59.9	7.36

[z] Days after inoculation with *Phytophthora infestans*, US8, A2.
[y] Days after final application of fungicide.
[x] RAUDPC, relative area under the disease progress curve calculated from day of inoculation to last evaluation of late blight.
[w] Incidence of tuber late blight after storage at 50°F.
[v] Application dates: A= 30 Jun; B= 9 Jul; C= 16 Jul; D= 23 Jul; E= 30 Jul; F= 6 Aug; G= 13 Aug; H= 20 Aug; I = 27 Aug.
[u] Values followed by the same letter are not significantly different at $p = 0.05$ (Tukey Multiple Comparison).

Funding: Agrochemical industry

Evaluation of fungicide programs for brown leaf spot and early blight control: 2008.

Potatoes (cut seed, treated with Maxim FS at 0.16 fl oz/cwt) were planted at the Michigan State University Muck Soils Experimental Station, Bath, MI on 25 May into two-row by 25-ft plots (34-in row spacing), separated by a five-foot unplanted row and 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 30 Jun to 27 Aug (9 applications, unless otherwise indicated in the table) 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 7 Jul to 27 Aug. Weeds were controlled by hilling and with Dual 8E (2 pt/A on 25 May), 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 and on 28 Jun), 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 brown leaf spot and/or early blight on 14, 21, 28 Aug and 11 Sep [15 days after final application (DAFA), 28 days after the initial evaluation (DAIE)] when there was about 50% foliar infection in the untreated plots. The relative area under the disease progress curve was calculated for each treatment from DAIE, 14 Aug to 11 Sep, a period of 28 days. Vines were killed with Reglone 2EC (1 pt/A on 11 Sep). Plots (2 x 25-ft row) were harvested on 3 Oct and individual treatments were weighed and graded. Meteorological variables were measured with a Campbell weather station located at the farm, latitude 42.8269 and longitude -84.365deg. Maximum, minimum and average daily air temperature (^{o}F) were 81.2, 25.3 and 53.1 (May); 91.9, 39.6 and 66. (Jun); 89.9, 38.3 and 68.5 (Jul); 87.9, 35.5 and 65.6 (Aug); 91.7, 33.3 and 59.3 (Sep). Maximum, minimum and average daily soil temperature (^{o}F) were 78.0, 41.4 and 58.1 (May); 81.6, 52.6 and 67.7 (Jun); 82.2, 55.8 and 71.1 (Jul); 85.7, 55.2 and 71.4 (Aug); 81.8, 51.6 and 65.3 (Sep). Maximum, minimum and average soil moisture (% of field capacity) 80.2, 74.0 and 76.6 (May); 91.1, 73.5 and 81.5 (Jun); 100.8, 77.0 and 83.2 (Jul); 97.0, 76.5 and 81.0 (Aug); 123.1 (flooding), 76.6 and 84.3 (Sep). Maximum, minimum and average daily soil temperature (^{o}F) were 78.0, 41.4 and 58.1 (May); 81.6, 52.6 and 67.7 (Jun); 82.2, 55.8 and 71.1 (Jul); 85.7, 55.2 and 71.4 (Aug); 81.8, 51.6 and 65.3 (Sep). Maximum, minimum and average relative humidity were 95.0, 16.0 and 62.8 (May); 95.6, 28.5 and 68.3 (Jun); 95.9, 29.1 and 69.4 (Jul); 96.3, 25.7 and 69.1 (Aug); 96.9, 28.8 and 73.7 (Sep). Precipitation was 1.08 in. (May), 3.59 in. (Jun), 3.69 in. (Jul), 1.56 in. (Aug) and 7.02 in. (Sep). Plots were irrigated to supplement precipitation to about 0.1 in./A/4-day period with overhead sprinkle irrigation.

Early blight and brown leaf spot developed steadily during Aug and untreated controls reached about 50-70% foliar infection by 11 Sep. The proportion of early blight to brown leaf spot in the first two evaluations was about 90:10 but by the third and fourth evaluations was about 20:80. All fungicide programs reduced foliar early blight and brown leaf spot significantly compared to the untreated control to the middle of Sep when crops had to be desiccated to accommodate harvest prior to frost. All fungicide programs significantly reduced the average amount of foliar early blight and brown leaf spot (RAUDPC) compared to the untreated control over the evaluation period from 14 Aug to 11 Sep. There were significant differences in marketable and total yield among treatments and treatments with greater than 265 and 406 cwt/A US1 and total weight, respectively were significantly greater than the untreated controls. Phytotoxicity was not noted in any of the treatments.

Funding: Agrochemical industry

Treatment and rate/A	Foliar early blight and brown leaf spot (%) 14 Aug	21 Aug	28 Aug	11 Sep 15 DAFA[z]	RAUDPC Max = 100[y] 0 - 28 DAIE[x]	Yield (cwt/A) US1	Total
Echo ZN 2.12 pt (A,C,E); Headline 2.09EC 6 fl oz + Echo ZN 1.5 pt (B,F); Endura 70WDG 2.5 oz + Echo ZN 1.5 pt (D); Dithane DF 2 lb (G,H,I[w])……………...........................	1.0abc[v]	3.3cde	3.8b-g	13.8e-i	5.8d-h	297a-e	419a-e
QFA 61 350EC 2.1 pt (A-I)…………...........................	0.8bcd	1.5e	4.3b-g	12.5f-i	5.2gh	281a-f	392c-g
LEM 17 200EC 16.8 fl oz (A,C,E,G,I); JE 874 2.1SE 6 fl oz + Manzate 75DF 1.5 lb (B,D,F,H)………………………	0.5cde	1.8de	1.8g	9.5i	3.5h	329ab	474a
LEM 17 200EC 24 fl oz (A,C,E,G,I); JE 874 2.1SE 6 fl oz + Manzate 75DF 1.5 lb (B,D,F,H)	0.5cde	1.5e	2.5efg	10.0hi	3.9h	265d-g	374d-g
LEM 17 200SC 16.8 fl oz (A,C,E,G,I); JE 874 2.1SE 6 fl oz + Manzate 75DF 1.5 lb (B,D,F,H)	0.8bcd	2.3de	2.5efg	12.5f-i	4.7gh	313a-d	425a-d
Endura 2.5 oz (A,C,E,G,I); JE 874 2.1SE 6 fl oz + Manzate 75DF 1.5 lb (B,D,F,H)	0.0e	1.0e	3.0d-g	11.3ghi	4.2gh	300a-e	412a-e
BravoWS 6SC 1.5 pt (A-I)…………………………….	1.0abc	4.5bcd	8.0b-e	20.0c-f	9.3c-f	259d-h	394c-g
BravoWS 6SC 1.5 pt (A,B,F,H); Quash 50WG 2.5 oz (C,D,G,I); Endura 70WDG 5.5 oz (E)…………………………….	0.5cde	1.3e	2.3fg	11.3ghi	4.0gh	276b-f	378d-g
Headline 2.09EC 6 fl oz (A-H)…………….………..	0.3de	1.8de	2.5efg	15.0d-i	5.2gh	284a-f	402b-f
BravoWS 6SC 1.5 pt (A-H)………………….…..…….	0.8bcd	5.5bc	7.8b-f	21.3cde	9.7cde	284a-f	406b-f
Quash 50WG 2.5 oz (C,D,G,I)………………………...	0.5cde	1.5e	3.0d-g	18.8c-g	6.3c-h	293a-e	417a-e
Quash 50WG 1.5 oz (A-H)…………………………….	0.8bcd	2.8cde	6.0b-g	20.0c-f	8.0c-g	265c-g	374d-g
Quash 50WG 2.0 oz (A-H)…………………………….	1.3ab	2.8cde	8.5bcd	23.8c	10.0c	281a-f	415a-e
Quash 2DC 3.0 oz (A-H)…………………...………….	0.8bcd	1.5e	2.8efg	20.0c-f	6.5c-h	235fgh	371d-g
Quash 2DC 4.0 oz (A-H)………………...…………….	0.8bcd	3.5cde	4.0b-g	20.0c-f	7.5c-h	275b-f	424a-d
Endura 70WDG 2.5 oz (A-H)………………………….	0.8bcd	2.5de	3.8b-g	15.0d-i	5.9d-h	259d-h	399b-f
Quadris 2.08SC 6.2 fl oz (A-H)………………………..	0.5cde	2.3de	9.3b	22.5cd	9.7cd	254e-h	377d-g
Revus Top 4.17SC 7 fl oz + Induce SL 0.25 pt (A,B,D,E); BravoWS 6SC 1.5 pt (C)………………………………	0.8bcd	3.3cde	3.5c-g	16.3c-i	6.3c-h	260d-h	392c-g
Revus Top 4.17SC 7 fl oz + Induce SL 0.25 pt (A,B,D,E); Endura 70WDG 2.5 oz (C)…………………………..……	0.0e	2.0de	3.3d-g	18.8c-g	6.4c-h	278b-f	405b-f
A31703 325SC 8 fl oz + Induce SL 0.25 pt (A,C,E); BravoWS 6SC 1.5 pt (B,D)……………………………	0.8bcd	2.5de	4.3b-g	16.3c-i	6.4c-h	322ab	433a-d
Endura 70WDG 2.5 oz (A,B,D,E); BravoWS 6SC 1.5 pt (C)………………………………	0.5cde	1.5e	3.5c-g	20.0c-f	6.8c-h	287a-f	401b-f
Tanos 50DF 6 oz + Manzate 75DF 1.5 lb (A,C,E); BravoWS 6SC 1.5 pt (B,D)……………………………	0.3de	2.0de	2.5efg	20.0c-f	6.5c-h	296a-e	400b-f
Sonata 500SC 4 pt + Biotune 1EC 4 fl oz + Dithane DF 1.5 lb (A,C,E); Headline 2.09EC 6 fl oz (B,D,F)………………………	0.8bcd	2.5de	3.3d-g	15.0d-i	5.7e-h	334a	463ab
Evito 4FL 2 fl oz + Induce SL 0.25 pt + BravoWS 6SC 1.5 pt (A,C,E); BravoWS 6SC 1.5 pt (B,D,F,G,H)…………………..….	0.0e	1.3e	2.8efg	16.3c-i	5.4fgh	320abc	433a-d
Untreated……………………………………………….	1.5a	8.8a	27.5a	66.3a	29.3a	212gh	332g
$HSD_{0.05}$	0.69	2.99	5.53	7.60	4.02	55.3	64.2

[z] Days after final application of fungicide.
[y] RAUDPC, relative area under the disease progress curve calculated from day of inoculation to last evaluation of late blight.
[x] DAIE, days after initial evaluation.
[w] Application dates: A= 30 Jun; B= 8 Jul; C= 16 Jul; D= 23 Jul; E= 30 Jul; F= 6 Aug; G= 13 Aug; H= 20 Aug; I = 27 Aug.
[v] Values followed by the same letter are not significantly different at $p = 0.05$ (Tukey Multiple Comparison).

Funding: Agrochemical industry

Evaluation of chemigated fungicide programs for white mold control in potatoes, 2008.

Potatoes (cut seed, treated with Maxim FS at 0.16 fl oz/cwt; FL1879 and Goldrush) were planted at the Michigan State University Muck Soils Experimental Station, Bath, MI on 28 May into eight-10 row by 50-ft plots per variety separated by a 15-ft gap on each side and replicated three times for a total of three replicated plots per treatment per variety. Plots were hilled immediately before sprays began. The trial was chemigated twice on a 14-day interval on 15 and 29 Jul with a Valley Irrigation overhead single span pivot delivering 5,000 gal water/A per application. 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 7 Jul to 27 Aug. Weeds were controlled by hilling and with Dual 8E (2 pt/A on 25 May), 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 and on 28 Jun), 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 white mold and bacterial stem blight on 15 and 20 Aug [17 and 22 days after final application (DAFA), 79 and 84 days after planting (DAP)]. Vines were killed with Reglone 2EC (1 pt/A on 6 Sep). Plots (2 x 25-ft row) were harvested on 7 Oct and individual treatments were weighed and graded. Meteorological variables were measured with a Campbell weather station located at the farm, latitude 42.8269 and longitude -84.365deg. Maximum, minimum and average daily air temperature (^{o}F) were 81.2, 25.3 and 53.1 (May); 91.9, 39.6 and 66.7 and 1-d with maximum temperature >90^{o}F (Jun); 89.9, 38.3 and 68.5 (Jul); 87.9, 35.5 and 65.6 (Aug); 91.7, 33.3 and 59.3 and 1-d with maximum temperature >90^{o}F (Sep). Maximum, minimum and average daily soil temperature (^{o}F) were 78.0, 41.4 and 58.1 (May); 81.6, 52.6 and 67.7 (Jun); 82.2, 55.8 and 71.1 (Jul); 85.7, 55.2 and 71.4 (Aug); 81.8, 51.6 and 65.3 (Sep). Maximum, minimum and average soil moisture (% of field capacity) 80.2, 74.0 and 76.6 (May); 91.1, 73.5 and 81.5 (Jun); 100.8, 77.0 and 83.2 (Jul); 97.0, 76.5 and 81.0 (Aug); 123.1 (flooding), 76.6 and 84.3 (Sep). Maximum, minimum and average daily soil temperatures (^{o}F) were 78.0, 41.4 and 58.1 (May); 81.6, 52.6 and 67.7 (Jun); 82.2, 55.8 and 71.1 (Jul); 85.7, 55.2 and 71.4 (Aug); 81.8, 51.6 and 65.3 (Sep). Maximum, minimum and average relative humidity were 95.0, 16.0 and 62.8 (May); 95.6, 28.5 and 68.3 (Jun); 95.9, 29.1 and 69.4 (Jul); 96.3, 25.7 and 69.1 (Aug); 96.9, 28.8 and 73.7 (Sep). Precipitation was 1.08 in. (May), 3.59 in. (Jun), 3.69 in. (Jul), 1.56 in. (Aug) and 7.02 in. (Sep). Plots were irrigated to supplement precipitation to about 0.1 in./A/4-day period with overhead sprinkle irrigation.

Despite frequent irrigation, white mold developed slowly during Aug and untreated controls reached 5.7 and 11.3% foliar infection by 20 Aug in FL1879 and Goldrush, respectively. In FL1879 and Goldrush, all treatments had significantly less white mold than the untreated control at the first evaluation but not the second. Bacterial vine rot developed during Aug and untreated controls reached 31.7% vine infection by 20 Aug in both FL1879 and Goldrush. There were no significant differences among treatments with respect to white mold or bacterial vine rot at either evaluation date. In FL1879, Endura had significantly greater total yield in comparison to the untreated control and LEM 17 but was not significantly different from Omega. There were no significant differences among any treatments with respect to total yield in Goldrush. Phytotoxicity was not noted in any of the treatments.

	White mold severity (%)		Bacterial vine rot severity (%)		
Treatment and rate/acre	8/15 17 DAFA	8/20 22 DAFA	8/15 17 DAFA	8/20 22 DAFA	Total yield (cwt/A)
FL1879					
Omega 500F 8 fl oz (A,B[z])……………	1.0 b[y]	3.7a	6.7 b	16.7a	388ab
Endura 7-WG 10 oz (A,B)……………	1.0 b	2.0a	7.3 b	18.3a	400a
LEM 17 200EC 16.8 fl oz (A,B)……...	1.3 b	6.7a	13.3 b	30.0a	352 b
Untreated...	2.3a	5.7a	21.7a	31.7a	352 b
$LSD_{0.05}$	0.88	5.68	7.23	15.71	30.3
Goldrush					
Omega 500F 8 fl oz (A,B)…….………	2.3 b	4.3a	10.0 b	18.3a	297a
Endura 7-WG 10 oz (A,B)……………	2.3 b	5.0a	8.3 b	16.7a	281a
LEM 17 200EC 16.8 fl oz (A,B)……...	2.0 b	10.0a	8.3 b	28.3a	294a
Untreated...	4.7a	11.3a	18.3a	31.7a	261a
$LSD_{0.05}$	1.60	9.16	5.77	17.38	36.8

[z] Application dates: A= 15 Jul; B= 27 Jul.
[y] Values followed by the same letter are not significantly different at P = 0.05 (Tukey Multiple Comparison).

Funding: Agrochemical industry

Evaluation of fungicide programs for potato late blight control: 2009

Potatoes (cut seed, treated with Maxim FS at 0.16 fl oz/cwt) were planted at the Michigan State University Muck Soils Experimental Station, Bath, MI on 25 May into two-row by 25-ft plots (34-in row spacing), separated by a five-foot unplanted row and 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 a 7 to 13-day interval from 13 Jul to 7 Sep (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), 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 percentage foliar area affected by early blight and brown leaf spot on 20, 27 Aug and 8 and 15 Sep [8 days after final application (DAFA), 26 days after the initial evaluation (DAIE)]; Botrytis tan spot on 15 Sep and late blight on 10, 17 and 23 Sep [16 days after final application (DAFA), 57 days after inoculation (DAI)] when there was about 80% foliar infection in the untreated plots. The relative area under the early blight and brown leaf spot disease progress curves were calculated for each treatment from DAIE, 20 Aug to 15 Sep, a period of 26 days. The relative area under the late blight disease progress curve was calculated for each treatment from date first symptoms were noted, 20 Aug to 15 Sep, a period of 26 days. Vines were killed with Reglone 2EC (1 pt/A on 6 Sep). Plots (20-ft row) were harvested on 1 Oct however there was insufficient tuber development due to three separate flooding events to justify yield analyses. 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 40 days. Meteorological variables were measured with a Campbell weather station located at the farm, latitude 42.8269 and longitude -84.365deg. Maximum, minimum and average daily air temperature (^{o}F) were 84.2, 28.9 and 55.9 and 0-d with maximum temperature >90^{o}F (May); 95.8, 35.9 and 64.9 and 2-d with maximum temperature >90^{o}F (Jun); 82.9, 40.1 and 64.2 (Jul); 91.5, 37.4 and 67.0 and 2-d with maximum temperature >90^{o}F (Aug); 83.1, 31.8 and 60.4 (Sep); 62.7, 23.8 and 44.5 (to 15 Oct). Maximum, minimum and average daily soil temperature (^{o}F) were 68.1, 47.4 and 57.9 (May); 78.7, 55.9 and 66.6 (Jun); 73.3, 61.4 and 67.4 (Jul); 75.6, 59.7 and 69.2 (Aug); 68.4, 55.9 and 63.6 (Sep); 56.3, 45.6 and 51.8^{o}F (to 15 Oct). Maximum, minimum and average soil moisture (% of field capacity) 77.2, 62.4 and 66.9 (May); 77.0, 60.8 and 67.2 (Jun); 76.7, 58.2 and 63.7 (Jul); 75.0, 55.1 and 61.7 (Aug); 58.7, 52.1 and 54.2 (Sep); 57.4, 52.5 and 54.5^{o}F (to 15 Oct). Precipitation was 2.98 in. (May), 5.76 in. (Jun), 5.62 in. (Jul), 5.25 in. (Aug), 1.09 in. (Sep) and 1.25 in. to 15 Oct. The total number of late blight disease severity values (DSV) over the disease development period was 51 using 90% ambient %RH as bases for DSV accumulation. Plots were irrigated to supplement precipitation to about 0.1 in./A/4 day period with overhead sprinkle irrigation.

Early blight and brown leaf spot developed steadily during Aug and untreated controls reached about 15.8% foliar infection (combined diseases) by 15 Aug. Fungicide programs with foliar Alternaria less than 10.8% were significantly different from the untreated control. No programs were significantly different from the untreated check in terms of the Alternaria RAUDPC. Fungicide programs with Botrytis tan spot less than 21.3 were significantly different from the untreated control. Late blight developed slowly after inoculation and untreated controls reached on average 85% foliar infection by 23 Sep. Fungicide programs with foliar late blight less than 85% were significantly different from the untreated control. All fungicide programs had significantly lower RAUDPC values in comparison to the untreated control (23.2). There were significant differences in the incidence of tuber late blight on the 26 Oct (26 days after harvest) among treatments. The untreated check had 6.3% incidence of tuber blight but only treatments with less than 5.0% incidence had significantly less tuber blight than the untreated check. Phytotoxicity was not noted in any of the treatments.

Funding: Agrochemical industry

Treatment and rate/A	Foliar Alternaria (%) 15 Aug		Foliar Alternaria (%) RAUDPC[z] 26 DAIE[y]		Foliar Botrytis Tan Spot (%) 15 Aug		Potato late blight Foliar (%) 23 Sep 16 DAFA[x]		Potato late blight RAUDPC 26 DAIE		Potato late blight Tuber blight (%)[w]	
BravoWS 6SC 1.5 pt (A-D[v]); Gavel 75DF 2 lb (E-H)………………....	7.5	d[u]	4.8	a	17.5	cd	15.0	fg	2.0	g	1.3	c
BravoWS 6SC 1.5 pt (A-H)……………	7.8	d	4.3	a	25.0	abc	12.5	g	2.3	g	2.5	bc
Revus Top 4.17SC 7 fl oz + Induce SL 0.25 pt (A,B,D,E); BravoWS 6SC 1.5 pt (C,F,G,H)……….	8.0	cd	4.1	a	16.3	d	15.0	fg	2.4	g	1.3	c
QRD709 1 pt (A-H)……………………	11.0	a-d	5.1	a	17.5	cd	61.3	cd	9.0	de	5.0	ab
QRD709 2 pt (A-H)……………………	7.5	d	3.9	a	21.3	bcd	62.5	cd	10.7	cd	2.5	bc
QRD709 3 pt (A-H)……………………	14.3	ab	5.9	a	16.3	d	65.0	bc	11.2	c	6.3	a
Kocide 3000 46.1DF 1.75 lb (A-H)……	12.5	a-d	4.9	a	21.3	bcd	53.8	cd	8.5	e	5.0	ab
Tanos 50WG 2.75 oz (A-H)…………...	8.5	cd	4.2	a	22.5	bcd	23.8	efg	3.8	fg	1.3	c
Ranman 400SC 2.1 fl oz + Dithane 75DF 1.0 lb (A-H)…………….	8.3	cd	4.0	a	26.3	ab	14.3	fg	2.1	g	1.3	c
Ranman 400SC 2.1 fl oz + Dithane 75DF 2.0 lb (A-H)…………….	11.5	a-d	4.2	a	32.5	a	13.0	g	2.0	g	1.3	c
Ranman 400SC 2.75 fl oz + Dithane 75DF 1.0 lb (A-H)…………….	10.8	bcd	4.0	a	25.0	abc	16.8	fg	2.8	g	0.0	c
Ranman 400SC 2.75 fl oz + Dithane 75DF 2.0 lb (A-H)…………….	12.0	a-d	4.7	a	21.3	bcd	35.0	e	5.2	f	1.3	c
Catamaran 5.2F 4.5 pt (A-D); Catamaran 5.2F 4.5 pt + Revus Top 4.17SC 7 fl oz (E,G); Catamaran 5.2F 5.5 pt (F,H)…………...	16.3	a	5.7	a	27.5	ab	51.3	d	10.1	cde	2.5	bc
Regalia Max 20SC 16 fl oz (A-H)……..	15.0	ab	5.9	a	23.8	bcd	85.0	a	14.2	b	5.0	ab
Regalia Max 20SC 8 fl oz + BravoWS 6SC 1.5 pt (A-H)……………………….	10.8	bcd	4.3	a	25.0	abc	76.3	ab	13.8	b	2.5	bc
Regalia Max 20SC 16 fl oz + BravoWS 6SC 1.5 pt (A-H)……………………….	13.3	abc	4.2	a	22.5	bcd	25.0	ef	3.7	fg	0.0	c
Untreated Check………………………..	15.8	ab	5.5	a	26.3	ab	85.0	a	23.2	a	6.3	a
$LSD_{0.05}$	5.44		2.60		8.01		11.32		2.03		3.54	

[z] RAUDPC, relative area under the disease progress curve calculated from day of appearance of initial symptoms.
[y] Days after initial symptoms observed and evaluated.
[x] Days after final application of fungicide.
[w] Incidence of tuber late blight after storage for 26 days at 50°F.
[v] Application dates: A= 13 Jul; B= 20 Jul; C= 28 Jul; D= 10 Aug; E= 18 Aug; F= 25 Aug; G= 1 Sep; H= 7 Sep.
[u] Values followed by the same letter are not significantly different at $p = 0.05$ (Fishers LSD).

Funding: Agrochemical industry

Evaluation of fungicide programs for potato early blight, brown leaf spot and tan spot control: 2009.

Potatoes (cut seed, treated with Maxim FS at 0.16 fl oz/cwt) were planted at the Michigan State University Muck Soils Experimental Station, Bath, MI on 25 May into two-row by 25-ft plots (34-in row spacing), separated by a five-foot unplanted row and 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 24 Jun to 24 Aug (9 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 27 Aug and 8 and 15 Sep [3, 15 and 22 days after final application (DAFA), respectively and 22 days after the initial evaluation (DAIE)]; and Botrytis tan spot on 15 Sep. The relative area under the early blight and brown leaf spot disease progress curve was calculated for each treatment from DAIE, 20 Aug to 15 Sep, a period of 25 days. Vines were killed with Reglone 2EC (1 pt/A on 6 Sep). Plots (20-ft row) were harvested on 1 Oct, however there was insufficient tuber development due to three flooding events to justify yield analyses. Meteorological variables were measured with a Campbell weather station located at the farm, latitude 42.8269 and longitude -84.365deg. a. Meteorological variables were measured with a Campbell weather station located at the farm, latitude 42.8269 and longitude -84.365deg. Maximum, minimum and average daily air temperature (^{o}F) were 84.2, 28.9 and 55.9 (May); 95.8, 35.9 and 64.9 and 2-d with maximum temperature >90^{o}F (Jun); 82.9, 40.1 and 64 (Jul); 91.5, 37.4 and 67.0 and 2-d with maximum temperature >90^{o}F (Aug); 83.1, 31.8 and 60.4 and 0-d with maximum temperature >90^{o}F (Sep); 62.7, 23.8 and 44.5 (to 15 Oct). Maximum, minimum and average daily soil temperature (^{o}F) were 68.1, 47.4 and 57.9 (May); 78.7, 55.9 and 66.6 (Jun); 73.3, 61.4 and 67.4 (Jul); 75.6, 59.7 and 69.2 (Aug); 68.4, 55.9 and 63.6 (Sep); 56.3, 45.6 and 51.8^{o}F (to 15 Oct). Maximum, minimum and average soil moisture (% of field capacity) 77.2, 62.4 and 66.9 (May); 77.0, 60.8 and 67.2 (Jun); 76.7, 58.2 and 63.7 (Jul); 75.0, 55.1 and 61.7 (Aug); 58.7, 52.1 and 54.2 (Sep); 57.4, 52.5 and 54.5^{o}F (to 15 Oct). Precipitation was 2.98 in. (May), 5.76 in. (Jun), 5.62 in. (Jul), 5.25 in. (Aug), 1.09 in. (Sep) and 1.25 in. to 15 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 30 Sep were 3515.

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 15 and 32% foliar infection by 8 and 15 Sep, respectively. All treatments had significantly less combined early blight and brown leaf spot on each evaluation date and RAUDPC. All fungicide programs had significantly less foliar tan spot values than the untreated control (36.3%). Treatments with less than 13.8% foliar tan spot had the greatest level of control. Phytotoxicity was not noted in any of the treatments.

Funding: Agrochemical industry

Treatment and rate/A	Foliar Early Blight + Brown Leaf Spot (%) 27 Aug 3 DAFA[z]		8 Sep 15 DAFA		15 Sep 22 DAFA		Foliar Early Blight + Brown Leaf Spot RAUDPC[y] 25 DAIE[x]		Foliar Botrytis Tan Spot (%) 15 Sep 22 DAFA	
Echo ZN 4.17SC 2.12 pt (A,C,E,I[w]); 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)…………………………	2.3	c	3.0	e	8.8	d	3.5	d	7.5	cd
LEM17 200EC 12 fl oz (A,C,E,G,I); Tanos 50WG 6 oz + Manzate 75WG 1.5 lb (B,D,F,H)...	3.0	c	8.0	cde	11.3	d	6.0	cd	12.5	bcd
LEM17 200EC 16 fl oz (A,C,E,G,I); Tanos 50WG 6 oz + Manzate 75WG 1.5 lb (B,D,F,H)..	4.3	bc	8.5	cd	11.5	d	6.7	cd	18.8	b
LEM17 200EC 24 fl oz (A,C,E,G,I); Tanos 50WG 6 oz + Manzate 75WG 1.5 lb (B,D,F,H)...	4.0	bc	9.5	bcd	16.5	bcd	7.8	bc	15.0	b
Endura 7WG 2.5 oz (A,C,E,G,I); Tanos 50WG 6 oz + Manzate 75WG 1.5 lb (B,D,F,H)..	2.8	c	6.0	de	14.3	cd	5.7	cd	13.8	bc
USF2018A 500SC 11 fl oz (A-I)………………………	3.3	c	7.0	cde	15.0	bcd	6.4	cd	13.8	bc
Echo ZN 4.17SC 2 pt (A,B,D,F,H); USF2018A 500SC 11 fl oz (C,E); Scala 606SC 7 fl oz + Echo ZN 4.17SC 1.5 pt (G,I)…………………………..	4.0	bc	6.3	cde	15.3	bcd	6.3	cd	7.5	cd
Echo ZN 4.17SC 2 pt (A,B,D,F,H); USF2018A 500SC 6.84 fl oz (C,E); Scala 606SC 7 fl oz + Echo ZN 4.17SC 1.5 pt (G,I)...…	6.3	b	11.5	bc	22.5	b	10.4	b	6.3	d
Endura 7WG 3.1 oz + Bravo WS 6SC 4.17SC 1.5 pt (A-I)……………………	6.3	b	14.0	b	21.5	bc	11.3	b	12.5	bcd
Untreated……………………………………………….	10.8	a	28.8	a	62.5	a	25.4	a	36.3	a
$LSD_{0.05}$	2.45		5.39		8.03		3.55		6.59	

[z] Days after final application of fungicide.
[y] RAUDPC, relative area under the disease progress curve calculated from day of appearance of initial symptoms (DAIE).
[x] DAIE, days after initial symptoms observed and evaluated.
[w] Application dates: A= 24 Jun; B= 1 Jul; C= 8 Jul; D= 16 Jul; E= 22 Jul; F= 29 Jul; G= 5 Aug; H= 12 Aug; I= 24 Aug.
[v] Values followed by the same letter are not significantly different at $p = 0.05$ (Fishers LSD).

Funding: MPIC, MSU GREEEN, USDA

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

W. Kirk, A. Rojas, P. Tumbalam, E. Gachango, P. Wharton, F. Abu-El Samen, D. Douches, J. Coombs, C. Thill, A. Thompson

Abstract

The interactions of different cultivars/Advance Breeding Lines (ABL) of potato with different genotypes of the potato late blight pathogen (*Phytophthora infestans*) at three storage temperatures on tuber late blight development were evaluated. The contribution of the medullar storage tissues was assessed rather than the periderm and outer cortical cell tissue. Tuber late blight severity measured as tuber darkening [mean Relative Average Reflectance Intensity {RARI (%)}] generally increased with temperature. There was little difference in tuber late blight development between 7 and 10°C treatments and in some combinations significantly more tissue darkening developed at 7 than at 10°C but little or no development occurred at 3°C. Resistance in tubers was observed only in Torridon and Stirling and to some extent Jacqueline Lee but the cultivar Missaukee had weak tuber resistance. The US-8 genotype isolates were the most aggressive in tubers in most years causing rapid and significantly more tuber damage than any other genotype of *P. infestans* and similar to the US-6, US-10 and US-14 isolates used in 2006. The variability of susceptibility of tubers to different genotypes of *P. infestans* has implications for plant breeding efforts in that the major emphasis in the past has been to breed for foliar resistance with limited emphasis on the reaction of the tuber.

Introduction

Potato late blight is the most important and most destructive disease of potato worldwide. The disease caused by the oomycete *Phytophthora infestans* (Mont. de Bary) is the greatest threat to the potato crop, accounting for significant annual losses in North America (Guenthner et al. 2001; Guenthner et al. 1999) and worldwide (Hijmans 2001). Tuber late blight results in tuber rotting both in the field and later in storage either in tubers intended for seed or consumption (Bonde and Schultz 1943; Johnson and Cummings 2009; Kirk et al. 1999; Lambert and Currier 1997; Melhus 1915; Murphy and McKay 1924; 1925; Olanya et al. 2009). Seed tubers infected with *P. infestans* will either rot in storage, after planting in the field or survive and initiate new epidemics of potato late blight (Doster et al. 1989; Dowley and O'Sullivan 1991; Kirk et al. 2009; Stevenson et al. 2007). The epidemiology of the foliar phase of the disease is correlated to infection in the tuber phase and vice versa (Bain et al. 1997). Tubers are usually infected by inoculum produced on the plant foliage that is subsequently washed down to the soil by water movement resulting from rainfall and irrigation (Andrivon 1995; Fry 2008; Porter et al. 2005; Stevenson et al. 2007). Tubers can become blighted shortly after the disease is established on the foliage. *P. infestans* survives in tubers where it rots tubers intended for commercial use (Niemira et al. 1999) or acts as primary source of inoculum for infection in the following growing season (Bonde and Schultz 1943).

Funding: MPIC, MSU GREEEN, USDA

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. 2001d; Lambert and Currier 1997). Historically, studies of the late blight pathogen on tubers were conducted when *P. infestans* populations were dominated by US-1, a clonal lineage (Goodwin et al. 1994). Today, populations of *P. infestans* have changed and tuber resistance studies need to continue because the US-8 genotype is now predominant and there is a gap in our understanding of these more aggressive genotypes. The dynamics of potato blight development in tubers are largely influenced by temperature (Kirk et al. 2001d) 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 objectives of this study were to evaluate the interactions of different cultivars/Advanced Breeding Lines (ABL) of potato between different genotypes of *P. infestans* and storage temperature on tuber late blight development.

Materials and Methods

Germplasm selection

Potato breeding efforts at Michigan State University and other potato breeding programs in the US have resulted in potato cultivars that are largely resistant to foliar late blight (Douches et al. 2004; Kirk et al. 2001b; Kirk et al. 2001c) but not significantly less susceptible than other cultivars in terms of tuber blight resistance (Kirk et al. 2001c). Potato late blight resistance estimates for the cultivars/Advanced Breeding Lines (ABL) used in this study were breeders' estimates and are given as foliar and tuber ratings below, respectively. US cultivars are exclusively rated against the US-8 genotype of *P. infestans* and were Jacqueline Lee [Resistant (R), Susceptible (S); Douches et al. (2001)]; Kalkaska [R,S; Douches et al. (2009)]; Missaukee [R,I; Douches et al. (2010)]; MSL171-A (R,R); MSL211-3 (R,I); MSL757-1 (R,I); MSL766-1 (R,I); MSM051-3 (R,I); MSM137-2 (I,I); MSM171-A (R,I); MSM182-1 (I,I); MSM183-AY (R,I); MSN105-1 (R,S); MN98642 (S,S); MN15620 (S,S); ND2470-27 (S,S); Dakota Diamond [S,S; Thompson et al. (2008)]; White Pearl [S,S; Groza et al. (2006)] and Megachip [S,S; Groza et al. (2007)]. Both UK cultivars Stirling and Torridon have a NIAB late blight resistance rating of 8 (foliage), 7 (tuber) equivalent to R,R in US scheme. All cultivars were classified as late maturing. Tubers for this study were obtained from the potato breeding programs at Michigan State University, University of Wisconsin, Madison, 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 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 immuno-diagnostic Alert Multi-well kit (Alert Multiwell Kit - *Phytophthora sp.* Neogen

Corporation, 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 in 2% sodium hypochlorite (Clorox) solution for 30 min. Tubers were dried in a controlled environment with continuous airflow at 15^{o}C in dry air (30% relative humidity) for 4 h prior to inoculation.

Culturing of *Phytophthora infestans* and tuber inoculations

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 selected isolates were from the collection of W. Kirk (Michigan State University). These isolates were acquired from field infections from 1995 to 2006 on foliage and tubers of potatoes of commonly grown in Michigan, USA. Pathogenicity was determined on foliage and tubers in tuber and detached leaf tests (Young et al. 2009). Since the genotypes US-1, US-1.7 and US-11 are rare in the US only single isolates representative of the range of genotypes were selected for this study. The experiments were carried out in controlled environment chamber studies. The trials were conducted from 2002 to 2007 (total of five experiments).

The isolates were grown in rye B media for 14 days in the dark at 18^{o}C 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^{o}C) 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 x 10^{6} total sporangia ml^{-1} (discharged and non-discharged). The sporangial suspensions were stored for 6 h at 4^{o}C to encourage zoospore release from the sporangia.

Whole tuber inoculation with P. infestans

Tuber late blight development caused by the different *P. infestans* genotypes on the tuber cultivars/ABL were evaluated at different commonly used post-harvest potato storage temperatures (3, 7 and 10^{o}C) using whole tuber sub–peridermal inoculation. 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 4 h. Tubers were dried in a controlled environment with forced air ventilation at 5950 l min^{-1} at 15^{o}C in dry air (30% relative humidity) for four hours prior to inoculation.

The washed, surface-sterilized tubers were inoculated by a sub-peridermal injection of a sporangia suspension of 2 x 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^{o}C) 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^{o}C and 95% humidity and the sample tubers were incubated for 40 days until evaluation. The tuber tissue inoculation experiments were conducted in December 2002 to January 2003 and annually through December to January 2003 to 2008.

Evaluation of tuber blight

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 area selection cut-off threshold was set to 10 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 40 days after inoculation (DAI).

Data Analysis

The presence of *P. infestans* in sample tubers was confirmed by ELISA (described above) and by isolating pure cultures of *P. infestans* from the infected tuber tissue and successful re-inoculation of potato tubers and leaves. 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) was calculated as:

$$RARI(\%) = \left(1 - \frac{mean \quad ARI \quad treatment}{mean \quad ARI \quad control}\right) \times 100$$

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). Treatment effects were determined by ANOVA and comparisons were made among different temperatures within different genotypes within individual cultivars/ABL for each year; among different genotypes within different temperatures and individual cultivars/ABL for each year; and among different cultivars/ABL within different genotypes within different storage temperatures for each year. Data were not combined across years as different genotypes of *P. infestans* and different cultivars/ABL were used in each year.

Results

Incubation of inoculated tubers at 10^{o}C resulted in greatest tuber infection and tuber tissue discoloration within 40 days after inoculation (DAI) in 2003 regardless of genotype of *Phytophthora infestans* or cultivar/ABL although differences in some genotypes e.g. US-1.7 were not significant (Fig. 1). In 2004, there were no differences between 7 and 10^{o}C although no measurable disease developed at 3°C. In 2005, tuber late blight only developed at 10°C (data not shown). In 2006, there were only differences between storage temperature treatments in US-8 and very little disease developed at 3 or 7°C (Fig. 1). In 2007, there was a general increase across all genotypes with increase in temperature. As an example, tubers of "White Pearl" inoculated with *P. infestans* isolate *Pi*-02-007 (US-8 genotype) and incubated at 10°C for 40 days resulted in significant tuber infection and a range of RARI (%) values (Fig. 2).

The effect of genotype of *P. infestans* regardless of temperature in the different cultivars/ABL of potatoes showed a broad range of responses for each year (Fig. 3). The data are expressed as a percentage of the mean RARI (%) and individual sections have discrete values and are not cumulative (Fig. 3). Interactions among storage temperature, genotype aggressiveness and cultivar/ABL resistance were determined in these tests.

The US−8 genotype was the most aggressive, regardless of temperature in all years although in 2007, US-6, US-10 and US-14 caused a significant amount of tuber late blight regardless of temperature or cultivar/ABL (Fig. 4).

Tuber late blight development 2003

In 2003, 10 cultivars/ABL were tested to measure the tuber response to inoculation with different genotypes of *P. infestans* (Table 1). The RARI (%) varied in the different cultivars/ABL among genotypes and the responses were reported relative to each genotype of *P. infestans* (Table 1). Among the tuber inoculations, the US−8 genotype was most aggressive, followed by the US−11 and US−14 genotypes. The ABL "ND 2470-27" was the most susceptible to *P. infestans* genotypes with the highest RARI (%) value, and "Kalkaska" was the least susceptible cultivar/ABL in 2003 although still relatively susceptible to US-8 (Fig. 1, Table 1). "Jacqueline Lee" was particularly susceptible to US-1 and US-8 in 2003 but relatively resistant to other genotypes of *P. infestans* (Table 1).

Tuber late blight development 2004

The evaluation of *P. infestans* isolates in 2004 at different storage temperatures among different cultivars/ABL differed to that in measured in 2003. No disease was observed in inoculated tubers incubated at 3°C (Fig. 1, Table 2). There were no significant differences in tuber late blight development between 7 and 10°C. Overall, US−8 was the most aggressive genotype and was significantly different from the other genotypes. "White Pearl" was the most susceptible cultivar overall and "Megachip" was the most resistant (Fig. 3, Table 2). Following US−8, genotypes US−14 and US−11 caused moderate tuber late blight and US-1.7 caused moderate disease development at 10°C in "MN15620" (Table 2).

Tuber late blight development 2005

In 2005, no tuber late blight developed at 3 or 7°C and data were collected only at 10°C. The US−8 genotype was the most aggressive across the cultivars/ABL and genotypes US−11 and US−14 caused moderate tuber late blight (Figs. 3 and 4). "White Pearl" was the most susceptible cultivar and "Jacqueline Lee" and "Megachip" were the most resistant (Fig. 3 and Table 3). "Missaukee" was particularly susceptible to US-8 and not significantly different from "White Pearl" or "MN15620" (Table 3).

Tuber late blight development 2006

Very little late blight developed in inoculated tubers in 2006 at 3, 7 or 10^{o}C in cultivars/ABL inoculated with any genotype of *P. infestans* other than US-8. The US-8 genotype caused tuber late blight of which the severity increased with temperature from 3 to 10^{o}C (Fig. 1). The US−8 genotype was consistently aggressive on different cultivars regardless of temperature (Figs. 3 and 4). The most susceptible cultivar in 2006 was "Missaukee" and the most resistant were "Jacqueline Lee", "Torridon" and "Stirling" (Fig. 3 and Table 4). "Missaukee" was very susceptible to US-8 but also moderately susceptible to US-11 in 2006 (Table 4).

Tuber late blight development 2007

In 2007, new isolates of the US-10 and US-14 genotypes were used and largely tested on cultivars/ABL from the MSU breeding program. The amount of tuber late blight increased with temperature regardless of cultivar/ABL and the US-8, US-10 and US-11 genotypes were the most aggressive (Figs 1 and 4). The cultivars/ABL "MSM171-A", Jacqueline Lee" and "Torridon" were the most resistant and "MSL211-3", "Missaukee", "MSM051-3" and MSN105-1" were the most susceptible (Fig. 3 and Table 5).

Discussion

The significance of tuber late blight in initiating storage problems has been reported in many studies (Kirk et al. 1999; Kirk et al. 2001d) and recently reviewed (Olanya et al. 2009). Infection of potato tubers by *P. infestans* may be initiated by zoospores, sporangia or oospores washed in precipitation or irrigation water from plant foliage and deposited in soil (Fry 2008). Although three major components contribute to late blight resistance in tubers; the phellem cells (periderm), the outer cortical cell layers and the medulla storage tissues characterized by reduced hyphal growth and sporulation of *P. infestans* (Pathak and Clarke 1987) in this study, only the contribution of the medullar storage tissues was assessed.

Temperature has a profound influence on the physiology of potato tubers (Kaur et al. 2009; Knowles et al. 2009; Kumar 2009) and also on the pathology of tubers as pertaining to late blight (Kirk et al. 2001d; Lambert and Currier 1997). The inclusion of the three temperature conditions was intended to simulate late blight development in tubers stored for seed, table-stock and processing, 3, 7 and 10^{o}C, respectively. In this study, tuber late blight severity measured as tuber darkening [RARI (%)] generally increased with temperature as previously reported (Kirk et al 2001d). However, in some years no late blight developed at 3 or 7^{o}C even in susceptible cultivars/ABL. Temperature in the controlled environments was measured through the season with data loggers and while the temperature in the 7^{o}C environment was consistently between 6 and 7^{o}C in 2004-05 late blight developed only at 10^{o}C, although in most other years disease developed at the 7^{o}C storage treatment. The reason for the failure of late blight development in tubers is therefore unclear. Generally, there was little difference in tuber late blight development between 7 and 10^{o}C treatments and in some combinations significantly more tissue darkening developed at 7 than at 10^{o}C e.g. Jacqueline Lee by US-1 and US-11 (Table 2). In future experiments, it may be useful to incubate tubers from cooler temperatures at e.g. 10^{o}C as seed used for planting would be warmed prior to planting and as it is known that *P. infestans* can survive temperature exposure down to

-3°C for 5 days (Kirk 2003) it is very likely that mycelium would spread through the tubers and infect sprouts. In addition, seed-borne inoculum of the late blight pathogen has been linked to the initiation of late blight disease in the field (Boyd 1974; 1980; Doster et al. 1989; Dowley and O'Sullivan 1991; Johnson and Cummings 2009; Johnson 2010; Keil et al. 2010; Kirk et al. 2009; Platt et al. 1999).

Unlike foliage resistance, the genetics of tuber blight resistance have not been extensively studied (Olanya et al. 2009). Generally, cultivars with foliage blight resistance show some tuber blight resistance (Collins et al. 1999), but this depends on plant genotype (Świeżyński and Zimnoch-Guzowska 2001) and in some instances the relationship does not hold (Kirk et al. 2001c; Platt and Tai 1998). In this study, the inoculation technique utilized aimed to examine the resistance of medulla storage tissues which is characterized by mainly by reduced hyphal growth of *P. infestans* and therefore tuber symptoms e.g. tissue necrosis (Pathak and Clarke 1987; Niemira et al. 1999; Flier et al. 2001; Kirk et al. 2001). Such resistance may be linked to major gene resistance as recently reviewed by (Olanya et al. 2009). Park et al. (2005) analyzed tuber resistance in three mapping populations carrying *R* genes or a major QTL for foliar resistance to late blight. In one mapping population, tuber blight resistance was inherited independently of foliar blight and the other two populations tuber and foliage resistance were linked. In these two populations, the *R1* (or *R1-like*) gene acted on both foliage and tuber resistance. Resistance in both foliage and tubers is a very desirable trait in potatoes, but in this study only Torridon and Stirling appeared to have this quality and to some extent Jacqueline Lee (Douches et al. 2001). Jacqueline Lee and Missaukee (Douches et al. 2009) have strong foliar resistance to the US-8 genotype of *P. infestans*; but in this study Jacqueline Lee had only moderate or in the case of Missaukee weak resistance. This suggests that the genes responsible for foliage resistance are not present or at least active in the tubers.

Inoculation with the US-8 genotype of *P. infestans,* the dominant genotype in North America (Young et al. 2009), resulted in significant tuber late blight development for most cultivars and ABL tested. These findings are in agreement with Lambert and Currier (1997) and Lambert et al. (1998) who found that the US-8 genotype isolates were the most aggressive in tubers causing rapid and significantly more tuber damage than any other genotype of *P. infestans.* In this study, the isolates of the US-10 and US-14 genotypes of *P. infestans* used in from 2005 to 2007 were as aggressive as the US-8 isolates used throughout. Results of recent tuber rot severity experiments demonstrated similar trends in cultivar susceptibility and genotype aggressiveness on plant emergence (Kirk et al. 2009). Data from the two experiments conducted were strongly negatively correlated, where cultivars/ABL that demonstrated the highest level of plant emergence had the least tuber rotting and vice-versa. Results from this study and that of (Kirk et al. 2009) circumstantially suggest that highly aggressive genotypes of *P. infestans*, such as the US-8 genotype, may produce limited primary inoculum due to severe tuber rotting and deterioration of tubers before emergence. However, this scenario will depend mostly on the amount of inoculum of *P. infestans* found in or on potato tubers. In both studies, tuber seed pieces and stored tubers were exposed to an excessive amount of inoculum and results suggest that this amount of inoculum was sufficient to cause severe tuber rotting in some cultivars/ABL. The significant extent of tuber rotting and deterioration appears to be the primary symptom after inoculation with *P. infestans.* The variability of susceptibility of tubers to different genotypes of *P. infestans* has implications for plant breeding efforts in that the major emphasis in the past has been to breed for foliar resistance with limited emphasis on the reaction of the tuber. It is clear that at least as much emphasis should be apportioned to the tuber resistance phenotype.

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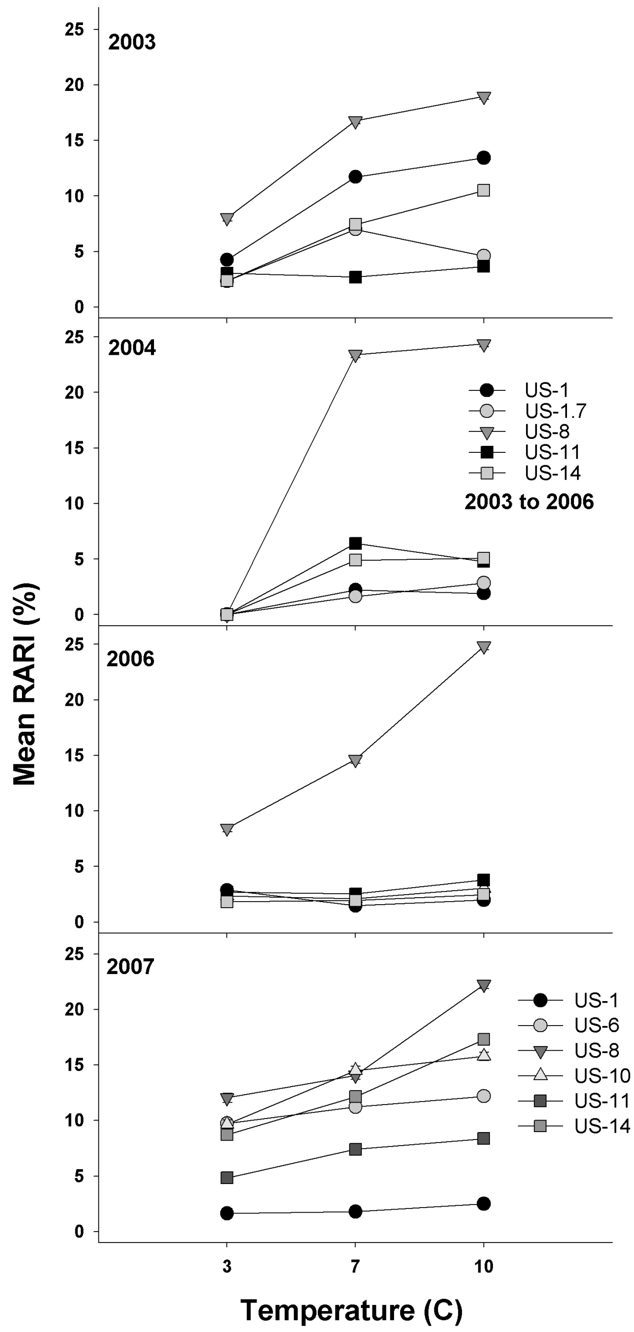

Figure 1. Main effect tuber responses of genotypes of *P. infestans* evaluated at three different temperatures representative of different storage regimes in tubers across cultivars and advanced breeding lines measured as mean Relative Average Reflection Intensity [RARI (%)]. The bars represent Fishers protected $LSD_{0.05}$.

Funding: MPIC, MSU GREEEN, USDA

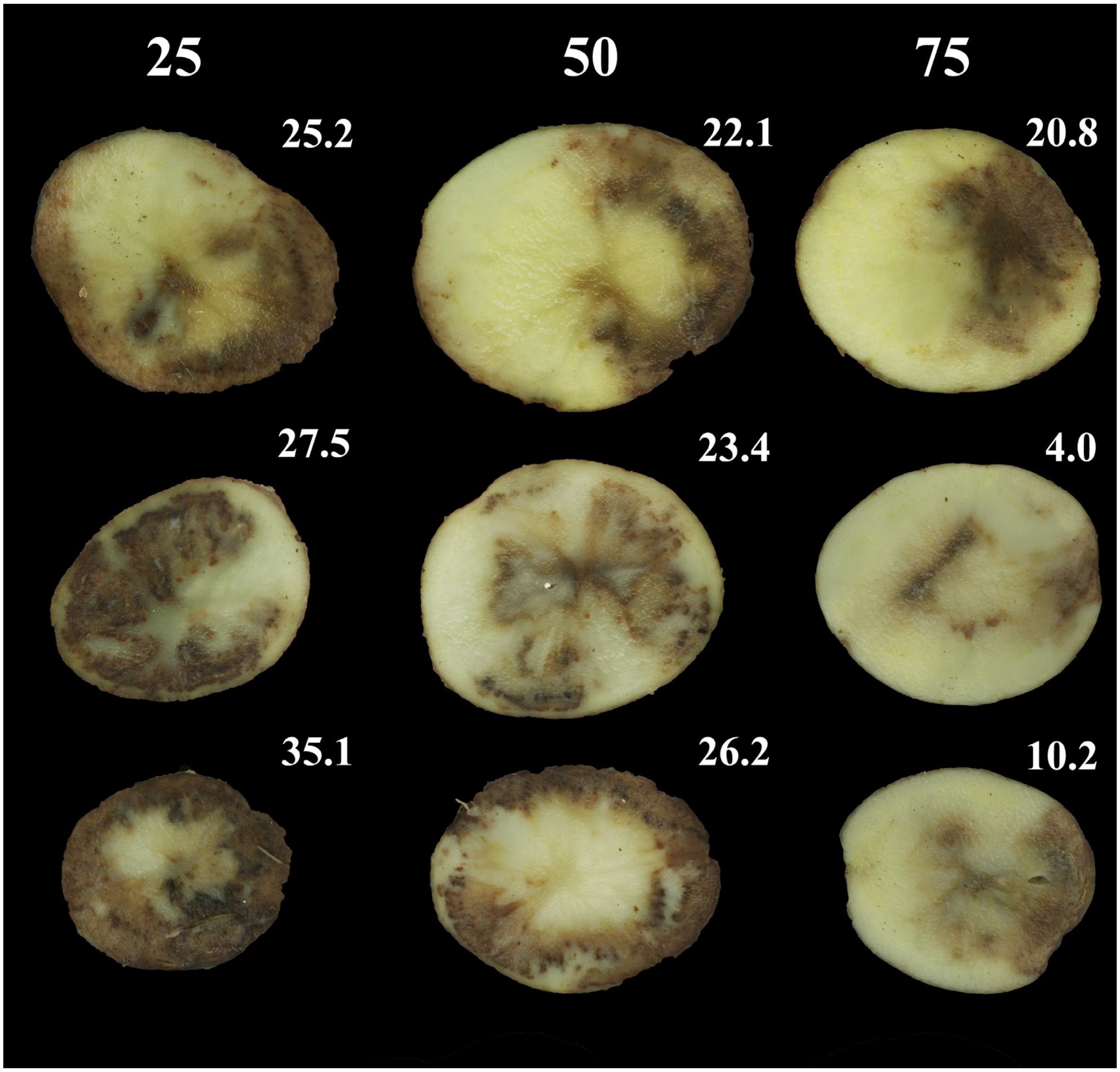

Figure 2. Digital image of three tuber sections from four potato tubers of White Pearl inoculated with *Phytophthora infestans* isolate *Pi*-02-007 (US-8 genotype). Numbers indicate relative average reflective intensity [RARI (%)] for each tuber section cut at 25, 50 and 75% from and parallel to the inoculated surface; RARI values are relative to the non-inoculated control tubers of the same ABL

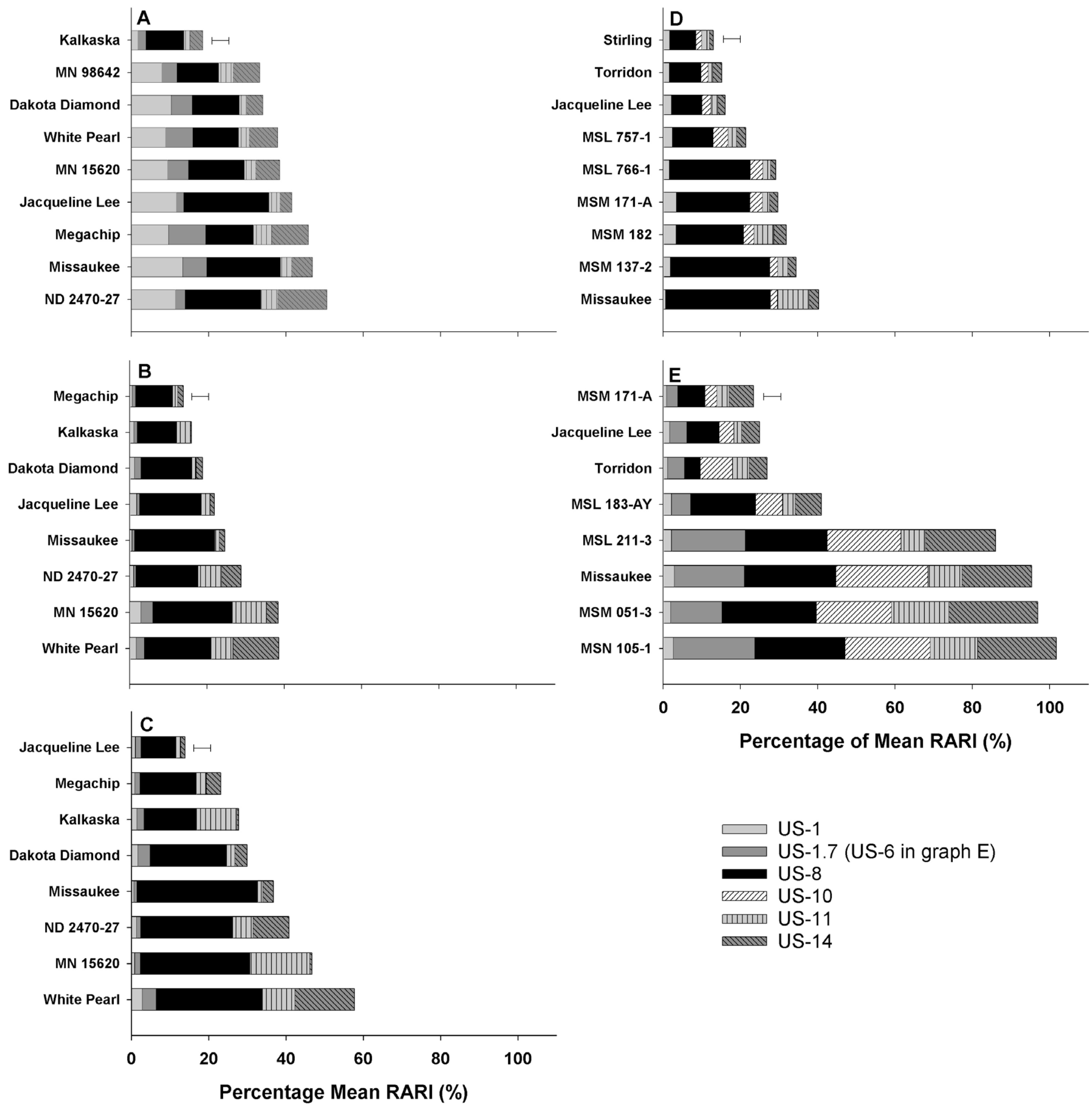

Figure 3. Tuber late blight response as percentage of mean Relative Average Reflection Intensity [RARI (%)], of different cultivars and advanced breeding lines inoculated with different *Phytophthora infestans* genotypes across the three storage temperatures in A) 2003; B) 2004; C) 2005; D) 2006 and E) 2007. The bars represent Fisher's protected $LSD_{0.05}$; A) 2003 = 3.16, B) 2004 = 3.10, C) 2005 = 3.11, D) 2006 = 3.10, E) 2007 = 3.03.

Funding: MPIC, MSU GREEEN, USDA

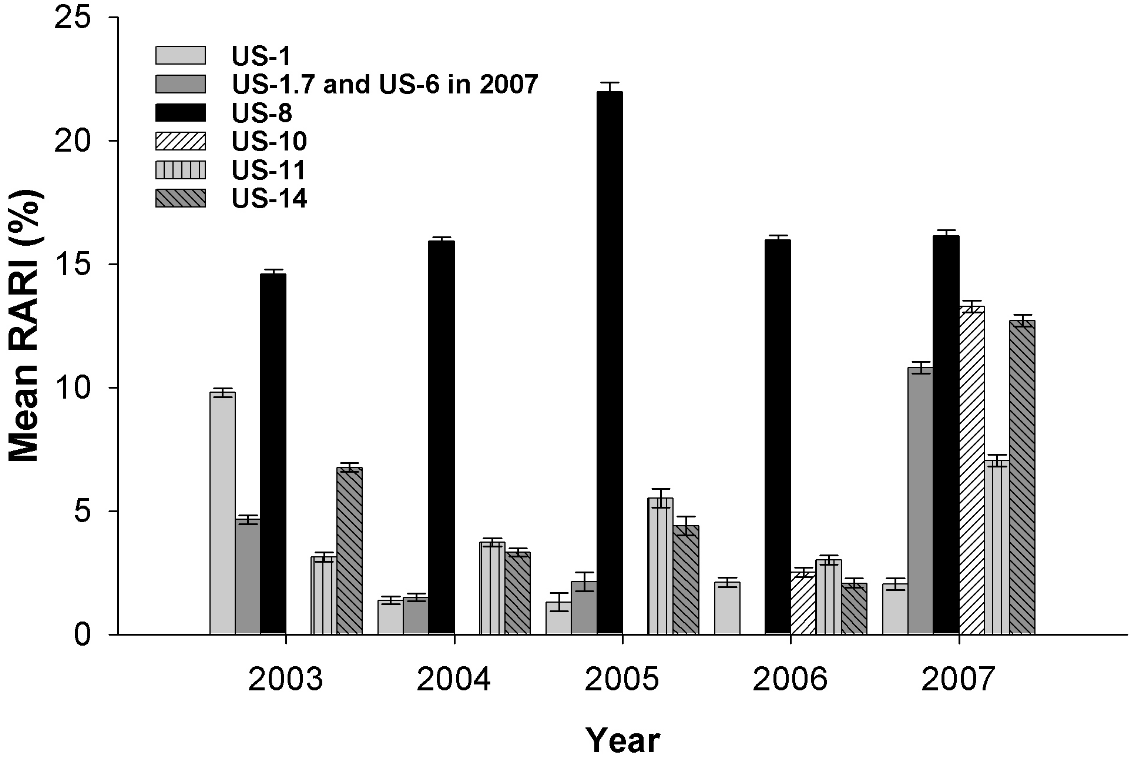

Figure 4. Main effects of different genotypes of *Phytophthora infestans* on tuber late blight on measured as mean Relative Average Reflection Intensity [RARI (%)] across different cultivars and Advanced Breeding Lines and storage temperature from 2003 to 2007. The bars represent Fisher's protected $LSD_{0.05}$.

Funding: MPIC, MSU GREEEN, USDA

Table 1. The 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* (2002 – 2003).

Cultivar/ABL	Storage Temperature (°C)	Tuber tissue darkening caused by different genotypes of *P. infestans* [Mean RARI (%)[a]] US-1		US-1.7		US-8		US-11		US-14	
Jacqueline Lee	3	5.71	h-m	1.36	i-k	11.86	f-k	2.78	b-e	2.30	i-k
	7	18.47	ab	3.74	f-k	30.87	a	2.78	b-e	3.67	f-k
	10	10.67	e-h	0.90	jk	23.41	bc	2.77	b-e	3.25	g-k
Kalkaska	3	1.42	m	1.37	i-k	4.74	m	0.70	e	1.53	jk
	7	1.90	m	2.81	g-k	10.05	h-m	1.84	c-e	3.12	h-k
	10	1.78	m	2.01	h-k	14.74	d-h	2.17	c-e	5.17	e-k
Megachip	3	6.35	g-m	5.67	e-g	7.69	j-m	5.21	a-d	4.51	f-k
	7	8.83	f-l	12.65	a	15.28	d-h	3.42	b-e	14.80	b
	10	13.85	b-f	10.54	a-c	14.14	e-i	5.29	a-d	9.14	c-e
Missaukee	3	4.44	k-m	3.11	g-k	5.41	lm	2.70	b-e	2.49	i-k
	7	16.72	a-d	9.37	a-d	19.29	c-e	1.86	c-e	5.85	e-j
	10	18.89	ab	5.86	d-g	32.69	a	3.94	a-e	8.05	c-f
MN15620	3	3.25	l-m	0.65	k	8.42	i-m	2.30	b-e	0.86	k
	7	10.17	e-j	11.07	ab	15.73	d-h	3.57	b-e	6.38	d-i
	10	14.65	b-e	4.64	f-i	19.29	c-e	2.69	b-e	11.37	bc
MN98642	3	4.54	j-m	1.30	i-k	6.43	k-m	2.98	b-e	2.36	i-k
	7	9.46	e-k	5.17	e-h	15.18	d-h	2.26	b-e	7.75	c-g
	10	9.62	e-k	5.33	e-h	10.91	g-l	5.66	a-c	10.77	b-d
ND 2470-27	3	4.11	k-m	2.01	h-k	10.47	h-m	7.72	a	3.05	i-k
	7	11.64	d-g	3.75	f-k	19.83	c-e	1.94	c-e	10.57	b-d
	10	18.35	ab	1.92	h-k	28.58	ab	3.22	b-e	24.58	a
Dakota Diamond	3	5.14	h-m	4.42	f-j	10.20	h-m	1.37	de	1.42	jk
	7	12.21	c-f	7.16	c-f	8.69	i-m	2.31	b-e	3.25	g-k
	10	13.77	b-f	4.67	f-i	17.52	d-f	2.24	b-e	7.71	c-h
White Pearl	3	4.73	i-m	2.12	h-k	6.81	j-m	1.66	de	2.10	i-k
	7	10.23	e-i	10.48	a-c	12.39	f-j	3.90	a-e	9.53	c-e
	10	11.64	d-g	8.64	b-e	16.32	d-g	2.45	b-e	10.60	b-d

[a] Normalized tuber tissue darkening score expressed as RARI (%) = $[1- \text{Mean ARI}_{treatment} / \text{Mean ARI}_{control}]$ *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).

Funding: MPIC, MSU GREEEN, USDA

Table 2. The 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* (2003 – 2004).

Cultivar/ABL	Temperature (°C)	Tuber tissue darkening caused by different genotypes of *P. infestans* [Mean RARI (%)[a]] US-1		US-1.7		US-8		US-11		US-14	
Jacqueline Lee	3	0.00	g[b]	0.00	f	0.00	i	0.00	f	0.00	f
	7	4.39	b	0.92	ef	21.28	ef	5.47	c-e	2.28	ef
	10	1.11	d-g	1.47	c-f	26.49	b-e	1.27	ef	1.06	f
Kalkaska	3	0.00	g	0.00	f	0.00	i	0.00	f	0.00	f
	7	2.57	b-e	1.25	d-f	18.48	fg	1.50	ef	0.37	f
	10	0.89	e-g	1.35	d-f	12.14	h	9.14	b-d	0.24	f
Megachip	3	0.00	g	0.00	f	0.00	i	0.00	f	0.00	f
	7	1.01	e-g	1.22	d-f	14.27	gh	1.56	ef	1.17	ef
	10	0.97	e-g	1.37	d-f	14.51	gh	2.59	ef	2.98	d-f
Missaukee	3	0.00	g	0.00	f	0.00	i	0.00	f	0.00	f
	7	1.19	c-g	1.18	d-f	31.16	ab	1.89	ef	1.59	ef
	10	0.72	fg	0.76	ef	31.26	ab	1.35	ef	2.67	ef
MN15620	3	0.00	g	0.00	f	0.00	i	0.00	f	0.00	f
	7	1.77	c-g	0.83	ef	27.38	b-d	16.33	a	1.50	ef
	10	7.03	a	8.42	a	34.34	a	10.22	bc	7.47	cd
ND2470-27	3	0.00	g	0.00	f	0.00	i	0.00	f	0.00	f
	7	1.76	c-g	0.84	ef	24.28	c-f	13.11	ab	5.64	c-e
	10	1.39	c-g	1.06	ef	23.87	d-f	5.19	de	9.33	c
Dakota Diamond	3	0.00	g	0.00	f	0.00	i	0.00	f	0.00	f
	7	2.02	c-f	1.84	c-f	19.73	fg	1.26	ef	1.58	ef
	10	1.77	c-g	3.13	b-e	19.78	fg	2.13	ef	3.18	d-f
White Pearl	3	0.00	g	0.00	f	0.00	i	0.00	f	0.00	f
	7	2.22	c-f	2.85	b-e	24.13	c-f	8.67	b-d	20.13	a
	10	2.92	b-d	3.53	b-d	27.50	b-d	8.41	b-d	15.36	b

[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).

Funding: MPIC, MSU GREEEN, USDA

Table 3. The 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* (2004 – 2005).

Cultivar/ABL	Temperature (^oC)	Tuber tissue darkening caused by different genotypes of *P. infestans* [Mean RARI (%)[a]]									
		US-1		US-1.7		US-8		US-11		US-14	
Jacqueline Lee	10[c]	1.11	k[b]	1.47	k	9.02	f-i	1.27	k	1.06	k
Kalkaska	10	1.52	k	1.87	k	13.51	d-f	10.47	e-g	0.43	k
Megachip	10	0.97	k	1.37	k	14.51	d-f	2.59	jk	3.76	h-k
Missaukee	10	0.72	k	0.76	k	31.26	a	1.35	k	2.67	jk
MN15620	10	0.92	k	1.46	k	28.35	ab	15.50	de	0.49	k
Dakota Diamond	10	1.77	k	3.13	h-k	19.78	cd	2.13	jk	3.18	h-k
ND2470-27	10	1.39	k	1.06	k	23.87	bc	5.19	g-k	9.33	e-h
White Pearl	10	2.92	i-k	3.53	h-k	27.50	ab	8.41	f-j	15.36	de

[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 among all *P. infestans* genotypes of cultivar/ABL combinations (Based on Fishers protected LSD).

[c] No tuber tissue infection occurred at 3 or 7^{o}C in 2004-05 tests.

Funding: MPIC, MSU GREEEN, USDA

Table 4. The 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* (2005 – 2006).

Cultivar/ABL	Temperature (°C)	Tuber tissue darkening caused by different genotypes of *P. infestans* [Mean RARI (%)[a]] US-1		US-8		US-10		US-11		US-14	
Jacqueline Lee	3	3.45	a-e	5.20	h-k	3.37	b-d	1.89	cd	2.66	
	7	2.22	a-f	7.19	h-k	2.47	b-d	3.18	b-d	2.14	
	10	0.89	ef	11.30	f-i	1.02	cd	0.36	cd	0.75	
Missaukee	3	0.85	ef	19.32	d-f	1.97	b-d	2.74	cd	1.71	c-f
	7	0.08	f	26.91	a-d	1.99	b-d	3.77	bc	3.37	a-e
	10	1.04	d-f	35.27	ab	1.29	cd	18.14	a	2.22	c-f
MSL757-1	3	4.10	a-d	0.88	k	3.37	b-d	2.55	cd	1.28	d-f
	7	1.02	d-f	7.24	h-k	0.82	d	1.38	cd	0.41	f
	10	2.08	b-f	23.56	cd	7.48	a	2.64	cd	5.45	ab
MSL766-1	3	1.71	c-f	9.63	g-k	1.19	cd	1.01	cd	1.34	d-f
	7	2.88	a-f	26.21	b-d	2.76	b-d	3.70	bc	1.91	c-f
	10	0.30	ef	27.03	a-d	5.73	ab	1.35	cd	0.56	ef
MSM137-2	3	0.85	ef	22.03	de	1.05	cd	2.49	cd	0.64	ef
	7	0.44	ef	23.81	cd	1.59	cd	2.67	cd	1.02	ef
	10	4.33	a-c	31.46	a-c	3.42	b-d	2.66	cd	4.58	a-c
MSM171-A	3	5.39	a	9.00	h-k	1.81	b-d	2.26	cd	3.14	a-f
	7	3.12	a-f	21.67	de	5.04	a-c	2.29	cd	2.29	c-f
	10	1.94	b-f	26.26	b-d	2.87	b-d	1.08	cd	1.00	ef
MSM182-1	3	3.35	a-e	5.59	h-k	2.48	b-d	6.38	b	2.07	c-f
	7	1.86	b-f	10.76	f-j	1.75	b-d	2.76	cd	1.74	c-f
	10	4.99	ab	35.95	a	3.88	a-d	6.26	b	5.72	a
Stirling	3	3.10	a-f	1.63	jk	3.08	b-d	3.73	bc	1.90	c-f
	7	0.47	ef	4.36	i-k	0.61	d	0.71	cd	0.41	f
	10	1.67	c-f	14.27	e-h	0.91	d	1.47	cd	0.71	ef
Torridon	3	3.04	a-f	2.62	i-k	2.82	b-d	1.14	cd	1.54	d-f
	7	1.16	c-f	3.44	i-k	2.06	b-d	2.23	cd	4.11	a-d
	10	0.66	ef	18.47	d-g	0.72	d	0.22	d	1.22	d-f

[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).

Funding: MPIC, MSU GREEEN, USDA

Table 5. The 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* (2006 – 2007).

Cultivar/ABL	Temperature (°C)	Tuber tissue darkening caused by different genotypes of *P. infestans* [Mean RARI (%)[a]] US-1		US-6		US-8		US-10		US-11		US-14	
Jacqueline Lee	3	1.48	c-f	4.10	fg	4.44	ij	3.17	j	1.90	fg	3.35	kl
	7	1.27	c-f	4.68	fg	5.56	i	5.09	ij	2.67	fg	2.97	kl
	10	2.32	b-f	4.84	fg	15.00	e-g	3.10	j	1.38	g	7.69	h-k
Missaukee	3	1.36	c-f[b]	13.09	de	17.44	d-f	18.40	c-e	3.41	f-g	12.14	e-h
	7	1.87	b-f	13.85	cd	20.74	cd	20.60	b-e	10.40	de	17.84	c-e
	10	5.60	a	27.15	a	33.11	a	32.47	a	12.55	b-d	24.15	ab
MSL183-AY	3	2.36	b-f	4.46	fg	11.42	gh	3.30	j	3.13	fg	6.63	h-l
	7	3.13	b-d	5.84	fg	14.73	fg	9.51	g-i	4.19	fg	7.60	h-k
	10	1.04	d-f	4.58	fg	24.42	b	7.91	h-j	2.51	fg	6.00	i-l
MSL211-3	3[c]	-		-		-		-		-		-	
	7	2.46	b-f	21.16	b	14.24	fg	19.91	b-e	5.00	fg	17.13	cf
	10	2.25	b-f	18.43	bc	32.09	a	22.04	bc	9.67	de	23.03	a-c
MSM051-3	3	0.94	d-f	8.63	ef	18.23	de	14.94	e-g	11.25	cd	14.44	d-g
	7	2.15	b-f	13.10	de	23.41	bc	20.85	b-d	15.86	ab	26.69	a
	10	2.93	b-e	18.14	bc	31.64	a	22.28	bc	17.37	a	28.00	a
MSM171-A	3	1.28	c-f	3.95	fg	7.79	hi	3.66	j	2.69	fg	2.33	kl
	7	0.94	d-f	3.00	g	7.15	i	3.07	j	3.60	fg	4.59	j-l
	10	0.54	f	1.82	g	6.29	i	2.35	j	3.14	fg	11.80	f-i
MSN105-1	3	3.39	a-c	21.90	b	18.47	de	15.31	d-f	9.84	de	15.48	d-g
	7	0.75	ef	22.71	ab	20.93	b-d	25.29	b	11.37	b-d	18.33	b-d
	10	3.92	ab	18.45	bc	30.67	a	25.59	b	15.57	a-c	27.10	a
Torridon	3	0.41	f	3.81	fg	1.45	j	2.94	j	2.12	fg	1.23	l
	7	1.74	b-f	5.39	fg	5.85	i	11.70	f-h	6.18	ef	1.99	kl
	10	1.39	c-f	4.10	fg	4.76	ij	10.45	f-i	4.76	fg	10.46	g-j

[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).

[c] Insufficient tubers of MSL 211-3 to inoculate and store at 3°C.

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Evaluation and comparison of biofungicides and fungicides for the control of post harvest potato tuber diseases.

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Summary

Potatoes are susceptible to a variety of storage pathogens, including late blight (*Phytophthora infestans*), Fusarium dry rot (*Fusarium sambucinum*), Pythium leak (*Pythium ultimum*) and silver scurf (*Helminthosporium solani*). Current recommendations for potato storage diseases include sanitation and exclusion as the primary controls for these pathogens in storage facilities. Few fungicides are registered for direct application to tubers for control of these important pathogens and few compounds are available for potato tuber treatment in storage, including chlorine-based disinfectants such as, sodium hypochlorite, calcium hypochlorite and chlorine dioxide.

In recent years several new biofungicides based on the biocontrol bacteria *Bacillus subtilis* (Serenade) and *B. pumilis* (Sonata) have been registered or are awaiting EPA approval for use on potato, and have shown promise in the control of seed and soil borne diseases such as late blight, black scurf and pink rot. These products have been evaluated for the control of pathogens under post-harvest potato tuber storage conditions. Thus, studies were initiated to evaluate the efficacy of these biofungicides for the control of potato storage pathogens under post-harvest conditions. For a comparison, several commercial storage products Phostrol (sodium, potassium and ammonium phosphates), and Oxidate (hydrogen dioxide) and experimental treatments such as Quadris (azoxystrobin) and mixtures of azoxystrobin and fludioxinil (Maxim) at different rates ± thiabendazole (Mertect) and more recently difenoconazole were evaluated for their effectiveness under storage conditions. Preliminary results show that in general the conventional fungicides (azoxystrobin, fludioxinil and difenoconazole) provided the most effective disease control. The biofungicides provided moderate control. The objective of these trials was to continue the evaluation of fungicides and biofungicides against the most common storage disease encountered in Michigan potato production.

Materials and Methods

Experiments were carried out in November 2009 with potato cultivars "FL1879", and "Dark Red Norland". The tests were carried out at two storage temperatures used in the potato industry; 10^{o}C (49^{o}F), chip processing and 4^{o}C (39^{o}F), table stock and seed. The cultivars used in the 10^{o}C test were cv. FL1879 a chip processing cultivar; cv. Dark Red Norland at 4^{o}C a red skinned table-stock cultivar. Potatoes free from visible diseases [except cv. Dark Red Norland that was uniformly infected with *H. solani* (*Hs*, silver scurf, 20% of surface area affected) at the time of application] were selected for the trials from tubers harvested in October 2006. Tubers were prepared for inoculation with *Phytophthora infestans* (*Pi*), *P. erythroseptica* (*Pe*), *Pythium ultimum* (*Py*), and *Fusarium sambucinum* (*Fs*) by grazing with a single light stroke with a wire brush, sufficient to abrade the skin of the tubers to a depth of 0.01 mm. Solutions (1 x 10^3/ml) of sporangia/zoosporangia of *Pi* (late blight), oospores/sporangia of *Pe* (pink rot), oospores of *Py* (Pythium leak), and macroconidia of *Fs* (dry rot) were prepared from cultures of the pathogens previously isolated from potato tubers in Michigan. All pathogens were grown in Potato Dextrose Nutrient Broth for 20 days prior to preparation of inoculum solutions. Two non-treated controls, either inoculated with one of the pathogens or non-inoculated were included in the trial.

Inoculated and damaged/inoculated tubers, (50/replicate/treatment; total 200 tubers/treatment) were sprayed with 10 ml of pathogen suspension, for a final dosage of about 0.25 ml per tuber. Tubers were stored for 2-d after inoculation at 20°C before treatment. Fungicides were applied as liquid treatments in a water suspension with a single R&D XR11003VS spray nozzle at a rate of 1L/ton at 50 psi onto the tuber surfaces, with the entire tuber surface being coated. After inoculation, tubers were incubated in the dark in plastic boxes at 10°C or 4°C (depending on cultivar and disease combination) for 90 (oomycete pathogens and dry rot) to xxx days. The oomycete diseases were evaluated as the percent incidence of tubers with any signs or symptoms of the pathogen. Tubers with surface sporulation, discoloration of the skin or blackened/dead sprouts were considered infected. The remaining tubers were cut open and the number of tubers with symptoms or signs of the individual pathogens were counted to determine incidence of disease. Dry rot was and silver scurf disease severity was assessed using a disease severity index. Disease severity classes were determined as class 0 = 0%; 1 = 1 - 10%; 2 = 11 - 20%; 3 = 21 - 50; 4 > 51 – 100% internal area of tuber tissue with disease (dry rot) or surface area affected (silver scurf). The disease severity index was then calculated as the number in each class multiplied by the class number and summed. The sum was then multiplied by a constant to express severity on a 0 – 100 scale. Data were analyzed by two-way ANOVA using ARM software (Version 7, Gylling Data Management) and mean separation calculated using Fisher's protected least significant difference (LSD) test at $P = 0.05$.

Results and Conclusions

In the late blight test at 10°C, late blight developed in several treatments and the inoculated check had 58.8% incidence (Table 1). No late blight developed in the non-inoculated check. Treatments with less than 58.8% incidence of late blight were significantly different from the inoculated check. Treatments with greater than 10.0% incidence of late blight were significantly different from the non-inoculated check.

In the pink rot test at 10°C, pink rot developed in several treatments and the inoculated check had 65.0% incidence (Table 2). No pink rot developed in the non-inoculated check. Treatments with less than 65.0% incidence of pink rot were significantly different from the inoculated check. Treatments with greater than 7.5% incidence of pink rot were significantly different from the non-inoculated check.

In the pythium leak test at 10°C, pythium developed in several treatments and the inoculated check had 60.0% incidence (Table 3). No pythium developed in the non-inoculated check. Treatments with less than 60.0% incidence of pythium were significantly different from the inoculated check. Treatments with greater than 6.3% incidence of pythium were significantly different from the non-inoculated check.

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In the Fusarium dry rot studies at 10^{o}C Fusarium dry rot developed in several treatments and the inoculated check had 70% incidence and 31.9-severity index (Table 4). The non-inoculated check had significantly less dry rot incidence and severity than the inoculated check. Treatments with less than 56.3% incidence of dry rot were significantly different from the inoculated check. Treatments with greater than 13.8% dry rot incidence were significantly different from the non-inoculated check. Treatments with less than 24.1 dry rot severity index were significantly different from the inoculated check. Treatments with greater than 5.9 dry rot severity index were significantly different from the non-inoculated check.

In the silver scurf leak test at 4^{o}C on Dark Red Norland, severe silver scurf developed in several treatments and the inoculated check had 93.1% incidence of silver scurf (percentage of tubers in class 0) and 55.6% severity index (Table 5). Although the percentage incidence and severity were relatively high in all treatments, they were all significantly lower than the untreated check.

In this study, the oomycetes were not all controlled equally by the same programs. For example, Ranman 400SC 0.25 fl oz gave excellent control of late blight and pythium leak but was moderately effective against pink rot. GWN-4700 alone and in mixture was effective against all three oomycetes and not significantly different from the standard program, Phostrol. Late blight was well controlled by many products including WE1042-1, which was possibly related to the inoculation technique in that the pathogen had not fully penetrated the lenticels by the time the fungicides/biofungicides were applied. This was also true of the Pythium study but the rate of growth and penetration of *Phytophthora erythroseptica* may have been at a rate great enough for the infection to occur and establish prior to the application of the products. The biological controls were generally les effective than the best chemical controls but still provide some useful reduction in the establishment of the oomycetes. For example, BUPots-4 in the Pythium trial and the late blight trial and BuPots-1 in the pink rot trial.

In the dry rot trial, the three-way mixtures of fludioxinil, azoxystrobin and difenoconazole produced excellent control and at all rates of the fungicides (especially at the highest mixture rate of difenoconazole). While treatment with fludioxinil and azoxystrobin together or difenoconazole alone provided effective but numerically less dry rot control than the three-way mixtures although in terms of severity there was no significant difference among treatments. The biological control products in some cases provided a moderate reduction in incidence and severity of dry rot.

In the silver scurf trial, azoxystrobin plus fludioxinil and all rates of difenoconazole in the three-way mixtures of fludioxinil, azoxystrobin and difenoconazole produced the best control but only suppressed the development of silver scurf. WE1042-1 75DS and the biological control products provided a moderate reduction in incidence and severity of silver scurf.

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USDA/ARS

Table 1. Incidence of tubers with potato late blight stored at 10°C for 90 days after treatment with fungicides/biofungicides.

Treatments and rate of application per cwt of tubers	Late blight incidence (%)[a]	
Non-inoculated check……………………………………………	0.0	l[b]
Inoculated check…………………………………………………	58.8	a
Ranman 400SC 0.025 fl oz…………………………………...	11.3	f-k
Ranman 400SC 0.05 fl oz…………………………………….	7.5	h-l
Ranman 400SC 0.125 fl oz…………………………………...	10.0	g-l
Ranman 400SC 0.25 fl oz…………………………………….	0.0	l
Phostrol 53.6SC 1.28 fl oz……………………………………	3.8	jkl
Oxidate 27SC 0.125 fl oz……………………………………..	6.3	i-l
GWN-4700 80WP 0.14 oz……………………………………	12.5	f-j
GWN-4700 80WP 0.14 oz + Phostrol 53.6SC 1.28 fl oz……….	15.0	e-i
GWN-4700 80WP 0.14 oz + Phostrol 53.6SC 1.28 fl oz[c]………	6.3	i-l
GWN-4700 80WP 0.14 oz + A8574 360FS[d] 0.03 fl oz…………	7.5	h-l
GWN-4700 80WP 0.14 oz + A9859 230SC[d] 0.03 fl oz…………	3.8	jkl
GWN-4700 80WP 0.14 oz + A8574 360FS 0.03 fl oz + A9859 230SC 0.03 fl oz………………………………………	1.3	kl
09 BuPots-1 100L 0.2 fl oz…………………………………...	18.8	d-g
09 BuPots-2 100WS 1.52 oz………………………………….	17.5	d-h
09 BuPots-3 100WS 1.52 oz………………………………….	23.8	de
09 BuPots-4 100LS 0.2 fl oz………………………………….	7.5	h-l
09 BuPots-5 100LS 0.3 fl oz………………………………….	13.8	e-j
WE1042-1 75DS 1 lb……………………………………………	3.8	jkl
ME02-7008A 100D 1 lb…………………………………………	26.3	cd
ME03-5709A 100D 1 lb…………………………………………	23.8	de
W103-5B 100D 1 lb……………………………………………..	36.3	bc
ND04-1A 100D 1 lb……………………………………………..	21.3	def
Vermiculite 100D 1 lb…………………………………………...	37.5	b
$LSD_{0.05}$	10.13	

[a] Late blight incidence (%); tubers with any symptoms and signs of *Phytophthora infestans*.
[b] Values followed by the same letter are not significantly different at $P = 0.05$ level according to Fisher's protected least significant difference (LSD) test.
[c] Applied in 4 pt H_2O/ton tubers.
[d] A8574D= difenoconazole; A9859= fludioxinil.

Funding: MPIC/Agrochemical Industry
USDA/ARS

Table 2. Incidence of tubers with pink rot stored at 10^{o}C for 90 days after treatment with fungicides/biofungicides.

Treatments and rate of application per cwt of tubers	Pink Rot incidence (%)[a]	
Non-inoculated check…………………………………………	0.0	k
Inoculated check………………………………………………	65.0	a
Ranman 400SC 0.025 fl oz…………………………………...	13.8	f-i
Ranman 400SC 0.05 fl oz……………………………………	18.8	efg
Ranman 400SC 0.125 fl oz…………………………………...	20.0	ef
Ranman 400SC 0.25 fl oz……………………………………	20.0	ef
Phostrol 53.6SC 1.28 fl oz……………………………………	10.0	hij
Oxidate 27SC 0.125 fl oz……………………………………..	3.8	jk
GWN-4700 80WP 0.14 oz……………………………………	8.8	ij
GWN-4700 80WP 0.14 oz + Phostrol 53.6SC 1.28 fl oz……….	7.5	ijk
GWN-4700 80WP 0.14 oz + Phostrol 53.6SC 1.28 fl oz[c]………	11.3	g-j
GWN-4700 80WP 0.14 oz + A8574 360FS[d] 0.03 fl oz…………	10.0	hij
GWN-4700 80WP 0.14 oz + A9859 230SC[d] 0.03 fl oz…………	8.8	ij
GWN-4700 80WP 0.14 oz + A8574 360FS 0.03 fl oz + A9859 230SC 0.03 fl oz………………………………………	8.8	ij
09 BuPots-1 100L 0.2 fl oz…………………………………...	7.5	ijk
09 BuPots-2 100WS 1.52 oz…………………………………	10.0	hij
09 BuPots-3 100WS 1.52 oz…………………………………	21.3	def
09 BuPots-4 100LS 0.2 fl oz…………………………………	22.5	de
09 BuPots-5 100LS 0.3 fl oz…………………………………	17.5	e-h
WE1042-1 75DS 1 lb…………………………………………	21.3	def
ME02-7008A 100D 1 lb………………………………………	8.8	ij
ME03-5709A 100D 1 lb………………………………………	28.8	cd
W103-5B 100D 1 lb…………………………………………..	35.0	c
ND04-1A 100D 1 lb…………………………………………..	28.8	cd
Vermiculite 100D 1 lb………………………………………...	33.8	c
Vermiculite 100D 1 lb	53.8	b
$LSD_{0.05}$	8.02	

[a] Late blight incidence (%); tubers with any symptoms and signs of *Phytophthora infestans*.
[b] Values followed by the same letter are not significantly different at P = 0.05 level according to Fisher's protected least significant difference (LSD) test.
[c] Applied in 4 pt H_2O/ton tubers.
[d] A8574D= difenoconazole; A9859= fludioxinil.

Funding: MPIC/Agrochemical Industry
USDA/ARS

Table 3. Incidence of tubers with pythium leak stored at 10^{o}C for 90 days after treatment with fungicides/biofungicides.

Treatments and rate of application per cwt of tubers	Pink Rot incidence (%)[a]	
Non-inoculated check…………………………………………	0.0	k
Inoculated check………………………………………………	60.0	a
Ranman 400SC 0.025 fl oz…………………………………...	8.8	g-j
Ranman 400SC 0.05 fl oz…………………………………….	13.8	e-h
Ranman 400SC 0.125 fl oz…………………………………...	8.8	g-j
Ranman 400SC 0.25 fl oz…………………………………….	6.3	ijk
Phostrol 53.6SC 1.28 fl oz……………………………………	3.8	jk
Oxidate 27SC 0.125 fl oz……………………………………..	5.0	ijk
GWN-4700 80WP 0.14 oz……………………………………	7.5	hij
GWN-4700 80WP 0.14 oz + Phostrol 53.6SC 1.28 fl oz……….	6.3	ijk
GWN-4700 80WP 0.14 oz + Phostrol 53.6SC 1.28 fl oz[c]………	3.8	jk
GWN-4700 80WP 0.14 oz + A8574 360FS[d] 0.03 fl oz…………	6.3	ijk
GWN-4700 80WP 0.14 oz + A9859 230SC[d] 0.03 fl oz…………	6.3	ijk
GWN-4700 80WP 0.14 oz + A8574 360FS 0.03 fl oz + A9859 230SC 0.03 fl oz………………………………………	6.3	ijk
09 BuPots-1 100L 0.2 fl oz…………………………………...	15.0	d-g
09 BuPots-2 100WS 1.52 oz………………………………….	13.8	e-h
09 BuPots-3 100WS 1.52 oz………………………………….	15.0	d-g
09 BuPots-4 100LS 0.2 fl oz………………………………….	11.3	f-i
09 BuPots-5 100LS 0.3 fl oz………………………………….	17.5	def
WE1042-1 75DS 1 lb…………………………………………	6.3	ijk
ME02-7008A 100D 1 lb………………………………………	18.8	de
ME03-5709A 100D 1 lb………………………………………	20.0	de
W103-5B 100D 1 lb…………………………………………..	27.5	c
ND04-1A 100D 1 lb…………………………………………..	21.3	cd
Vermiculite 100D 1 lb…………………………………………...	35.0	b
$LSD_{0.05}$	7.25	

[a] Late blight incidence (%); tubers with any symptoms and signs of *Phytophthora infestans*.
[b] Values followed by the same letter are not significantly different at $P = 0.05$ level according to Fisher's protected least significant difference (LSD) test.
[c] Applied in 4 pt H_2O/ton tubers.
[d] A8574D= difenoconazole; A9859= fludioxinil.

Funding: MPIC/Agrochemical Industry
USDA/ARS

Table 4. Severity and incidence of tubers with Fusarium dry rot 90 days after treatment with fungicides/biofungicides at 10°C.

Treatments and rate of application per cwt of tubers	Dry rot Incidence (%)		Dry rot Severity index[a]	
Non-inoculated check…………………………………………	2.5	f[b]	0.6	f
Inoculated check………………………………………………	70.0	a	30.6	ab
A12705 250SC[c] 0.03 fl oz + A9859 230SC[c] 0.03 fl oz……….	22.5	d	5.9	f
A8574D 360FS[c] 0.015 fl oz…………………………………...	20.0	de	5.0	f
A12705P 250SC 0.03 fl oz + A8574D 360FS 0.0075 fl oz + A9859 230SC 0.03 fl oz……………………………………….	13.8	def	4.4	f
A12705P 250SC 0.03 fl oz + A8574D 360FS 0.015 fl oz + A9859 230SC 0.03 fl oz……………………………………….	7.5	ef	2.2	f
A12705P 250SC 0.03 fl oz + A8574D 360FS 0.0226 fl oz + A9859 230SC 0.03 fl oz……………………………………….	8.8	def	2.8	f
A12705P 250SC 0.03 fl oz + A8574D 360FS 0.03 fl oz + A9859 230SC 0.03 fl oz……………………………………….	3.8	f	0.9	f
09 BuPots-1 100L 0.2 fl oz……………………………………	62.5	abc	29.1	abc
09 BuPots-2 100WS 1.52 oz…………………………………..	61.3	abc	26.9	a-e
09 BuPots-3 100WS 1.52 oz…………………………………..	53.8	c	22.2	cde
09 BuPots-4 100LS 0.2 fl oz…………………………………..	52.5	c	20.9	cde
09 BuPots-5 100LS 0.3 fl oz…………………………………..	68.8	ab	31.9	a
WE1042-1 75DS 1 lb…………………………………………	55.0	bc	22.5	b-e
ME02-7008A 100D 1 lb………………………………………	51.3	c	20.3	de
ME03-5709A 100D 1 lb………………………………………	51.3	c	20.3	de
W103-5B 100D 1 lb…………………………………………..	56.3	abc	24.1	a-e
ND04-1A 100D 1 lb…………………………………………..	50.0	c	19.7	e
Vermiculite 100D 1 lb………………………………………...	68.8	ab	28.1	a-d
$LSD_{0.05}$	14.33		8.33	

[a] Severity classes were determined as class 0 = 0%; 1 = 1 - 10%; 2 = 11 - 20%; 3 = 21 - 50; 4 > 51 – 100% internal area of tuber tissue with disease and incidence is percentage of tubers in class 1 - 4.

[b] Values followed by the same letter are not significantly different at $P = 0.05$ level according to Fisher's protected least significant difference (LSD) test.

[c] A12705= azoxystrobin; A8574D= difenoconazole; A9859= fludioxinil.

Funding: MPIC/Agrochemical Industry
USDA/ARS

Table 5. Severity and incidence of tubers with silver scurf 101 days after treatment with fungicides/biofungicides at 4°C.

Treatments and rate of application per cwt of tubers	Silver scurf incidence (%)		Silver scurf Severity index[a] (%)	
Non-inoculated check…………………………………………	93.1	a[b]	55.6	a
A12705 250SC[c] 0.03 fl oz + A9859 230SC[c] 0.03 fl oz………	85.6	b	43.2	de
A8574D 360FS[c] 0.015 fl oz…………………………………..	69.7	gh	32.2	h
A12705P 250SC 0.03 fl oz + A8574D 360FS 0.0075 fl oz + A9859 230SC 0.03 fl oz……………………………………….	74.1	fg	32.3	gh
A12705P 250SC 0.03 fl oz + A8574D 360FS 0.015 fl oz + A9859 230SC 0.03 fl oz……………………………………….	84.7	bcd	36.6	fg
A12705P 250SC 0.03 fl oz + A8574D 360FS 0.0226 fl oz + A9859 230SC 0.03 fl oz……………………………………….	80.9	cde	36.9	f
A12705P 250SC 0.03 fl oz + A8574D 360FS 0.03 fl oz + A9859 230SC 0.03 fl oz……………………………………….	66.3	h	33.0	fgh
09 BuPots-1 100L 0.2 fl oz……………………………………	86.9	b	46.3	b-e
09 BuPots-2 100WS 1.52 oz…………………………………..	85.0	bc	49.0	b
09 BuPots-3 100WS 1.52 oz…………………………………..	78.1	ef	44.5	cde
09 BuPots-4 100LS 0.2 fl oz…………………………………..	85.9	b	47.7	bc
09 BuPots-5 100LS 0.3 fl oz…………………………………..	80.3	de	42.4	e
WE1042-1 75DS 1 lb…………………………………………	84.1	bcd	47.5	bcd
$LSD_{0.05}$				

[a] Severity classes were determined as class 0 = 0%; 1 = 1 - 10%; 2 = 11 - 20%; 3 = 21 - 50; 4 > 51 – 100% internal area of tuber tissue with disease and incidence is percentage of tubers in class 1 - 4.
[b] Values followed by the same letter are not significantly different at *P* = 0.05 level according to Fisher's protected least significant difference (LSD) test.
[c] A12705= azoxystrobin; A8574D= difenoconazole; A9859= fludioxinil.

2009 Research Report to Michigan Potato Industry Commission Research Committee

Characterization of *Streptomyces* Species That Cause Potato Common Scab in Michigan Soil and Determination of Microbial Structure of Disease Suppressive Soil

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Collaborators: David Douches, William Kirk, Chris Long, Ray Hammerschmidt
Project personnel: Anthony Adesemoye, Qingxiao Meng

INTRODUCTION

Common scab is the most important soilborne disease in the potato industry. It is caused by multiple *Streptomyces* species, but *S. scabies* is documented as a predominant pathogen worldwide. Knowing what species is distributed in the soil helps the production to make a strategic plan for disease management. We were to investigate potato field in Michigan and determine if there are more species or diversified groups of the pathogen. We also studied disease suppressive soil, and looked for microorganisms that are contributing to the suppressiveness. Our objectives were to (1) Characterize the new pathogenic Streptomyces sp. strain; (2) Survey Michigan soil for Streptomyces genetic diversity and geographic distribution; and (3) Characterize the soil that suppresses pathogenic Streptomyces spp..

PROCEDURE

1. Characterize the new pathogenic *Streptomyces* sp. strain

Streptomyces isolates were obtained from Michigan potato field or potato tubers with common scab symptoms, using *Streptomyces* selective media STR. Other *Streptomyces* species have been collected from National Center for Agricultural Utilization Research. DNA extraction from *Streptomyces* were done by using DNeasy kit (Qiagen Inc, Valencia, CA). The 16S rRNA gene was amplified from DNA of *Streptomyces* isolates by PCR using primers 16S-1F and 16s-1R. Analysis of the presence of gene characteristic of the pathogenic island (PAI) genes were carried out by PCR using primers specific to the *txtAB*, *tomA* gene and the *nec-1*.

Pathogenicity of *Streptomyces* spp. was confirmed by a fast assay by inoculating it onto potato tuber slices, and further confirmed in the greenhouse. Inocula were made in vermiculite, which was mixed in potting soil before potato tubers were seeded. Thaxtomin production was examined using the following method: 200 ml of oatmeal broth with trace elements were inoculated with 200 μl of a concentrated spore suspension of *Streptomyces* strains. The culture was incubated at 28 °C for 7 days, centrifuged, and the supernatant was extracted two times with equal volume of ethyl acetate. The combined ethyl acetate extracts were evaporated and the yellow residue was taken up in methanol. The suspension was analysed using high performance liquid chromatography/Quattro Micro.

2. **Survey Michigan soil for *Streptomyces* spp. genetic diversity and geographic distribution**.

Potato tubers with typical scab symptoms were collected from various locations in representative Michigan potato production areas. Scab lesions were excised with a scalpel, surface sterilized with 0.62% of NaOCl, and macerated. The tissue was spread on the STR media. After incubation at 28 °C for 7 to 10 days, *Streptomyces* spp. were picked and pure cultures were obtained after serial transfers to new media plates. Morphological and molecular methods were used for identification of the isolates. Molecular identification was done by PCR amplification of the 16S rRNA gene from DNA of *Streptomyces* isolates using primers 16S-1F and 16s-1R.The pathogenicity and virulence of the isolated *Streptomyces* were determined by using PCR with marker genes, including *nec1*, *txtAB*, and *tomA*. The frequency and virulence of each species were analyzed by location and potato cultivar.

3. **Characterize the soil that suppresses pathogenic *Streptomyces* spp.**

Ten-inch pots were filled with potting soil on the bottom (1/3 of total volume), while the upper 2/3's of the pot was filled with the different soil treatments. Two soil treatment methods were used to conduct this study. In the first method, soil was a mixture of different ratios of potting soil and suppressive soil: 0, 20, 40, 60, 80 and 100% of suppressive soil by volume. In the second method, the suppressive soil was treated with various temperatures for 30 min: room temperature, 30, 45, 60, 75, 90 and 121 °C. *S. scabies* inocula were mixed into the soils in pots. At harvesting, potato tubers were evaluated for scab symptom.

A spiral autoplate was used for microbial population enumeration. Semi-selective media include STR for *Streptomyces*, S1 for florescent *Pseudomonas*, 1/10 Tryptic soy agar with fungicides for general bacteria, and Rose bengal agar for total fungi. *Bacillus* was enumerated on 1/10 TSA with the soil dilution is heated at 80°C for 30 min.

Terminal restriction fragment length polymorphism (T-RFLP) analysis was used for characterizing the microbial community structure, focusing on bacterial populations. Total microbial DNA was extracted from the soils. 16S rDNA of bacteria was amplified using PCR. The PCR products were digested separately with *MspI* and *RsaI* restriction enzymes. Fragment size analysis was carried out on an ABI PRISM® 3130*xl* Genetic Analyzer (Applied Biosystems, UK). T-RFLP profiles were generated from the Genetic Analyzer data using GeneMapper software (ABI, UK). The binary data were analyzed using cluster analysis.

The *Streptomyces* and other bacterial isolates were tested by a co-plate assay for inhibition to pathogenic *Streptomyces scabies in vitro*. Plates were examined for the presence of inhibition zones, and colonies that exhibited inhibition zones were re-isolated from the original plate, cultured, and stored for further tests. These isolates will also be examined for pathogenicity on potato tuber slices.

RESULT

We have characterized a new Streptomyces strain DS3024. It causes scab symptoms on potato tubers, as *S. scabies* does (Fig. 1). DS3024 has marker gene *txtAB* and *tomA*, but lacks of *nec1*. It can survive at low pH condition (pH=4.5) (Table 1).

It is distinct from any other known streptomycete pathogens phylogenetically (Fig. 2). The data on diversity indicated that pathogenic *Streptomyces* spp. in Michigan is diversified. *S. scabies* is predominant, but other species may exist, for example, *S. stelliscabiei* (Table 2). More data is currently being analysed that will provide more information.

The disease suppressive soil was identified to be due to biological factors. Increasing the ratio of suppressive soil in the pot significantly decreased the disease severity and increased plant growth both in radish and potato (Fig. 3 to 5); higher temperature treatment caused higher disease severity (Fig. 5). T-RFLP result showed that the disease suppressive soil has distinct microbial profile compared to disease conducive soil (Fig. 6). Further studies are needed to identify the microorganisms that contribute to the disease suppression. Several bacteria isolated from the disease suppressive soil showed strong inhibition to *Streptomyces* spp. that were pathogenic to potatoes. These can be potential biological control agents for managing potato common scab.

Publications

– Hao, J. J., Meng, Q. X., Yin, J. F., and Kirk, W. W. 2009. Characterization of a new *Streptomyces* strain, DS3024, that causes potato common scab. Plant Dis. 93:1329-1334.
– MENG, Q., Yin, J. Hammerschmidt, R., Kirk, W., Hao, J. 2009. Characterization of a naturally occurred suppressive soil to potato common scab in Michigan. Phytopathology 99:S84
– MPIC bulletin, 2009.

Table 1. Characterization of DS3024

Isolate	ATCC49173	DS3024
Location	New York	MSU, MI
Color on YME	Orange brown	Dark brown
16S rRNA	S. scabies	Ref. Sp.ME02.6979.3a
TxtAB	+	+
TomA	+	+
Nec1	+	-
Pathogenesis on potato	+	+
Lowest pH for growth	5.8	4.5

Table 2. Characterization of *Streptomyces* species isolated from Michigan soil

Isolate	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
***Streptomyces* spp.**	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
S. scabies	-	-	-	-	-	-	-	-	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+
S. stelliscabiei	-	-	+	+	+	+	+	+	+	-	-	-	+	+	+	-	-	-	-	-	-	-	-
Nec1	-	-	-	-	-	-	-	-	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+
TxtAB	-	-	+	+	+	+	+	+	+	-	-	-	-	-	-	+	+	+	+	+	+	+	+

Table 3. Frequency of bacterial isolates showing antibiotic characteristics and pathogenicity from different soils.

Soil type	Frequency of antagonistic isolates against S. scabies (%)		Symptom positive (%)
	Bacillus spp.	Streptomyces spp.	
Suppressive soil	26.3	13.5	8.9
Disease conducive soil	19.5	14.8	12.9

Figure 1. Comparison of *Streptomyces* spp., from left to right: *S. scabies* (ATCC isolate 49173), DS3024, and control. Upper panel: inoculation of bacterial suspension on potato tuber slices; lower panel: inoculation of bacterial suspension in soil that cause scab symptoms on potato tubers. All the three isolates produce thaxtomin.

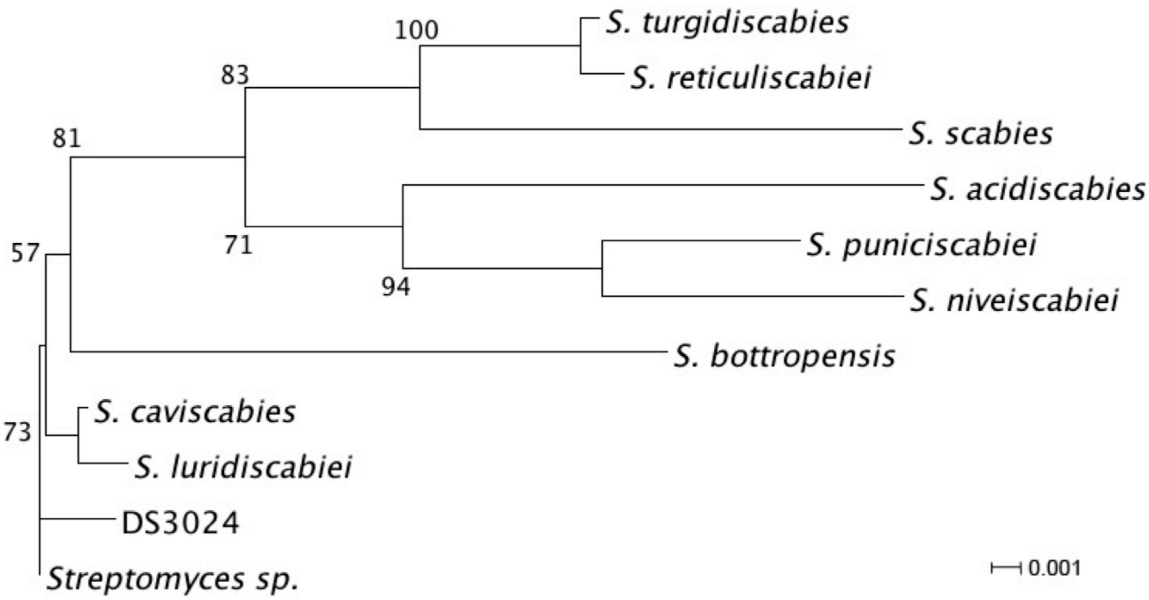


Figure 2. Phylogenetic tree of *Streptomyces* spp..

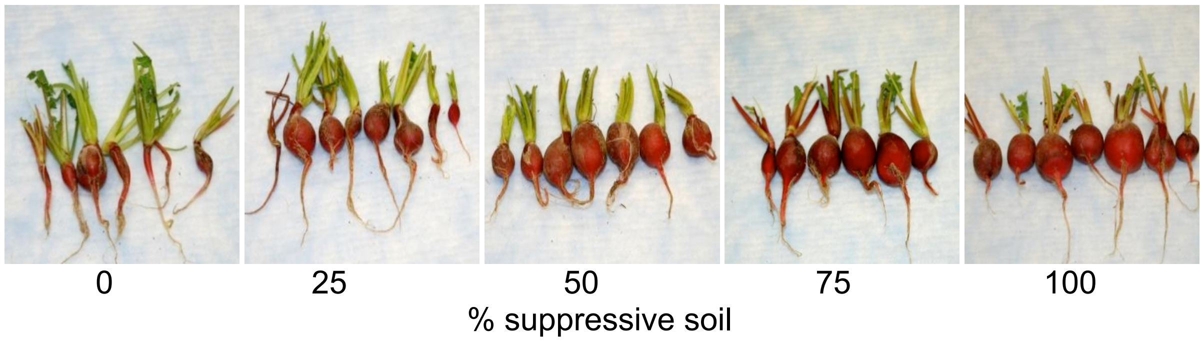


Figure 3. Effect of soil mixing on scab severity in radish.

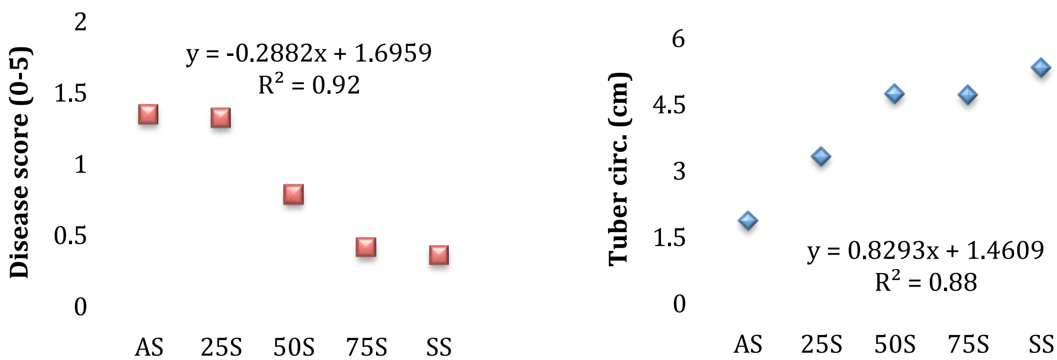


Figure 4. Effect of siol mixture on disease severity in radish. AS: autoclaved suppressive soil, 25S, 50S, 75S, and SS are soil mixed with 25, 50, 70, and 100% of suppressive soil.

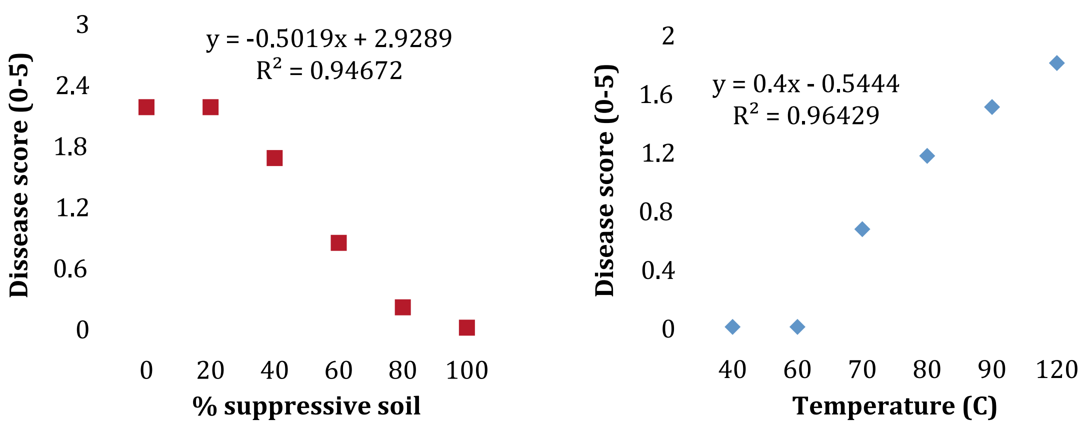


Figure 5. Effect of soil mixture (left panel) and temperature treatment (right panel) on disease severity in potato.

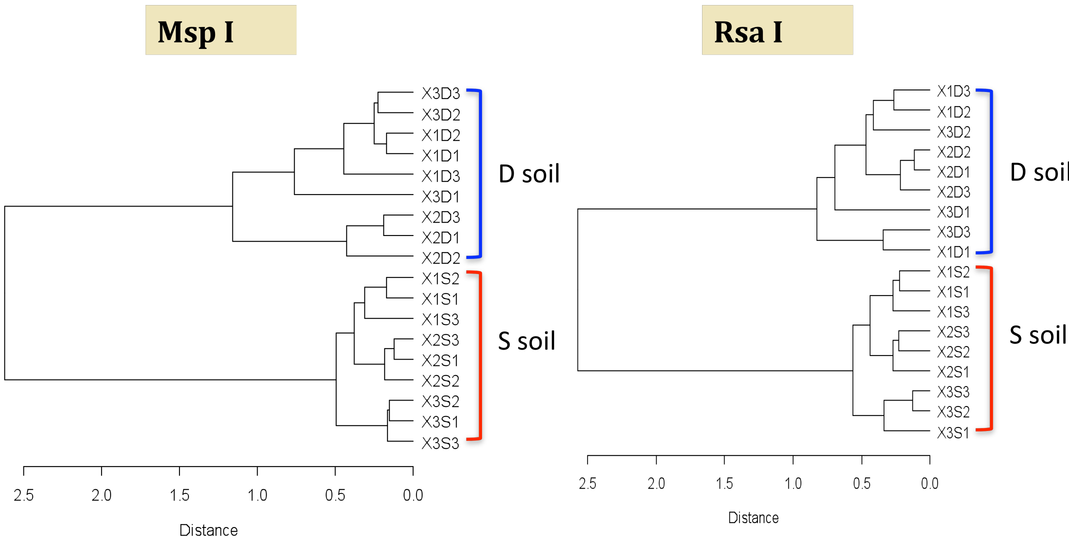


Figure 6. Profiles of two types of soils characterized using T-RFLP. D soil = disease conducive soil; and S soil = disease suppressive soil.

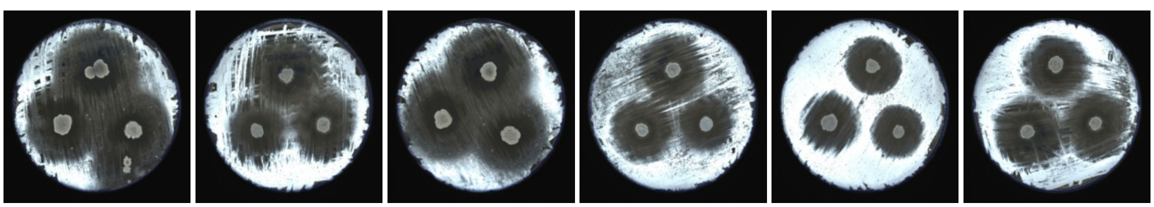


Figure 7. Effect of bacterial isolates from disease suppressive soil on Streptomyces scabies. All isolates were *Bacillus* spp. (left to right: BCA1 to BCA6).

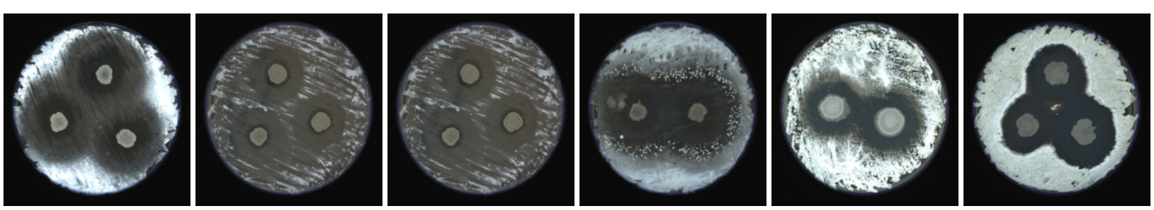


Figure 8. Effect of BCA3 isolated from disease suppressive soil on the growth of *Streptomyces* spp. (left to right: S. aureofaciens, S. scabies, S. acidiscabies, AC-1, 0095, and DS3024).

2008-2009 Corky Ring-Spot Disease of Potato Research

Loren Wernette, George Bird, Willie Kirk, Karl Richie and John Davenport

There are many diseases that cause economic losses in potato production. Many of these are well known in Michigan. A disease that was not detected in MI until very recently is Corky Ring-Spot Disease of Potato (CRSD). This is caused by a *Tobravirus* (Tobacco Rattle Virus) known as TRV. It is a tubular shaped virus that historically has caused dark necrotic corky tissue to form in mature tubers. These areas are usually found in arcs or rings and can sometimes be seen on the skin of tubers in ring patterns. It has also been reported from other geographic locations and in greenhouses as foliar symptoms in the shape of chevrons. This virus is transported (vectored) to plant roots by stubby-root nematodes (*Trichodorus, Paratrichodorus).* In MI there are seven known species of stubby-root nematodes, with several of them known to be vectors of TRV. Stubby-root nematode populations are commonly found in agriculture fields and have a wide host range. This includes all the main cash crops grown in MI, as well as most weed species. TRV also has a wide host range, surviving on corn, wheat, soybeans, and most weed species. These alternative hosts for both the vector and the virus help the virus persist in the soil for many years. In research outside of MI, it has been shown that the most effective chemical controls are Telone II and Vydate. The objective of this MPIC-funded research was to identify effective chemical controls for CRSD in MI. The studies were conducted in 2008 and 2009 on a 14 acre field molecularly confirmed to have the disease in 2007. This field was managed by Walther's F Potato Farms and is located in White Pigeon MI. The trial for the 2008 study consisted of 16 treatments replicated 5 times for a total of 80 plots (Table 1).

Table 1. 2008 CRSD research treatments and rates.

Treatment	Rate(lb/A)
Control	0.0
Vydate C-LV at plant (low)	0.5
Vydate C-LV at plant (high)	1.0
Vydate C-LV at plant(low) + Post emergence	2.0
Metam Sodium	158.25
Metam Sodium + Vydate C-LV at plant (low)	158.75
Metam Sodium + Vydate C-LV at plant (high)	159.05
Metam Sodium + Vydate C-LV at plant(low)+ post emergence	160.25
Telone II	177.3
Telone II + Vydate C-LV at plant(low)	177.8
Telone II + Vydate C-LV at plant (high)	178.3
Telone II + Vydate C-LV at plant(low) +post emergence	179.3
Metam Sodium + Telone II	335.55
Metam Sodium + Telone II + Vydate C-LV at plant (low)	336.05
Metam Sodium + Telone II + Vydate C-LV at plant (high)	336.55
Metam Sodium + Telone II + Vydate C-LV at plant(low) +post emergence	337.55

Telone II was applied in the fall of 2007 by Hendrix and Dail Inc. at the 18 gal/A. Metam sodium was applied in the spring of 2008 by John Davenport at 37.5 gal/A, the most commonly applied rate for potato growers in MI. The Vydate C-LV was applied in-furrow on pre-established hills two weeds prior to planting to ensure there was no phytotoxicity effects on the newly planted potatoes. Frito Lay cv 1879 were planted at the end of May. Post emergence applications of Vydate C-LV were made by Rob Schafer at regular intervals throughout the growing season at a rate of 2.1 pints/A. The 2008 tuber harvest consisted of digging 20 ft of row from every plot with Chris Long's one row digger. The tubers were then placed in crates and transported to the Clarksville Research Station and stored at 55˚F. One month following harvest, all the potatoes were weighed to determine yield and ten tubers were selected from each plot and cut from stem end to bud end to visually inspect for CRSD symptoms. Any tubers that expressed symptoms were taken to Dr. William Kirk's lab and RT-PCR was used to confirm that the agent of infection was Tobacco Rattle Virus. Two additional symptom ratings were made.

In 2009, the research was repeated with some modifications. The trial was done on the adjacent side of the field , where corn was grown 2008. In 2009, soybeans were grown on the east side with potatoes on the west side. The 2009 trial consisted of 24 total plots, with seven treatments that were replicated three or four times. Each plot was 180 feet long and 32 feet wide. Walther's planted Frito Lay cv 1879 on May 30 and managed insect and disease pressure and nutrient requirements throughout the season. The 2009 treatments included metam sodium and Vydate C-LV at different timings and combinations (Table 2). Telone II was not used for several reasons. It has almost no market share in the MI potato industry. It also was not available at the time we needed it for application, and we did not see significant results using it in 2008. Metam sodium was applied at the maximum labeled rate of 75 gal/A by John Davenport in April, prior to planting. Two weeks prior to planting, the in furrow application of Vydate C-LV was applied to the pre- formed hills by Rob Shafer at a rate of 4 pints/A. Following planting, four more applications of Vydate C-LV were applied as a foliar spray at 2pints/A. The first was made at tuber initiation and then at two week intervals until four treatments was reached. Throughout the season, five soil samples were taken in all 24 plots and analyzed to determine stubby-root nematode populations. The samples were taken before fumigation with Sectagon 42, before application of Vydate C-LV in furrow, before second foliar application of Vydate C-LV, before the fourth foliar application of Vydate C-LV, and at harvest. The nematodes were extracted using the centrifugal flotation method.

Table 2. 2009 CRSD control research treatments and chemical rates.

Treatments	Lbs Active Ingredient/A
Control	0.0
Vydate C-LV	1.89
4 Foliar applications Vydate C-LV	3.77
Vydate C-LV in furrow + 2 Foliar applications Vydate C-LV	3.77
Vydate C-LV in furrow + 4 Foliar applications Vydate C-LV	5.66
Metam Sodium	316.5
Metam Sodium +Vydate C-LV in furrow + 4 Foliar applications Vydate C-LV	322.16

Tuber harvest was conducted on the 5th of October. Chris Long's one row potato digger was used to dig four ten foot sections of row from each plot. Each ten foot section was labeled and crated separately. The 96 crates were then transported to Clarksville Research station where they were kept at 55˚F. One month after the beginning of storage, the weights of the potatoes from each crate was measured and the yield determined. Ten tubers were also selected at random from each crate and cut from bud end to stem end to visually determine if symptoms of CRSD were present. This visual rating was done three more times after this, with one additional sampling to be done in March of 2010. Data from the last sampling date are not included in this report.

Results and Discussion

In 2008, yields ranged from 397 to 496 cwt per acre (Table 3). These yields were quite high for MI which has an average state yield of 350 cwt. This was probably due to the low incidence of potato early die. It also indicates that CRSD did not affect tuber weight (Table 3).

Table 3. 2008 CRSD research tuber yield (cwt/acre).

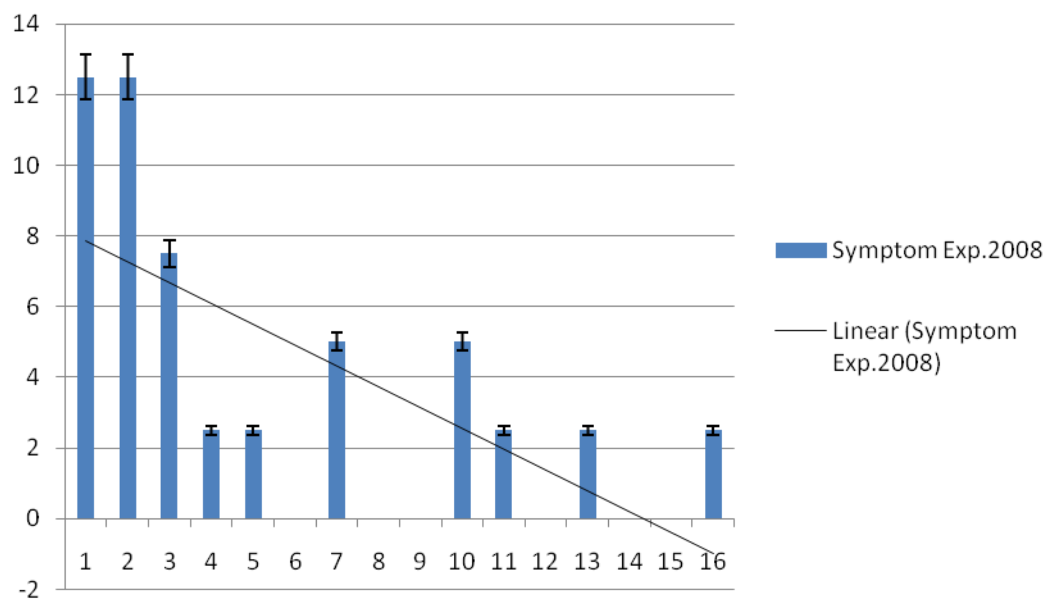
Treatment	Yield (cwt)
Control	424
Vydate C-LV at plant (low)	459
Vydate C-LV at plant (high)	466
Vydate C-LV at plant(low) + Post emergence	451
Metam Sodium	460
Metam Sodium + Vydate C-LV at plant (low)	443
Metam Sodium + Vydate C-LV at plant (high)	459
Metam Sodium + Vydate C-LV at plant(low)+ post emergence	481
Telone II	397
Telone II + Vydate C-LV at plant(low)	496
Telone II + Vydate C-LV at plant (high)	447
Telone II + Vydate C-LV at plant(low) +post emergence	469
Metam Sodium + Telone II	478
Metam Sodium + Telone II + Vydate C-LV at plant (low)	478
Metam Sodium + Telone II + Vydate C-LV at plant (high)	456
Metam Sodium + Telone II + Vydate C-LV at plant(low) +post emergence	463

The symptom expression data (Table 4) shows that there is a general trend (Figure 1.) that the more chemical applied the less CRSD symptom expression observed. Symptom expression ranged from 0.0% in many of the treatments to 12.5% in the control and the Vydate in-furrow at the low rate. The treatments that showed symptom expression were located throughout the field, with no noticeable hotspots. Soil samples taken thoughout the season showed a very low population of stubby-root nematode, which is not surprising due to the fact that the vector threshold is two nematodes per 100 cc of soil and the stubby-root nematode does not prefer to feed on potato roots.

Table 4. 2008 CRSD research symptom expression.

Treatment	Symptom (%)
Control	12.5
Vydate C-LV at plant (low)	12.5
Vydate C-LV at plant (high)	7.5
Vydate C-LV at plant(low) + Post emergence	2.5
Metam Sodium	2.5
Metam Sodium + Vydate C-LV at plant (low)	0.0
Metam Sodium + Vydate C-LV at plant (high)	5.0
Metam Sodium + Vydate C-LV at plant(low)+ post emergence	0.0
Telone II	0.0
Telone II + Vydate C-LV at plant(low)	5.0
Telone II + Vydate C-LV at plant (high)	2.5
Telone II + Vydate C-LV at plant(low) +post emergence	0.0
Metam Sodium + Telone II	2.5
Metam Sodium + Telone II + Vydate C-LV at plant (low)	0.0
Metam Sodium + Telone II + Vydate C-LV at plant (high)	0.0
Metam Sodium + Telone II + Vydate C-LV at plant(low) +post emergence	2.5

Figure 1. 2008 Symptom Expression by Treatment Number (lbs./acre).

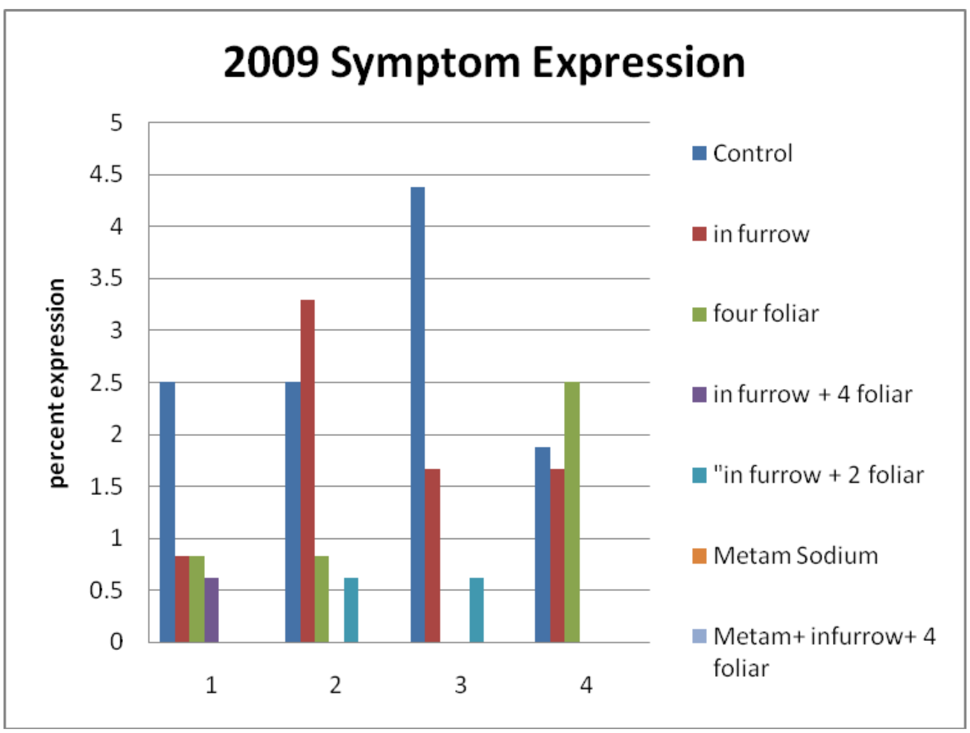


The 2009 results were similar to those of 2008 (Table 5). The highest yields were 488 cwt/A and the lowest 442 cwt/acre. The yield data also indicatethe trend that the more lb/acre of active ingredient applied the higher the tuber yield. This could have to do with the ability for metam sodium to have fungicidal properties at the 75gal/A rate. This would help to alleviate some of the potato early die stress that would normally be a yield limiting factor. An additional component was to determine the relationship between symptom expression and length of storage. Symptoms expression varies among treatments, ranging from 0 to 4.4% (Figure 2). Symptom expression appeared to increased in storage.

Table 5. 2009 CRSD research tuber yields.

Treatments	Yield (cwt)
Control	449
Vydate C-LV	445
4 Foliar applications Vydate C-LV	442
Vydate C-LV in furrow + 2 Foliar applications Vydate C-LV	478
Vydate C-LV in furrow + 4 Foliar applications Vydate C-LV	474
Metam Sodium	488
Metam Sodium +Vydate C-LV in furrow + 4 Foliar applications Vydate C-LV	484

Figure 2. 2009 CRSD symptom expression.



As with all virus diseases, the best way to prevent CRSD is through the use of TRV-free certified seed and TRV/SRN-free equipment. Once a given site is infested with both TRN and SRN, the only current economically viable options are to use both a pre-plant soil fumigant and a post-plant non-fumigant nematicide. In the 2008-2009 MI trial, the 75 gal/acre metham sodium treatment was more successful than the lower rate of metham sodium or the use of Telone II. While symptom expression appeared to increase in storage, the current data are not statistically significant for this attribute. While CRSD had a negative impact on marketable tubers, it did not reduce overall tuber tonnage.

2009 Michigan Metam Sodium Atmospheric Emission Study

George Bird, Ben Kudwa, David Sullivan, Loren Wernette and Mark Otto

The following is a pre-print of an abstract that has been submitted for a paper that will be presented at the 2010 Annual Meeting of The Potato Association of America.

Soil fumigants, including metam sodium are under going the Environmental Protection Agency (EPA) re-registration process. Buffer zones designed to prevent off-site exposure were proposed as part of the Re-registration Eligibility Decision (RED). The RED buffer zone recommendation was based on research conducted at relatively high soil and air temperatures in Bakersfield, California (CA). The proposed RED buffer zones for shank injected metham sodium have the potential to reduce Michigan (MI) potato acreage by about 30%. In MI potato production, metham sodium is applied in late fall under cool soil and air temperatures. The MI potato industry believed that RED buffer zones should be based on atmospheric emission data from current application technology and local environmental conditions. In 2009, they funded a research project designed to develop an atmospheric emission data set for metham sodium applied by shank injection under cool soil and air temperatures. The research included both a post-application cultipaker dry seal and a wet seal with irrigation water. Two one-acre plots, 1.3 miles apart, were used. The quality assurance component mandated that no other fumigation be conducted in the Township during the time of trial. Prior to metham sodium application, Sullivan Environmental Consulting Inc. (SEC) assembled charcoal sorbent atmospheric monitoring sensors and weather stations at both sites. Metham sodium was applied at 75 gal/acre with a commercial shank injection fumigator at a 12-inch soil depth. The atmospheric emission monitoring sensors were activated prior to application of metham sodium and maintained active until 96 hours post-application. At both sites, the applicator was followed immediately by a cultipacker. One of the sites also received a post-application water seal of 0.33 inches. Metham sodium was extracted from the charcoal sorbent tubes and quantitatively analyzed using gas chromatography. The highest peak emissions were slightly greater than 2 micrograms per meter square per second, compared to more than 50 micrograms per meter square per second for the CA. When a water seal was included, the peak emission was less than 0.5 micrograms per meter square per second. These data were presented to EPA by MI potato growers and SEC on 25 Feb. 2010. The project was replicated by the Wisconsin potato industry and support was provided by both Minnesota and North Dakota. Dr. Bird has been selected to provide the quality assurance component of an additional replication of the research which will take place the next to last week of March 2010.

Funding: 1,4-Sight Group

Effect of 1,4-SIGHT® post-harvest potato dormancy treatment on sugars of stored chip stock in Michigan

Chris Long and Greg Steere

Introduction:

This is a brief summary of the 2008-2009 storage trial conducted at Sackett Potatoes, Mecosta Co., MI. In this trial, 1,4-Sight was applied to three chip processing varieties and the tubers were evaluated for adverse sugar accumulation resulting from the Dimethylnaptheline (DMN) application. The experiments began in late September 2008 and concluded in late March 2009. At the start of this experiment, Dimethylnaptheline was also being evaluated for its ability to reduce tuber weight loss in storage and increase tuber dormancy. Due to tuber rot in FL1833 and sample loss resulting from bin shipment of Pike and FL1922, accurate tuber weight loss values were not collected.

Results:

Please see attached graphs of sugar concentration vs. pile temperature and a graph of chip color and color defects for each variety tested.

Discussion:

The variety FL1833 was used as a long-term storage variety in this trial in 2007-2008 and again here in 2008-2009. DMN was applied to the treated samples of FL1833 on October 28th, 2008. Early in the experiment, the sucrose concentrations in the pile, in the untreated and in the treated samples, tracked very closely to each other (Figure 1). On January 26th 2009 the sugar quality of these samples began to diverge. During the months of January and February the treated sample had a significantly higher sucrose level than either the pile or untreated samples (Figure 1). In late March when this bin of FL1833's was shipped, the treated and pile sucrose levels were very similar. It is hard to explain why the sucrose level in the untreated sample did not rise in synchronization with the pile and treated samples. Glucose levels in the treated samples were generally higher than the glucose levels in the pile and the untreated samples. Based on the chip color, it was difficult to say if there were any treatment effects (Figure 2). The percent chip color defects for the pile and untreated samples appeared to be similar, but the treated sample contained a considerably higher percentage of color related defects in late March 2009. CIPC was applied to all FL1833 samples approximately six weeks after the DMN application. There was no observed effect of the DMN on sugar quality of the pile, untreated or treated samples 60 days after application. During this two month period, an impact of the DMN product would have be expected if it was going to influence tuber quality.

Pike was tested in this experiment because it is a short term storage variety with excellent early chip quality. It is generally put into storage early in the storage season when the tuber temperatures are high (70ºF). Pike may greatly benefit from a DMN application early in storage. Also, the DMN application does not require the added heat as in a CIPC application, thus preventing any possible storage loss due to additional elevated storage temperatures. CIPC is not typically applied until the tubers have suberized where as the DMN may be applied a week after tubers have been placed in storage. The DMN was applied to these treated samples on September 26th, 2008. The tubers had a pulp temperature of 65.6 ºF at the time of DMN application. The sugar concentrations of the samples tracked in a similar and consistent pattern for both sucrose and glucose across treatments with the exception of the untreated sample sucrose which was slightly elevated in December (Figure 3). Chip color was identical for all treatments (Figure 4). There was some slight variability between the color related chip defects in the pile and untreated samples. The treated sample had the highest percent of color defects on January 26th, 2009. Just as in the FL1833 variety, the DMN did not influence tuber sugar quality in the Pike variety, but it was notable that the treated samples for each variety contained the greatest number of color related defects at the end of the storage season.

The FL1922 variety was chosen because of its excellent long term storability. This variety was treated with DMN on October 17th, 2008. Of the three varieties tested, this variety exhibited the least amount of variability in sugar concentration, resulting in good chip color and minimal chip color defects (Figures 5-6). These observations are consistent with same experiment conducted during the 2007-2008 storage season. The sucrose levels of the three treatments tracked very closely and the glucose levels were identical. This also held true for the chip color and color defects. The treated FL1922 sample exhibited little deviation from the control as related to chip color and color defects. The DMN application appeared to have no negative influence on chip quality for this variety.

Overall:

For the three varieties tested, no negative effect of the DMN application was observed on tuber chip quality. In two cases, with the FL1833 and Pike varieties, there was some variation in chip color defects across treatments, but not in the SFA color scoring. This variation in chip color defects is difficult to correlate to the DMN application because it occurred across all treatments and did not occur in a uniform pattern. There was some variability in sugar concentration observed for both FL1833 and Pike across all treatments. In general, this variation is typical of the sugar analysis process. No consistent trend was observed that would lead one to believe that DMN was involved in causing this variation. In the FL1922 variety, there was almost no variability observed in sugar concentration or chip color or color related defects. No negative effect of the DMN application was observed on the sugar quality of the FL1922 variety in this study.

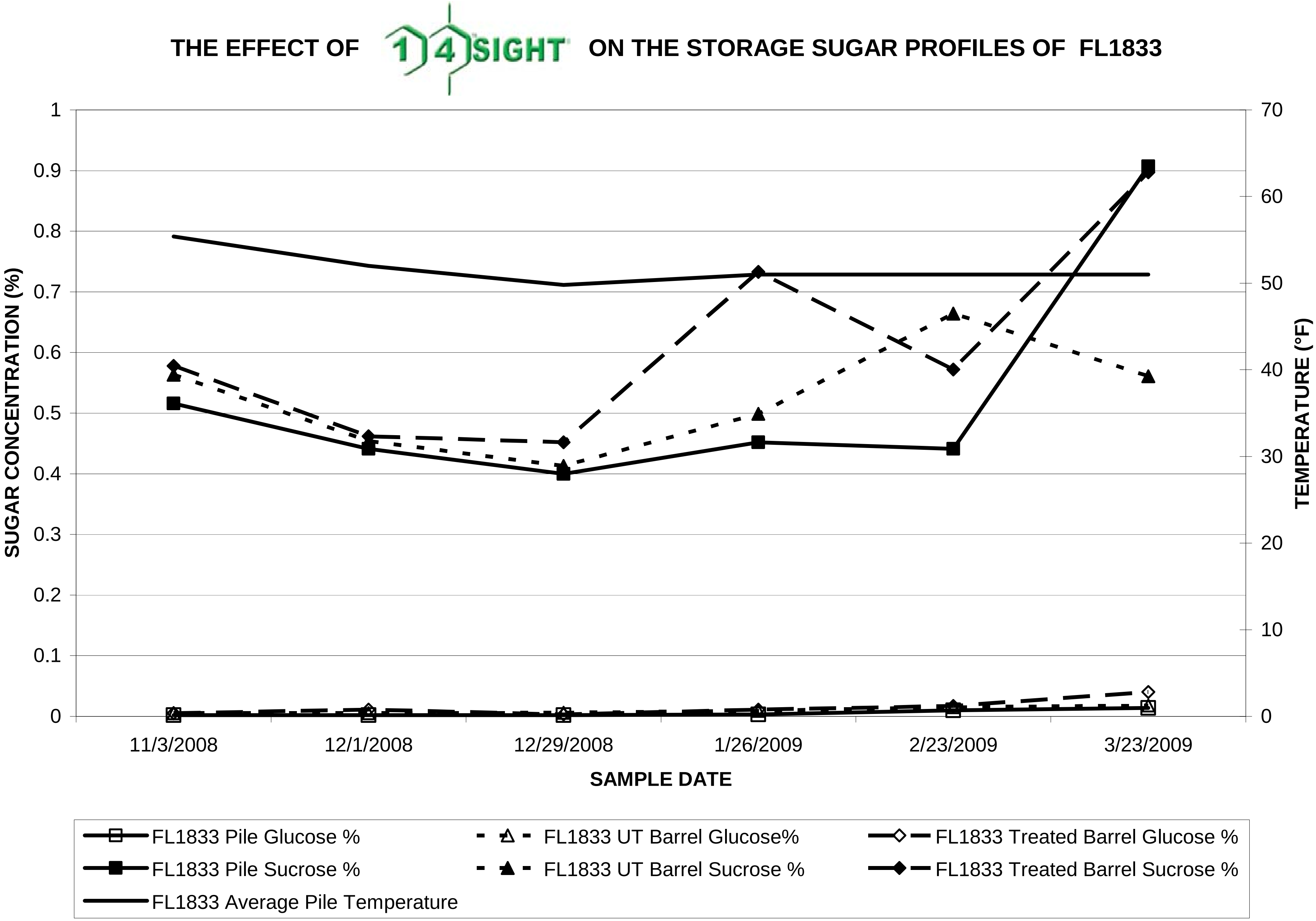
Dormancy Observations:

The dormancy enhancement of the DMN product was inconclusive in the variety Pike based on two observations made 66 and 94 days after treatment. The efficacy of this product was most likely diminished after 60 days. No CIPC was applied to the Pike variety and only one application of DMN was made at the start of the experiment. Both FL1833 and FL1922 were treated with CIPC six weeks after the DMN application. No dormancy break was noted in any of the FL1922 or the FL1833 treatments. DMN appears to have a short window of dormancy enhancement that can, in turn, be reduced by large volumes of fresh air exchange in the storage environment.

Weight Loss Observations:

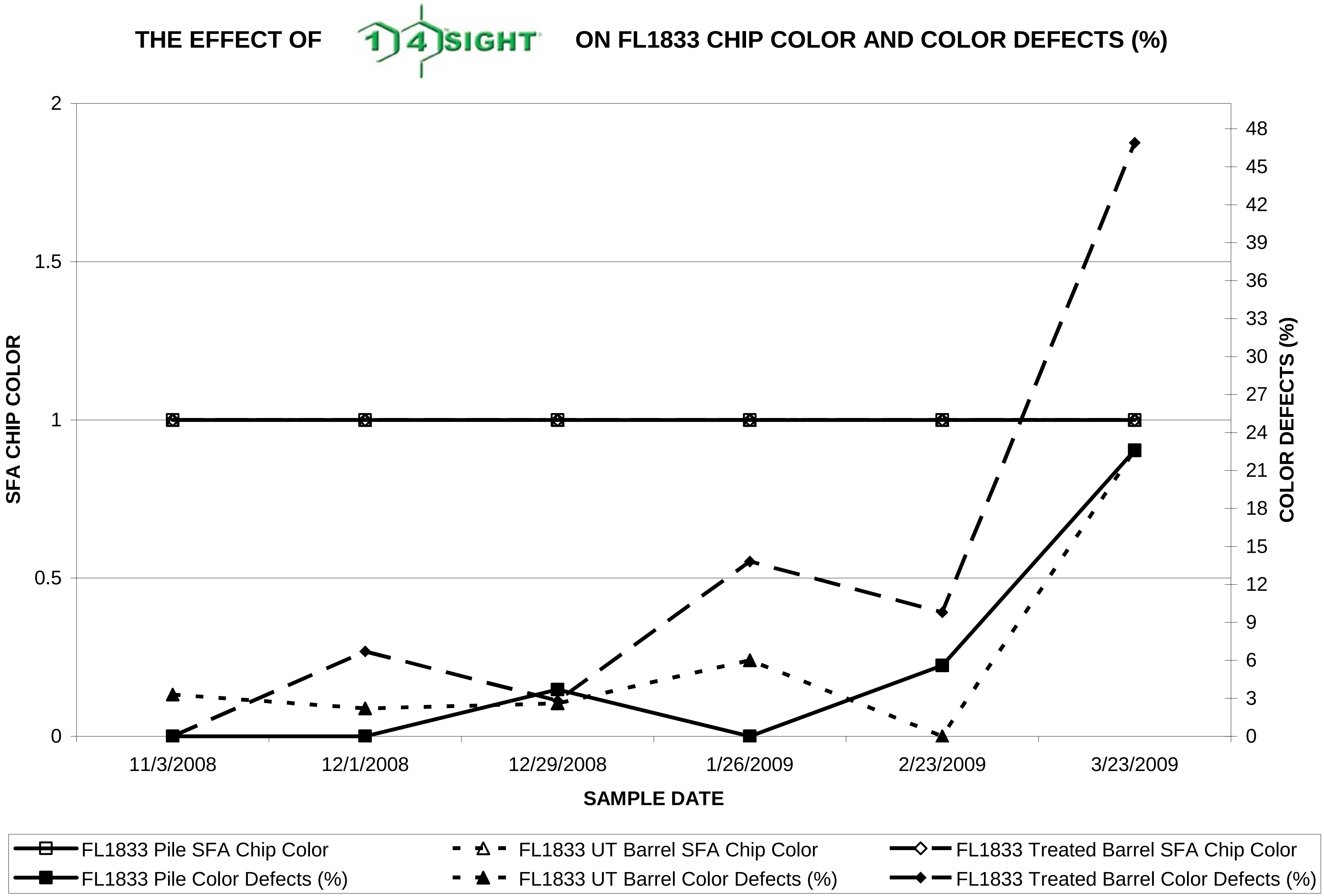
The effect of a DMN application on tuber weight loss is of interest in order to reduce pressure bruising and tuber shrinkage but was not able to be evaluated in this study.

Figure 1



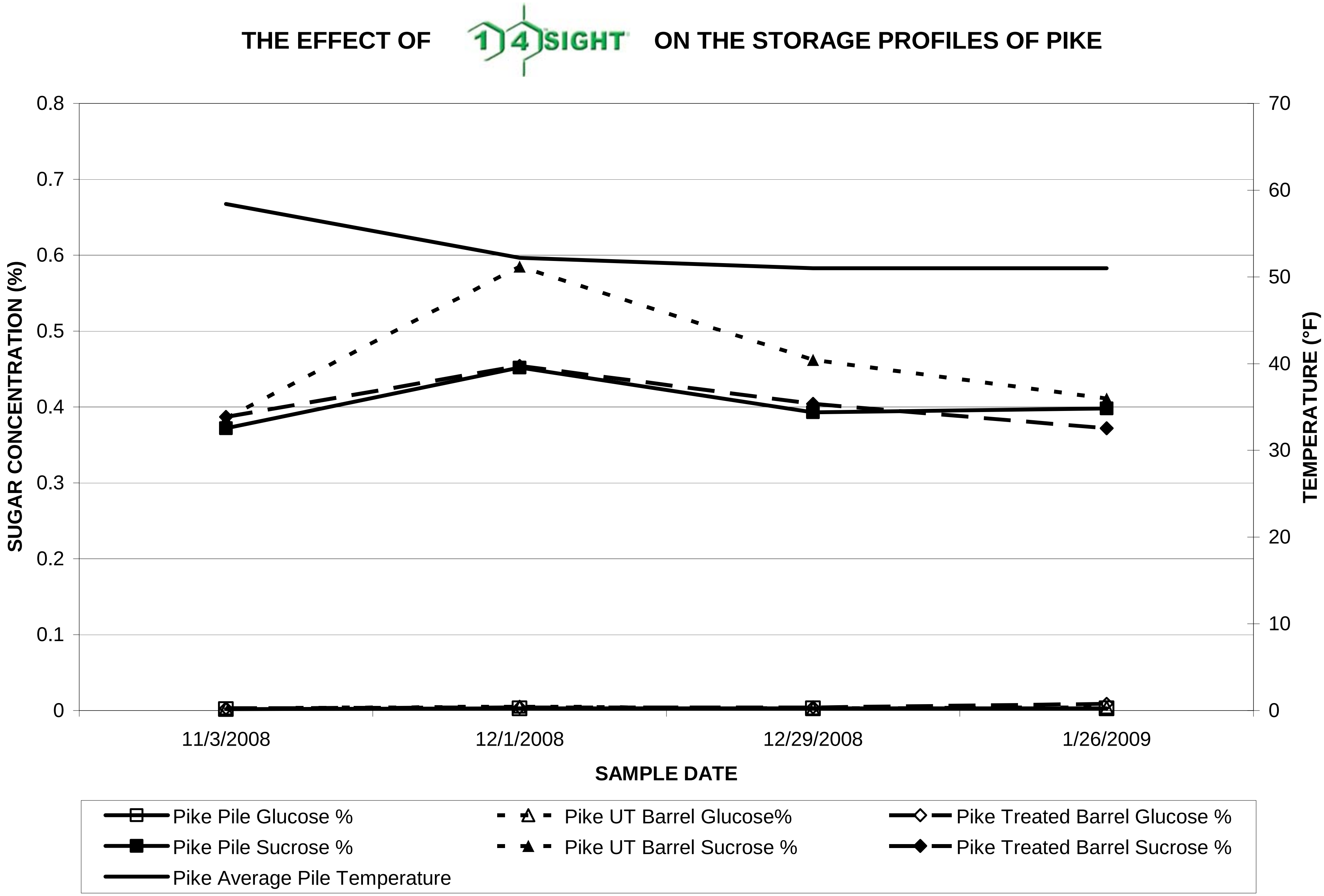
THE EFFECT OF 1-4SIGHT ON THE STORAGE SUGAR PROFILES OF FL1833
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
70
60
50
40
30
20
10
0
SUGAR CONCENTRATION (%)
TEMPERATURE (°F)
11/3/2008
12/1/2008
12/29/2008
1/26/2009
2/23/2009
3/23/2009
SAMPLE DATE
FL1833 Pile Glucose %
FL1833 UT Barrel Glucose%
FL1833 Treated Barrel Glucose %
FL1833 Pile Sucrose %
FL1833 UT Barrel Sucrose %
FL1833 Treated Barrel Sucrose %
FL1833 Average Pile Temperature

Figure 2



THE EFFECT OF 1-4SIGHT ON FL1833 CHIP COLOR AND COLOR DEFECTS (%)
SFA CHIP COLOR
2
1.5
1
0.5
0
COLOR DEFECTS (%)
48
45
42
39
36
33
30
27
24
21
18
15
12
9
6
3
0
11/3/2008
12/1/2008
12/29/2008
1/26/2009
2/23/2009
3/23/2009
SAMPLE DATE
FL1833 Pile SFA Chip Color
FL1833 UT Barrel SFA Chip Color
FL1833 Treated Barrel SFA Chip Color
FL1833 Pile Color Defects (%)
FL1833 UT Barrel Color Defects (%)
FL1833 Treated Barrel Color Defects (%)

Figure 3



THE EFFECT OF 1)4)SIGHT ON THE STORAGE PROFILES OF PIKE
SUGAR CONCENTRATION (%)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
TEMPERATURE (°F)
70
60
50
40
30
20
10
0
11/3/2008
12/1/2008
12/29/2008
1/26/2009
SAMPLE DATE
Pike Pile Glucose %
Pike UT Barrel Glucose%
Pike Treated Barrel Glucose %
Pike Pile Sucrose %
Pike UT Barrel Sucrose %
Pike Treated Barrel Sucrose %
Pike Average Pile Temperature

Figure 4

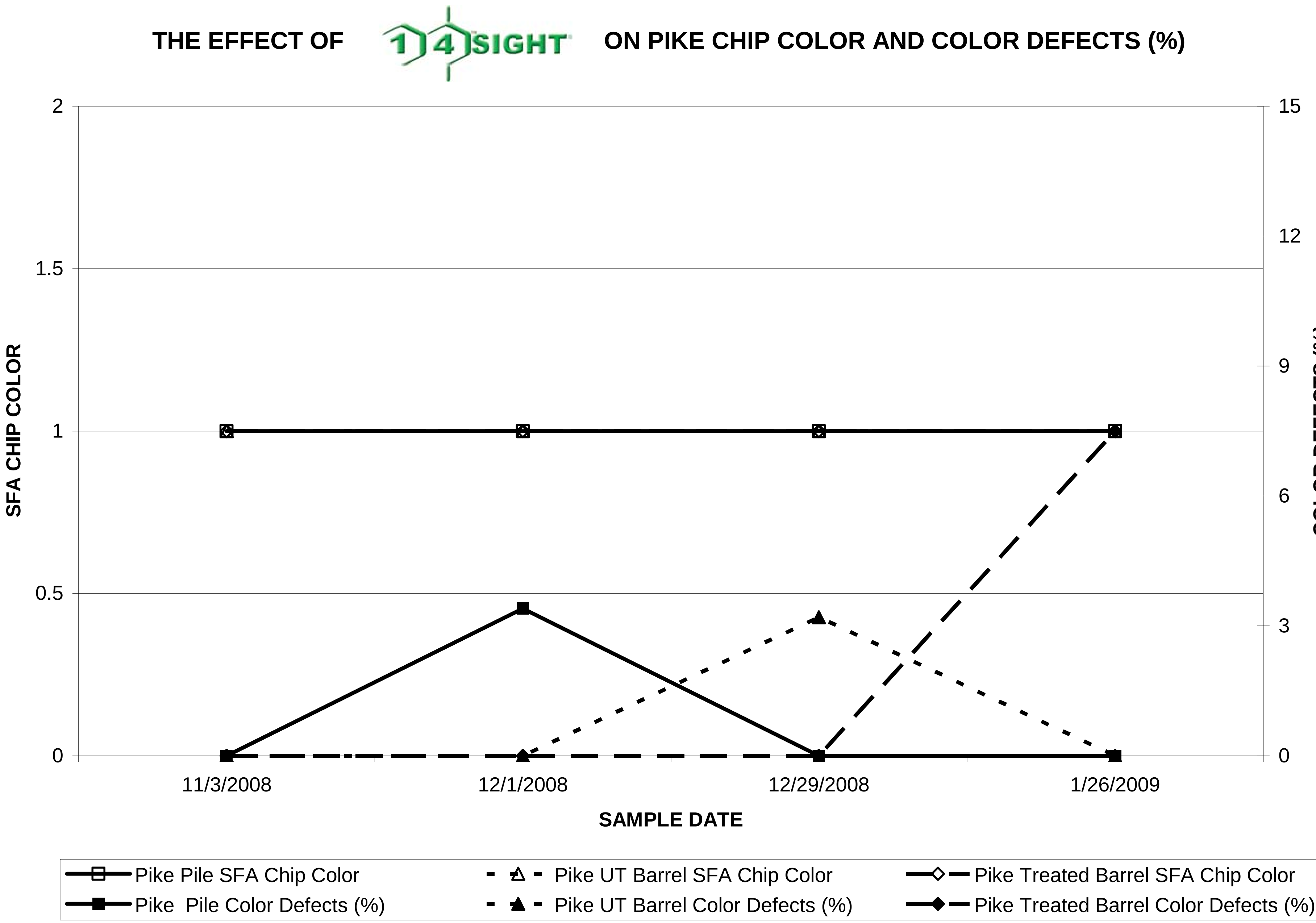

THE EFFECT OF 1 4 SIGHT ON PIKE CHIP COLOR AND COLOR DEFECTS (%)
SFA CHIP COLOR
COLOR DEFECTS (%)
SAMPLE DATE
2
1.5
1
0.5
0
15
12
9
6
3
0
11/3/2008
12/1/2008
12/29/2008
1/26/2009
Pike Pile SFA Chip Color
Pike UT Barrel SFA Chip Color
Pike Treated Barrel SFA Chip Color
Pike Pile Color Defects (%)
Pike UT Barrel Color Defects (%)
Pike Treated Barrel Color Defects (%)

Figure 5

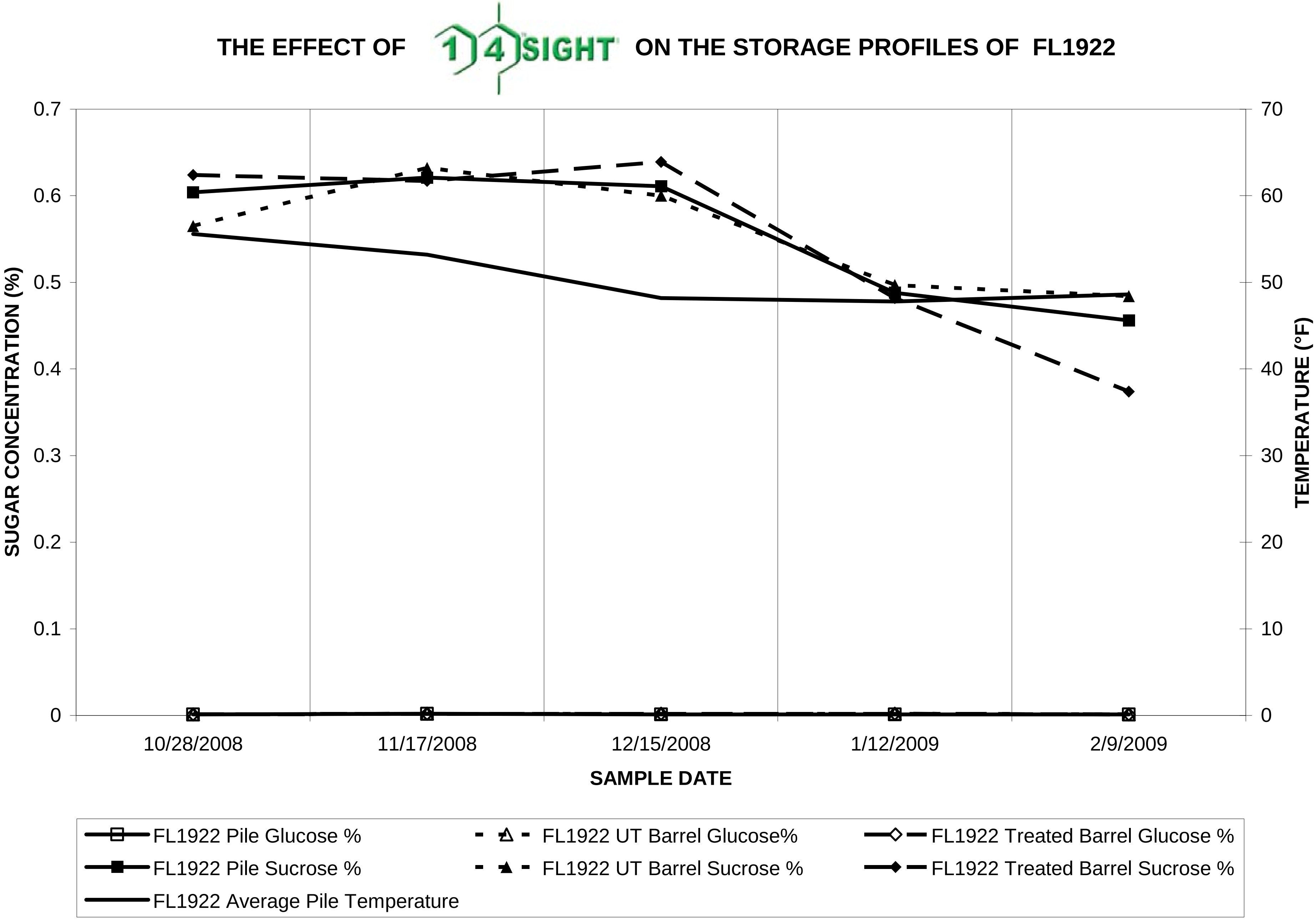
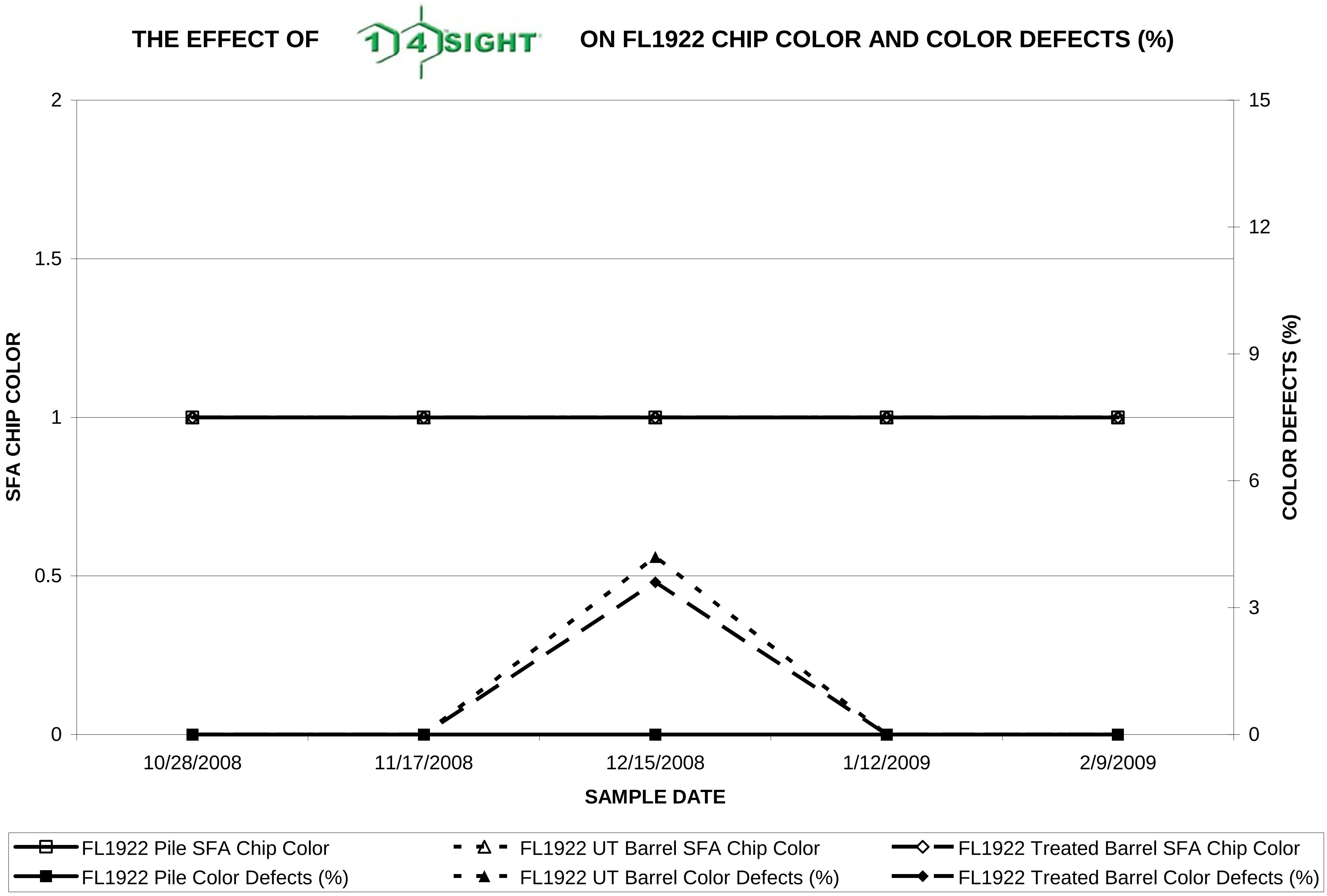

THE EFFECT OF 1,4SIGHT ON THE STORAGE PROFILES OF FL1922
SUGAR CONCENTRATION (%)
TEMPERATURE (°F)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
70
60
50
40
30
20
10
0
10/28/2008
11/17/2008
12/15/2008
1/12/2009
2/9/2009
SAMPLE DATE
FL1922 Pile Glucose %
FL1922 UT Barrel Glucose%
FL1922 Treated Barrel Glucose %
FL1922 Pile Sucrose %
FL1922 UT Barrel Sucrose %
FL1922 Treated Barrel Sucrose %
FL1922 Average Pile Temperature

Figure 6


THE EFFECT OF
1 4 SIGHT
ON FL1922 CHIP COLOR AND COLOR DEFECTS (%)
SFA CHIP COLOR
COLOR DEFECTS (%)
SAMPLE DATE
0
0.5
1
1.5
2
0
3
6
9
12
15
10/28/2008
11/17/2008
12/15/2008
1/12/2009
2/9/2009
FL1922 Pile SFA Chip Color
FL1922 UT Barrel SFA Chip Color
FL1922 Treated Barrel SFA Chip Color
FL1922 Pile Color Defects (%)
FL1922 UT Barrel Color Defects (%)
FL1922 Treated Barrel Color Defects (%)

Funded by AgChem Industry

Vine Desiccation in Potato with Vida.

Wesley J. Everman and Andrew J. Chomas. Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824.

A study was conducted in 2009 to evaluate the efficacy of Vida applied as a vine kill product. The study was conducted at the Montcalm Research Farm and in a grower field near Morley, MI. Treatments included Vida at 5.5 fl oz plus Reglone at 1 pt plus NIS at 0.5%, Vida at 5.5 fl oz plus Reglone at 2 pt plus NIS at 0.5%, Vida at 5.5 fl oz plus COC at 1% followed by (fb) Vida at 5.5 fl oz plus COC at 1%, Vida at 5.5 fl oz plus COC at 1% fb Reglone at 2 pt plus NIS at 0.5%, Reglone at 2 pt plus NIS at 0.5% fb Vida at 5.5 fl oz plus COC at 1%, Vida at 2.75 fl oz plus Reglone at 1 pt plus NIS at 0.5% fb Vida at 2.75 fl oz plus Reglone at 1 pt plus NIS at 0.5%, Vida at 5.5 fl oz plus Reglone at 1 pt plus NIS at 0.5% fb Vida at 5.5 fl oz plus Reglone at 1 pt plus NIS at 0.5%, Vida at 5.5 fl oz plus Reglone at 2 pt plus NIS at 0.5% fb Vida at 5.5 fl oz plus Reglone at 2 pt plus NIS at 0.5%, and Reglone at 2 pt plus NIS at 0.5% fb Reglone at 2 pt plus NIS at 0.5%. 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. Vine kill was 100% for all treatments at 28 days after application, excluding the Vida fb Vida treatment, which provided 88% vine kill.

VINE DESICCATION IN POTATO WITH VIDA, 2009

Trial ID: PO909 Study Dir.:
Conducted: MONTCALM RSCH STA. Investigator: Christy Sprague

Date Planted:	5/11/09	**Row Spacing:**	34 IN
Variety:	SNOWDEN	**No. of Reps:**	4
Population:	1/FT	**% OM:**	1.1
Soil Type:	Loamy Sand	**pH:**	6.0
Plot Size:	10 **X** 20 **FT**	**Design:**	RANDOMIZED COMPLETE BLOCK

Tillage: Spring Disc 3X. Spring Chisel. Field Cultivated.
Fertilizer: 20 gal/A of 19-17-0, 12 gal/A of 10-34-0 in Row. 23 gal/A of 28% N at Cultivation. 23 gal/A of 28%N at Hilling. 100 lbs/A of 46-0-0 Broadcast.

Application Description

	A	**B**
Application Timing:	SEN	YELL
Date Treated:	8/12/09	8/19/09
Time Treated:	11:00 AM	11:15 AM
% Cloud Cover:	0	20
Air Temp., Unit:	78 F	79 F
% Relative Humidity:	71	46
Wind Speed/Unit/Dir:	2 mph SW	2 mph SE
Soil Temp., Unit:	73 F	70 F
Soil/Leaf Surface M:	5	5
Soil Moist (1=w 5=d):	3	5

Crop Stage at Each Application

	A	**B**
Crop Name:	SOLTU	SOLTU
Height (In.):	18	18

Weed Stage at Each Application

	A	**B**
Weed 1 Name:	ANGR	ANGR
Weed 2 Name:	CHEAL	CHEAL
Weed 3 Name:	POROL	POROL

Application Equipment

Appl	**Sprayer Type**	**Speed MPH**	**Nozzle Type**	**Nozzle Size**	**Nozzle Height**	**Nozzle Spacing**	**Boom Width**	**GPA**	**Carrier**	**PSI**
A	BKPK	3.5	FF	8003	29"	20"	100"	20	H2O	30
B	BKPK	3.5	FF	8003	33"	20"	120"	20	H2O	30

VINE DESICCATION IN POTATO WITH VIDA, 2009

Trial ID: PO909 Study Dir.:
Conducted: MONTCALM RSCH STA. Investigator: Christy Sprague

Trt No.	Treatment Name	Form Conc	Form Type	Rate	Rate Unit	Grow Stg	1	2	3	4	5
Weed Code									ANGR	CHEAL	POROL
Crop Code							SOLTU	SOLTU			
Rating Data Type							injury	injury	control	control	control
Rating Unit							percent	percent	percent	percent	percent
Rating Date							8/15/09	8/19/09	8/19/09	8/19/09	8/19/09
Trt-Eval Interval							3 DASEN	7 DASEN	7 DASEN	7 DASEN	7 DASEN
1	Vida	.208	L	5.5	fl oz/a	SEN	89	95	95	92	96
1	Reglone	2	L	1	pt/a	SEN					
1	Activator 90		L	0.5	% v/v	SEN					
2	Vida	.208	L	5.5	fl oz/a	SEN	91	86	91	98	98
2	Reglone	2	L	2	pt/a	SEN					
2	Activator 90		L	0.5	% v/v	SEN					
3	Vida	.208	L	5.5	fl oz/a	SEN	46	66	98	100	100
3	Herbimax		L	1	% v/v	SEN					
3	Vida	.208	L	5.5	fl oz/a	YELL					
3	Herbimax		L	1	% v/v	YELL					
4	Vida	.208	L	5.5	fl oz/a	SEN	55	71	98	100	100
4	Herbimax		L	1	% v/v	SEN					
4	Reglone	2	L	2	pt/a	YELL					
4	Activator 90		L	0.5	% v/v	YELL					
5	Reglone	2	L	2	pt/a	SEN	86	94	93	90	98
5	Activator 90		L	0.5	% v/v	SEN					
5	Vida	.208	L	5.5	fl oz/a	YELL					
5	Herbimax		L	1	% v/v	YELL					
6	Vida	.208	L	2.75	fl oz/a	SEN	80	92	96	96	100
6	Reglone	2	L	1	pt/a	SEN					
6	Activator 90		L	0.5	% v/v	SEN					
6	Vida	.208	L	2.75	fl oz/a	YELL					
6	Reglone	2	L	1	pt/a	YELL					
6	Activator 90		L	0.5	% v/v	YELL					
7	Vida	.208	L	5.5	fl oz/a	SEN	83	93	94	95	100
7	Reglone	2	L	1	pt/a	SEN					
7	Activator 90		L	0.5	% v/v	SEN					
7	Vida	.208	L	5.5	fl oz/a	YELL					
7	Reglone	2	L	1	pt/a	YELL					
7	Activator 90		L	0.5	% v/v	YELL					
8	Vida	.208	L	5.5	fl oz/a	SEN	96	90	95	99	100
8	Reglone	2	L	2	pt/a	SEN					
8	Activator 90		L	0.5	% v/v	SEN					
8	Vida	.208	L	5.5	fl oz/a	YELL					
8	Reglone	2	L	2	pt/a	YELL					
8	Activator 90		L	0.5	% v/v	YELL					
9	Reglone	2	L	2	pt/a	SEN	86	83	89	88	95
9	Activator 90		L	0.5	% v/v	SEN					
9	Reglone	2	L	2	pt/a	YELL					
9	Activator 90		L	0.5	% v/v	YELL					
10	Non-Treated						21	0	0	0	0
LSD (P=.05)							15.4	10.6	7.1	10.5	5.9
Standard Deviation							10.6	7.3	4.9	7.2	4.0
CV							14.47	9.53	5.74	8.41	4.55

VINE DESICCATION IN POTATO WITH VIDA II, 2009

Trial ID: P1509 Study Dir.: Andy Chomas
Conducted: SandyLand Investigator: Christy Sprague

Date Planted:		**Row Spacing:**	IN
Variety:	MSJ147-1	**No. of Reps:**	4
Population:		**% OM:**	
Soil Type:		**pH:**	
Plot Size:	10 **X** 20 **FT**	**Design:**	RANDOMIZED COMPLETE BLOCK

Application Description

	A	B
Application Timing:	SEN	YELL
Date Treated:	9/8/09	9/15/09
Time Treated:		12:15 PM
% Cloud Cover:		30
Air Temp., Unit:		76 F
% Relative Humidity:		56
Wind Speed/Unit/Dir:		3 mph N
Soil/Leaf Surface M:		5
Soil Moist (1=w 5=d):		5

Crop Stage at Each Application

	A	B
Crop Name:	SOLTU	SOLTU
Height (In.):		21-18(12)

Application Equipment

Appl	Sprayer Type	Speed MPH	Nozzle Type	Nozzle Size	Nozzle Height	Nozzle Spacing	Boom Width	GPA	Carrier	PSI
A	BKPK	3.5	FF	8003	30"	20"	100	20	H20	30
B	BKPK	3.5	FF	8003	30"	20"	100"	20	H2O	30

Comments: Spray solution was buffered to a pH of 6.0.

VINE DESICCATION IN POTATO WITH VIDA II, 2009

Trial ID: P1509 Study Dir.: Andy Chomas
Conducted: SandyLand Investigator: Christy Sprague

Weed Code										
Crop Code						SOLTU	SOLTU	SOLTU	SOLTU	SOLTU
Rating Data Type						control	control	control	control	control
Rating Unit						percent	percent	percent	percent	percent
Rating Date						9/11/09	9/15/09	9/22/09	9/30/09	10/6/09
Trt-Eval Interval						3 DASEN	7 DASEN	14 DASEN	22 DASEN	28 DASEN
Trt No. / Treatment Name	Form Conc	Form Type	Rate	Rate Unit	Grow Stg	1	2	3	4	5
1 Vida	.208	L	5.5	fl oz/a	SEN	76	75	91	92	100
1 Reglone	2	L	1	pt/a	SEN					
1 Activator 90		L	0.5	% v/v	SEN					
2 Vida	.208	L	5.5	fl oz/a	SEN	83	79	90	93	99
2 Reglone	2	L	2	pt/a	SEN					
2 Activator 90		L	0.5	% v/v	SEN					
3 Vida	.208	L	5.5	fl oz/a	SEN	15	34	56	75	88
3 Herbimax		L	1	% v/v	SEN					
3 Vida	.208	L	5.5	fl oz/a	YELL					
3 Herbimax		L	1	% v/v	YELL					
4 Vida	.208	L	5.5	fl oz/a	SEN	11	35	90	96	100
4 Herbimax		L	1	% v/v	SEN					
4 Reglone	2	L	2	pt/a	YELL					
4 Activator 90		L	0.5	% v/v	YELL					
5 Reglone	2	L	2	pt/a	SEN	93	82	97	100	100
5 Activator 90		L	0.5	% v/v	SEN					
5 Vida	.208	L	5.5	fl oz/a	YELL					
5 Herbimax		L	1	% v/v	YELL					
6 Vida	.208	L	2.75	fl oz/a	SEN	79	78	95	97	100
6 Reglone	2	L	1	pt/a	SEN					
6 Activator 90		L	0.5	% v/v	SEN					
6 Vida	.208	L	2.75	fl oz/a	YELL					
6 Reglone	2	L	1	pt/a	YELL					
6 Activator 90		L	0.5	% v/v	YELL					
7 Vida	.208	L	5.5	fl oz/a	SEN	90	81	95	99	100
7 Reglone	2	L	1	pt/a	SEN					
7 Activator 90		L	0.5	% v/v	SEN					
7 Vida	.208	L	5.5	fl oz/a	YELL					
7 Reglone	2	L	1	pt/a	YELL					
7 Activator 90		L	0.5	% v/v	YELL					
8 Vida	.208	L	5.5	fl oz/a	SEN	90	86	99	100	100
8 Reglone	2	L	2	pt/a	SEN					
8 Activator 90		L	0.5	% v/v	SEN					
8 Vida	.208	L	5.5	fl oz/a	YELL					
8 Reglone	2	L	2	pt/a	YELL					
8 Activator 90		L	0.5	% v/v	YELL					
9 Reglone	2	L	2	pt/a	SEN	92	87	98	100	100
9 Activator 90		L	0.5	% v/v	SEN					
9 Reglone	2	L	2	pt/a	YELL					
9 Activator 90		L	0.5	% v/v	YELL					
10 Non-Treated						0	0	23	43	68
LSD (P=.05)						9.0	6.9	5.1	5.7	2.3
Standard Deviation						6.2	4.8	3.5	3.9	1.6
CV						9.91	7.48	4.23	4.39	1.65

VINE DESICCATION IN POTATO WITH VIDA III, 2009

Trial ID: P1609 Study Dir.: Andy Chomas
Conducted: Walthers Farm Investigator: Christy Sprague

Date Planted: 5/25/09
Variety:
Population:
Soil Type:
Plot Size: 10 **X** 20 **FT**

Row Spacing: 34 IN
No. of Reps: 4
% OM:
pH:
Design: RANDOMIZED COMPLETE BLOCK

Application Description

	A	B
Application Timing:	SEN	YELL
Date Treated:	9/10/09	9/17/09
Time Treated:	1:00 PM	12:30 PM
% Cloud Cover:	20	10
Air Temp., Unit:	75 F	74 F
% Relative Humidity:	68	40
Wind Speed/Unit/Dir:	3 mph	3 mph
Soil Temp., Unit:	78 F	68 F
Soil/Leaf Surface M:	5	5
Soil Moist (1=w 5=d):	3	4

Crop Stage at Each Application

	A	B
Crop Name:	SOLTU	SOLTU
Height (In.):	14-24(18)	12-24(18)

Application Equipment

Appl	Sprayer Type	Speed MPH	Nozzle Type	Nozzle Size	Nozzle Height	Nozzle Spacing	Boom Width	GPA	Carrier	PSI
A	BKPK	3.5	FF	8003	16"	20"	100"	20	H2O	30
B	BKPK	3.5	FF	8003	35"	20"	100"	20	H2O	30

Comments: 3 ROW PLOTS

Spray solution was buffered to a pH of 6.0.

VINE DESICCATION IN POTATO WITH VIDA III, 2009

Trial ID: P1609 Study Dir.: Andy Chomas
Conducted: Walthers Farm Investigator: Christy Sprague

Weed Code								
Crop Code							SOLTU	SOLTU
Rating Data Type							control	control
Rating Unit							percent	percent
Rating Date							9/17/09	9/22/09
Trt-Eval Interval							7 DASEN	5 DAYELL
Trt No.	Treatment Name	Form Conc	Form Type	Rate	Rate Unit	Grow Stg	1	2
1	Vida	.208	L	5.5	fl oz/a	SEN	64	53
1	Reglone	2	L	1	pt/a	SEN		
1	Activator 90		L	0.5	% v/v	SEN		
2	Vida	.208	L	5.5	fl oz/a	SEN	68	74
2	Reglone	2	L	2	pt/a	SEN		
2	Activator 90		L	0.5	% v/v	SEN		
3	Vida	.208	L	5.5	fl oz/a	SEN	30	39
3	Herbimax		L	1	% v/v	SEN		
3	Vida	.208	L	5.5	fl oz/a	YELL		
3	Herbimax		L	1	% v/v	YELL		
4	Vida	.208	L	5.5	fl oz/a	SEN	29	81
4	Herbimax		L	1	% v/v	SEN		
4	Reglone	2	L	2	pt/a	YELL		
4	Activator 90		L	0.5	% v/v	YELL		
5	Reglone	2	L	2	pt/a	SEN	74	95
5	Activator 90		L	0.5	% v/v	SEN		
5	Vida	.208	L	5.5	fl oz/a	YELL		
5	Herbimax		L	1	% v/v	YELL		
6	Vida	.208	L	2.75	fl oz/a	SEN	71	91
6	Reglone	2	L	1	pt/a	SEN		
6	Activator 90		L	0.5	% v/v	SEN		
6	Vida	.208	L	2.75	fl oz/a	YELL		
6	Reglone	2	L	1	pt/a	YELL		
6	Activator 90		L	0.5	% v/v	YELL		
7	Vida	.208	L	5.5	fl oz/a	SEN	64	89
7	Reglone	2	L	1	pt/a	SEN		
7	Activator 90		L	0.5	% v/v	SEN		
7	Vida	.208	L	5.5	fl oz/a	YELL		
7	Reglone	2	L	1	pt/a	YELL		
7	Activator 90		L	0.5	% v/v	YELL		
8	Vida	.208	L	5.5	fl oz/a	SEN	71	95
8	Reglone	2	L	2	pt/a	SEN		
8	Activator 90		L	0.5	% v/v	SEN		
8	Vida	.208	L	5.5	fl oz/a	YELL		
8	Reglone	2	L	2	pt/a	YELL		
8	Activator 90		L	0.5	% v/v	YELL		
9	Reglone	2	L	2	pt/a	SEN	70	91
9	Activator 90		L	0.5	% v/v	SEN		
9	Reglone	2	L	2	pt/a	YELL		
9	Activator 90		L	0.5	% v/v	YELL		
10	Non-Treated						1	86
LSD (P=.05)							13.5	14.1
Standard Deviation							9.3	9.7
CV							17.22	12.22

Funded by AgChem Industry

Vine Desiccation in Potato.

Wesley J. Everman, Chris Long, and Andrew J. Chomas. Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824.

A study was initiated in 2008 and continued in 2009 to investigate the effects of vine kill herbicides on storage quality. Vine kill herbicides act rapidly to desiccate foliage from potato plants prior to harvest. Four herbicides representing 3 classes of herbicides are currently labeled for use as vine kill in potato. We routinely investigate the effectiveness of potato vine kill products in the field; however the effects of vine kill products on tuber quality and storage have not been extensively investigated. There are many physiological effects of herbicides on plant growth and development, and investigating the effects of vine kill herbicides will help determine if storage life and tuber quality are compromised. We evaluated the effect of several available vine kill herbicides and one experimental compound under evaluation on tuber quality at harvest including grade and internal defects, and are determining the effect of vine kill herbicides on potato storage life and chipping quality. Herbicide products were applied on Snowden to test effectiveness of vine kill with herbicide treatments consisting of 1) Rely at 28.7 oz/A 2) Rely + AMS at 3 lb/A 3) Reglone at 1 pt/A followed by Reglone at 1 pt 4) BAS 800 at 0.5 oz/A 5) BAS 800 at 1 oz/A 6) BAS 800 at 2 oz/A 7) BAS 800 at 4 oz/A 8) Aim at 3.2 oz/A 9) Aim at 3.2 oz/A fb Aim at 3.2 oz/A. All herbicide treatments were compared with a non-treated control treatment. Vine kill was evaluated weekly after treatment until harvest. Plots were harvested after vine kill and marketable yield was determined. No yield effects were observed due to treatment, and all products resulted in excellent vine kill at the time of harvest. Tubers were then placed by treatment into storage in the new potato storage unit. Tuber samples were taken on a monthly basis to determine sugar levels, internal defects, and chip quality. Results of this research will determine if storage quality and life is affected by herbicide treatments for vine kill.

VINE DESICCATION AND STORAGE IN POTATO, 2009

Trial ID: P0509 Study Dir.:
Conducted: MONTCALM RSH FARM Investigator: Christy Sprague

Date Planted:	5/11/09	**Row Spacing:**	34 IN
Variety:	SNOWDEN	**No. of Reps:**	4
Population:	1/FT	**% OM:**	1.2
Soil Type:	Loamy Sand	**pH:**	5.4
Plot Size:	10 **X** 30 **FT**	**Design:**	RANDOMIZED COMPLETE BLOCK

Tillage: Spring Disc 3X. Spring Chisel. Field Cultivated.
Fertilizer: 20 gal/A of 19-17-0, 12 gal/A of 10-34-0 in Row. 23 gal/A of 28% N at Cultivation. 23 gal/A of 28%N at Hilling. 100 lbs/A of 46-0-0 Broadcast.

Application Description

	A	**B**
Application Timing:	SEN	YELL
Date Treated:	8/19/09	8/27/09
Time Treated:	10:30 AM	
% Cloud Cover:	20	
Air Temp., Unit:	79 F	
% Relative Humidity:	46	
Wind Speed/Unit/Dir:	2 mph SE	
Soil Temp., Unit:	70 F	
Soil/Leaf Surface M:	5	
Soil Moist (1=w 5=d):	5	

Crop Stage at Each Application

	A	**B**
Crop Name:	SOLTU	SOLTU
Height (In.):	18	18

Application Equipment

Appl	**Sprayer Type**	**Speed MPH**	**Nozzle Type**	**Nozzle Size**	**Nozzle Height**	**Nozzle Spacing**	**Boom Width**	**GPA**	**Carrier**	**PSI**
A	BKPK	3.5	FF	8003	33"	20"	120"	20	H2O	30
B	BKPK	3.5	FF	8003		20"	120"	20	H20	30

VINE DESICCATION AND STORAGE IN POTATO, 2009

Trial ID: P0509 Study Dir.:
Conducted: MONTCALM RSH FARM Investigator: Christy Sprague

Weed Code														
Crop Code						SOLTU	SOLTU	SOLTU	SOLTU	SOLTU	SOLTU	SOLTU	SOLTU	SOLTU
Rating Data Type						control	control	control	<1 7/8"	<1 7/8"	PickOut	PickOut	oversize	oversize
Rating Unit						percent	percent	percent	kilogram	count	kilogram	count	kilogram	count
Rating Date						8/27/09	9/1/09	9/8/09	9/22/09	9/22/09	9/22/09	9/22/09	9/22/09	9/22/09
Trt-Eval Interval						7 DASEN	5 DAYEL	12 DAYEL	HARVEST	HARVEST	HARVEST	HARVEST	HARVEST	HARVEST
Trt No.	Treatment Name	Form Conc	Form Type	Rate	Rate Unit / Grow Stg	1	2	3	4	5	6	7	8	9

Trt No.	Treatment Name	Form Conc	Form Type	Rate	Rate Unit	Grow Stg	1	2	3	4	5	6	7	8	9
1	Untreated						90	88	100	3.6625	44.5	0.0000	0	0.000	0
2	Rely 200	1.67	L	28.7	fl oz/a	SEN	99	100	100	3.2175	54.8	0.0000	0	0.148	1
3	Rely 200	1.67	L	28.7	fl oz/a	SEN	98	99	100	2.1250	44.8	0.0000	0	0.123	0
3	Ammonium Sulfate	100	DF	3	lb/100 gal	SEN									
4	Reglone	2	L	1	pt/a	SEN	97	99	100	2.0113	40.3	0.0000	0	0.000	0
4	Activator 90		L	0.25	% v/v	SEN									
4	Reglone	2	L	1	pt/a	YELL									
4	Activator 90		L	0.25	% v/v	YELL									
5	Sharpen	2.9	L	0.5	fl oz/a	SEN	98	99	100	3.3788	60.3	0.0000	0	0.000	0
5	Herbimax		L	1	% v/v	SEN									
5	Ammonium Sulfate	100	DF	2	% w/w	SEN									
6	Sharpen	2.9	L	1	fl oz/a	SEN	97	96	100	4.3050	49.3	0.0000	0	0.000	0
6	Herbimax		L	1	% v/v	SEN									
6	Ammonium Sulfate	100	DF	2	% w/w	SEN									
7	Sharpen	2.9	L	2	fl oz/a	SEN	100	100	100	3.5188	58.3	0.0000	0	0.000	0
7	Herbimax		L	1	% v/v	SEN									
7	Ammonium Sulfate	100	DF	2	% w/w	SEN									
8	Sharpen	2.9	L	4	fl oz/a	SEN	100	99	100	2.6875	57.0	0.1488	1	0.000	0
8	Herbimax		L	1	% v/v	SEN									
8	Ammonium Sulfate	100	DF	2	% w/w	SEN									
9	Aim	2	L	0.032	lb ai/a	SEN	95	98	100	3.2788	55.0	0.0000	0	0.000	0
9	MSO		L	1	% v/v	SEN									
10	Aim	2	L	0.025	lb ai/a	SEN	95	99	100	4.5513	55.5	0.0000	0	0.000	0
10	MSO		L	1	% v/v	SEN									
10	Aim	2	L	0.032	lb ai/a	YELL									
10	MSO		L	1	% v/v	YELL									
LSD (P=.05)							4.0	3.2	0.0	2.53880	26.72	0.13651	0.5	0.1791	0.5
Standard Deviation							2.8	2.2	0.0	1.74971	18.41	0.09408	0.3	0.1235	0.4
CV							2.86	2.25	0.0	53.45	35.45	632.46	632.46	457.23	478.34

VINE DESICCATION AND STORAGE IN POTATO, 2009

Trial ID: P0509 Study Dir.:
Conducted: MONTCALM RSH FARM Investigator: Christy Sprague

Weed Code												
Crop Code						SOLTU	SOLTU	SOLTU	SOLTU	SOLTU	SOLTU	SOLTU
Rating Data Type						Grade A	Grade A	dry	wet	SPEC. GRAV.	HH	VD
Rating Unit						kilogram	count				0-10	0-10
Rating Date						9/22/09	9/22/09	9/22/09	9/22/09	9/22/09	9/22/09	9/22/09
Trt-Eval Interval						HARVEST	HARVEST	HARVEST	HARVEST	HARVEST	HARVEST	HARVEST
Trt No. / Treatment Name	Form Conc	Form Type	Rate	Rate Unit	Grow Stg	10	11	12	13	14	15	16
1 Untreated						22.1012519	159	9.5963	0.78475	1.0891491	1	4
2 Rely 200	1.67	L	28.7	fl oz/a	SEN	20.1337510	178	9.8700	0.74975	1.0831081	0	2
3 Rely 200	1.67	L	28.7	fl oz/a	SEN	21.9650023	182	8.9875	0.72950	1.0883448	0	6
3 Ammonium Sulfate	100	DF	3	lb/100 gal	SEN							
4 Reglone	2	L	1	pt/a	SEN	17.6237524	172	9.4763	0.77688	1.0891869	0	4
4 Activator 90		L	0.25	% v/v	SEN							
4 Reglone	2	L	1	pt/a	YELL							
4 Activator 90		L	0.25	% v/v	YELL							
5 Sharpen	2.9	L	0.5	fl oz/a	SEN	15.3712507	143	8.6500	0.65813	1.0821524	0	5
5 Herbimax		L	1	% v/v	SEN							
5 Ammonium Sulfate	100	DF	2	% w/w	SEN							
6 Sharpen	2.9	L	1	fl oz/a	SEN	20.0362512	167	9.7150	0.73788	1.0829724	0	3
6 Herbimax		L	1	% v/v	SEN							
6 Ammonium Sulfate	100	DF	2	% w/w	SEN							
7 Sharpen	2.9	L	2	fl oz/a	SEN	16.6150014	161	8.6925	0.65763	1.0830008	0	5
7 Herbimax		L	1	% v/v	SEN							
7 Ammonium Sulfate	100	DF	2	% w/w	SEN							
8 Sharpen	2.9	L	4	fl oz/a	SEN	19.3675022	170	9.6513	0.79325	1.0895522	0	4
8 Herbimax		L	1	% v/v	SEN							
8 Ammonium Sulfate	100	DF	2	% w/w	SEN							
9 Aim	2	L	0.032	lb ai/a	SEN	20.8987524	182	9.7800	0.82563	1.0922733	0	5
9 MSO		L	1	% v/v	SEN							
10 Aim	2	L	0.025	lb ai/a	SEN	22.4500011	202	10.5200	0.90300	1.0927483	0	3
10 MSO		L	1	% v/v	SEN							
10 Aim	2	L	0.032	lb ai/a	YELL							
10 MSO		L	1	% v/v	YELL							
LSD (P=.05)						6.22607866	43.7	2.76942	0.241073	0.01134400	0.7	3.1
Standard Deviation						4.29093785	30.1	1.90865	0.166144	0.00781814	0.5	2.1
CV						21.83	17.6	20.1	21.81	0.72	483.05	53.0

ARM Action Codes

T1 = ([12])/([12]-[13])